

Morphological investigation and typification of *Eunotia denticulata* (Brébisson ex Kützing) Rabenhorst and *Eunotia major* (W.Smith) Rabenhorst (*Eunotiaceae*, *Bacillariophyta*)

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In the present contribution, the type material of two *Eunotia* species is discussed: *Eunotia denticulata* (Brébisson ex Kützing) Rabenhorst and *Eunotia major* (W.Smith) Rabenhorst.

Eunotia denticulata (Brébisson ex Kützing) Rabenhorst (1864: 73) was originally described as *Himantidium denticulatum* Brébisson ex Kützing (1849: 10) based on specimens from France ('in Gallia') sent by Louis Alphonse de Brébisson (1798-1872) to Kützing '*Specimina misit amic. De Brébisson* [specimens sent by my friend De Brébisson]'. The species was described as follows '*H. latere secundario angustissimo, arcuato, dorso denticulato, apicibus leviter recurvis. Long. 1/60 – 1/40"*. *Latitudo lateris primarii 1/150–1/120"*. *H[imantidium]* with a very narrow, arcuate valve face, dorsally dented, with slightly recurving poles. Length 37–56 µm. Frustule width 15–19 µm (Lange-Bertalot & al. 2011: 83). Rabenhorst (1864: 73) transferred the species to *Eunotia denticulata* indicating '*prope Falaise in Gallia (De Brébisson)* [near Falaise in France (De Brébisson)]' as original locality. In the Van Heurck collection, kept in (BR) Meise Botanic Garden, Belgium, a sample labelled '*Himantidium denticulatum* - Sp. alg. 10' (Fig. 1) was found, most likely referring to Kützing's description, with 'La Trappe' given as sampling locality. La Trappe is currently known as Soligny-la-Trappe, a small town and the location of La Trappe Abbey, c. 60 km south-east of Falaise, France. Lange-Bertalot & al. (2011: pl. 158: figs 1–5; pl. 172: figs 1–15; pl. 173: figs 1–6) made LM observations of specimens in Brébisson's material from La Trappe, held at the Natural History Museum, London (BM 17871), and in addition of specimens in samples from Falaise (Normandy, France) and from La Fontaine de Barenton (Paimpont, Brittany). Several SEM images from France and Greenland were shown, but no SEM images were shown from the La Trappe material. Moreover, a formal lectotypification of the original material was not carried out. In the present contribution, we illustrate specimens contained in Brébisson's material from La Trappe and Falaise, both conserved in the Van Heurck collection in Meise Botanic Garden (BR).

Eunotia denticulata (Brébisson ex Kützing) Rabenhorst, 1864 (Figs 1–22)

Basionym: *Himantidium denticulatum* Brébisson ex Kützing, *Species algarum*, p. 10, 1849.

Lectotype (here designated): BR-4724 (represented by Fig. 5), slide prepared from the Brébisson sample *Himantidium denticulatum* from La Trappe [Soligny-la-Trappe, Normandy], France, leg. L.A. de Brébisson, original material present in the Van Heurck collection (BR).

Registration (of lectotypification): <http://phycobank.org/103178>

Heterotypic synonym: *Eunotia denticulata* var. *genuina* Cleve-Euler 1953, *nom. inval.* (Art. 26.2).

Description: Frustules in girdle view rectangular, in dorsal view with two dense rows of small marginal spines (Fig. 3). Valves arcuate with slightly convex dorsal and slightly concave ventral margin (Figs 4–7, 10–14). Spines distinctly visible on dorsal margin in LM (Figs 3, 4, 7, 9–14). Poles protracted, broadly rounded, subcapitate to capitate. Valve dimensions (n=9, specimens from La Trappe and Falaise combined): length 36.0–73.5 µm, width 7–8 µm. Terminal raphe fissures short, straight, terminating below half the width of the poles. Ventrally, raphe branches relatively long, clearly curved away from the valve margin. Striae more or less parallel, equidistant throughout the valve, 16–17 in 10 µm (measured in the central part of the valve). In

SEM, 3–4 irregular rows of small, conical, acute spines located at and near the valve face/mantle junction (Figs 15–18). Largest spines irregularly placed at the valve face/mantle junction, fewer smaller spines on the valve face, and two rows of more densely spaced smaller spines located on the mantle. Few smaller granules present on the valve mantle. Entire cingulum composed of a broad valvocopula and copula, and three narrower pleurae (Figs 17–20). Valvocopula and abvalvar margins of the copula and pleurae covered by dense pattern of small, irregularly spaced, granules. Up to seven rows of small pores present on the pars exterior of the valvocopula, and up to 6 on the pars exterior of the copula. Two rows of pores visible on the pleurae. Striae uniseriate, composed of rounded, occluded areolae, located in shallow grooves (Fig. 18). Striae continuing without interruption onto the mantle. Near the poles, below the raphe branches, irregular pattern of small pores visible (Figs 19, 20). Raphe moderately sigmoid, central ends surrounded by large hyaline areas, terminal raphe fissures surrounded by smaller hyaline areas, (Figs 18–20). Internally distal raphe ends terminate in small helictoglossae (Figs 21, 22). Rimoportulae not observed.

The range of measurements of the specimens observed in the La Trappe and Falaise samples is smaller compared to the dimensions given in Lange-Bertalot & al. (2011: 82) who studied the type and other populations, length: 20–100 μm , width 6–10 μm , striae 13–16, 18 towards the poles, in 10 μm .

Similar species include *Eunotia neoborealis* Lange-Bertalot, replacing *Eunotia denticulata* var. *borealis* A.Cleve (Werum & Lange-Bertalot 2004: 153, 154), and synonymous with *E. denticulata sensu* Hustedt (1932: fig. 757: a–d). *Eunotia neoborealis* has large spines on the dorsal margin, reflexed poles and slightly narrower valves (4–6.5 μm). *Eunotia fennica* (Hustedt) Lange-Bertalot, as illustrated in Hamilton & Siver (2010, figs 1–11, 16–29) and in Simonsen (1987: pl. 217: figs 3–7), has reflexed poles and narrower valves (<4.5 μm) but the type material of the latter requires further analysis as the species is currently regarded as a synonym of *Eunotia paludosa* Grunow. The latter species has irregularly spaced, solitary spines along the dorsal margin, barely discernible in LM (Van de Vijver & al. 2022: figs 30–36). *Eunotia pyrenaica* Manguin (Allorge & Manguin 1941: 175, 176, fig. 54) also possesses dorsal spines and has a similar size range as *E. denticulata*, but with a higher stria density (20–22 in 10 μm). The original drawing in Allorge & Manguin (1941: fig. 54) suggests that the poles are only shortly protracted but inspection of the original material of this species will be necessary to confirm that it is distinct.

The second species, *Himantidium majus* W.Smith (1856: 14, pl. 33: fig. 286), was described as follows ‘*V. arcuate, dorsum elevated, extremities inflated and rounded; striae 27 in .001". Length of F. .0055" to .0075". Breath of valve .0006" v.s.*’. Smith listed three samples containing the species: Gap of Dunloe, Killarney [Co. Kerry, Ireland] July 1855, W. Sm.; Forfarshire [Scotland], Dr. Dickie; Braemar [Aberdeenshire, Scotland], Dr. Balfour, Aug. 1854. A separate variety, “ β ” but otherwise un-named, was separated in having ‘two dorsal ridges’, but Smith linked that invalid designation to *Himantidium bidens* W.Gregory, and is not taken into account in the current contribution.

Rabenhorst (1864) transferred the species to the genus *Eunotia* as *Eunotia major* (W.Smith) Rabenhorst (1864: 72, “*majus*”). Hustedt (1930) considered it to be a variety of *Eunotia monodon* Ehrenberg, *E. monodon* var. *major* (Hustedt 1930: 186, fig. 255, ‘*maior*’). This combination most likely resulted in the later ideas that *E. major* was simply a synonym for *E. monodon* Ehrenberg. The identification of these and similar taxa is discussed in Lange-Bertalot (1993) and Lange-Bertalot & al. (2011). The specimen(s) in the Ehrenberg Collection require investigation, Ehrenberg’s illustration of *E. monodon* was designated as lectotype in Lange-Bertalot & al. (2011).

A formal lectotypification of *E. major*, however, was not carried out, although in Lange-Bertalot & al. (2011: pl. 215, figs 1–7; pl. 216, fig. 1), several illustrations of original William Smith material were shown, but without specifying which material was studied.

Almost all the samples used by the Reverend William Smith (1808–1857) for his *Synopsis of British Diatomaceae* (Smith 1853, 1856) are kept in the Van Heurck collection, part of **BR** (Meise Botanic Garden, Belgium). Two samples are listed (Hoover 1976) for *Himantidium majus*. One of the samples was labelled ‘syntype’ by Hoover (1976: 58): ‘Gap of Dunloe, Killarney, 22.7.55’, and corresponds to the first of the localities mentioned by Smith (1856: 14). In the Van Heurck slide collection, an original slide, made by Charles Coppock, a nephew of William Smith, of *H. majus* material is conserved (**BR**, VI-46-A6). The number 286, referring to the figure number in Smith (1856), is engraved on the slide. A new slide was prepared using the original Gap of Dunloe material. Inspection of both the original Coppock slide and the newly prepared slide showed, however, that both may not be made from the same material as the associated diatom species in the newly prepared slide are absent in the Coppock slide, effectively a monoculture of *H. majus*. Since there is no indication of the origin of the Coppock slide and despite the indication of fig. 286, we choose here to designate the newly made slide as lectotype, as the latter was prepared from the original Smith Gap of Dunloe material.

Eunotia major (W.Smith) Rabenhorst 1864 (Figs 23–36)

Basionym: *Himantidium majus* W.Smith, *Synopsis of the British Diatomaceae*, p. 14, 1856.

Lectotype (here designated): BR-4725 (represented by Fig. 24), slide prepared from W. Smith sample Gap of Dunloe, Killarney, Co. Kerry, Ireland; coll. date July 22, 1855, leg. W. Smith, original material present in the Van Heurck collection (**BR**).

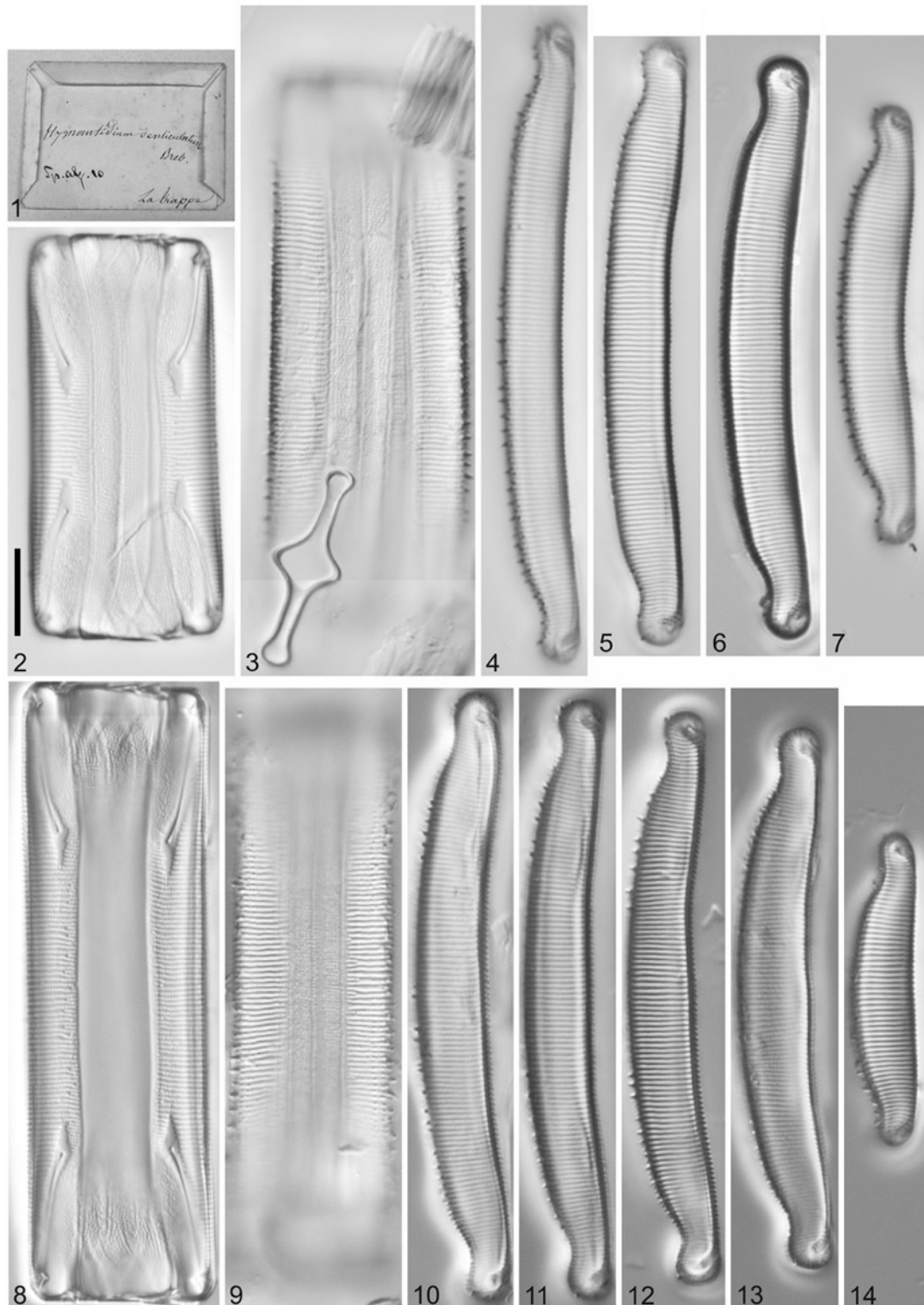
Registration (of lectotypification): <http://phycobank.org/103179>

Homotypic synonyms: *Himantidium arcus* var. *majus* (W.Smith) Brun 1880, *Eunotia monodon* var. *major* (W.Smith) Hustedt 1930 (‘*maior*’).

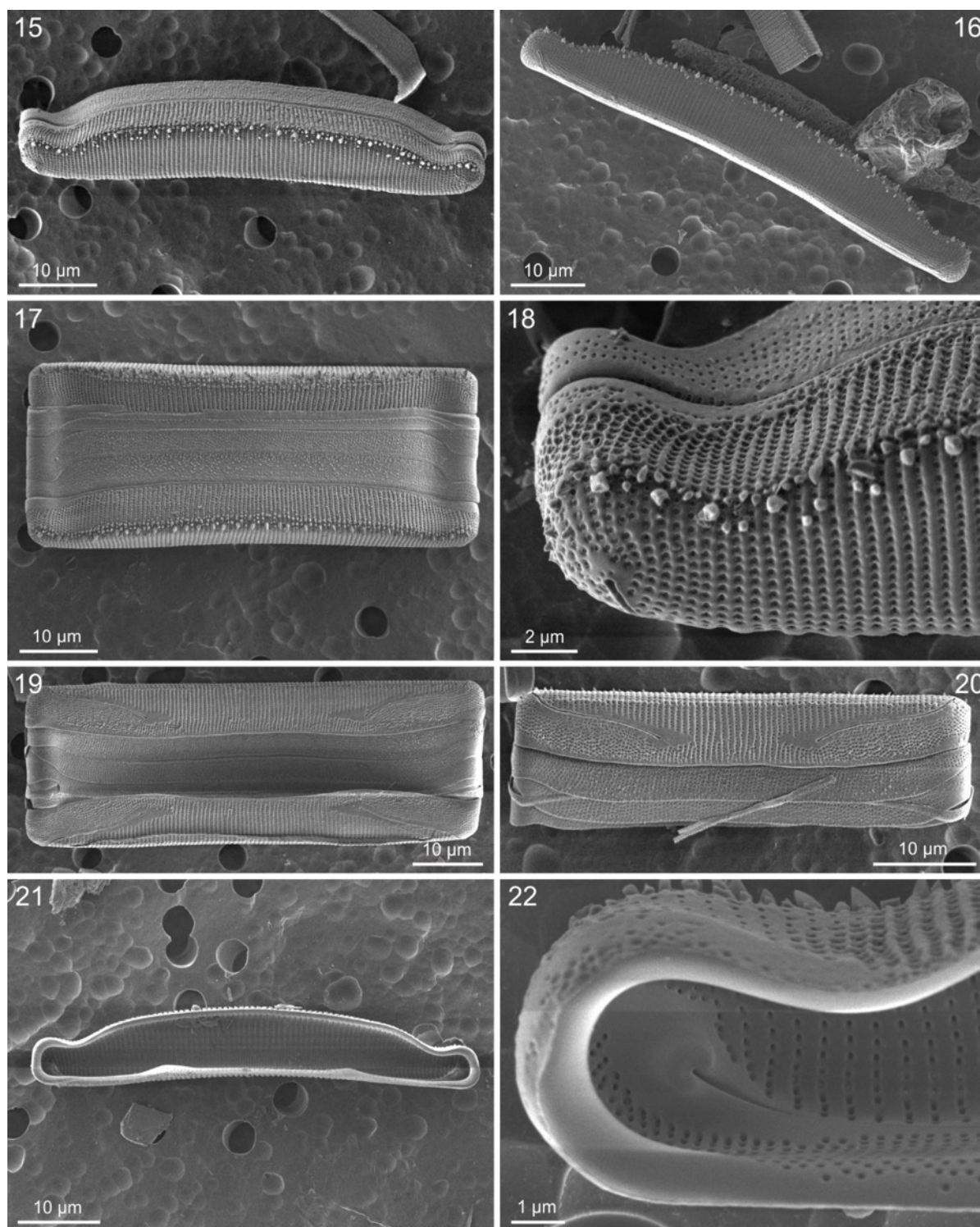
Description: Frustules in girdle view rectangular. Valves clearly arcuate with convex dorsal and concave ventral margin (Figs 23–26). Poles protracted, broadly rounded, subcapitate. Valve dimensions [$n=7$]: length 73–179 μm , width 12.0–13.5 μm . Terminal raphe fissures continuing on the valve face, curving around the pole. Striae more or less parallel, slightly irregularly spaced: 12–14 in 10 μm (measured in the central part of the valve). In SEM a small ridge visible at the valve margin consisting of irregularly spaced small, pointed teeth (Figs 30, 32–35). Entire cingulum composed of a valvocopula, copula, an adjoining pleura of similar width and 3 other pleurae with progressively decreasing widths (Figs 30–32). Many small, irregularly spaced, granules present on the cingulum (Figs 30–34). Valvocopula with up to seven rows of pores on the pars exterior, up to 6 on the pars interior of the copula. Two to four rows of pores visible on the pleurae. Striae uniseriate, composed of round, occluded areolae in shallow grooves (Figs 33, 35). Striae interrupted at the valve face/mantle junction by a marginal ridge, striae continuing further onto the mantle on the ventral mantle 9–10 rows of pores between the raphe slits, below the raphe from the central raphe endings to the pole 4–14 irregular rows of pores (Figs 33, 34). Raphe sigmoid on the mantle with central raphe endings surrounded by larger hyaline areas, terminating in a small round pore (Figs 33, 34). Raphe fissure curves onto the valve face near the end of the pole, continuing around the pole, terminating on the dorsal mantle at a short distance from the marginal ridge (Figs 30, 33–35). Internally, terminal raphe endings terminating in large helictoglossae. A single rimoportula located at the pole just above the helictoglossa (Fig. 36).

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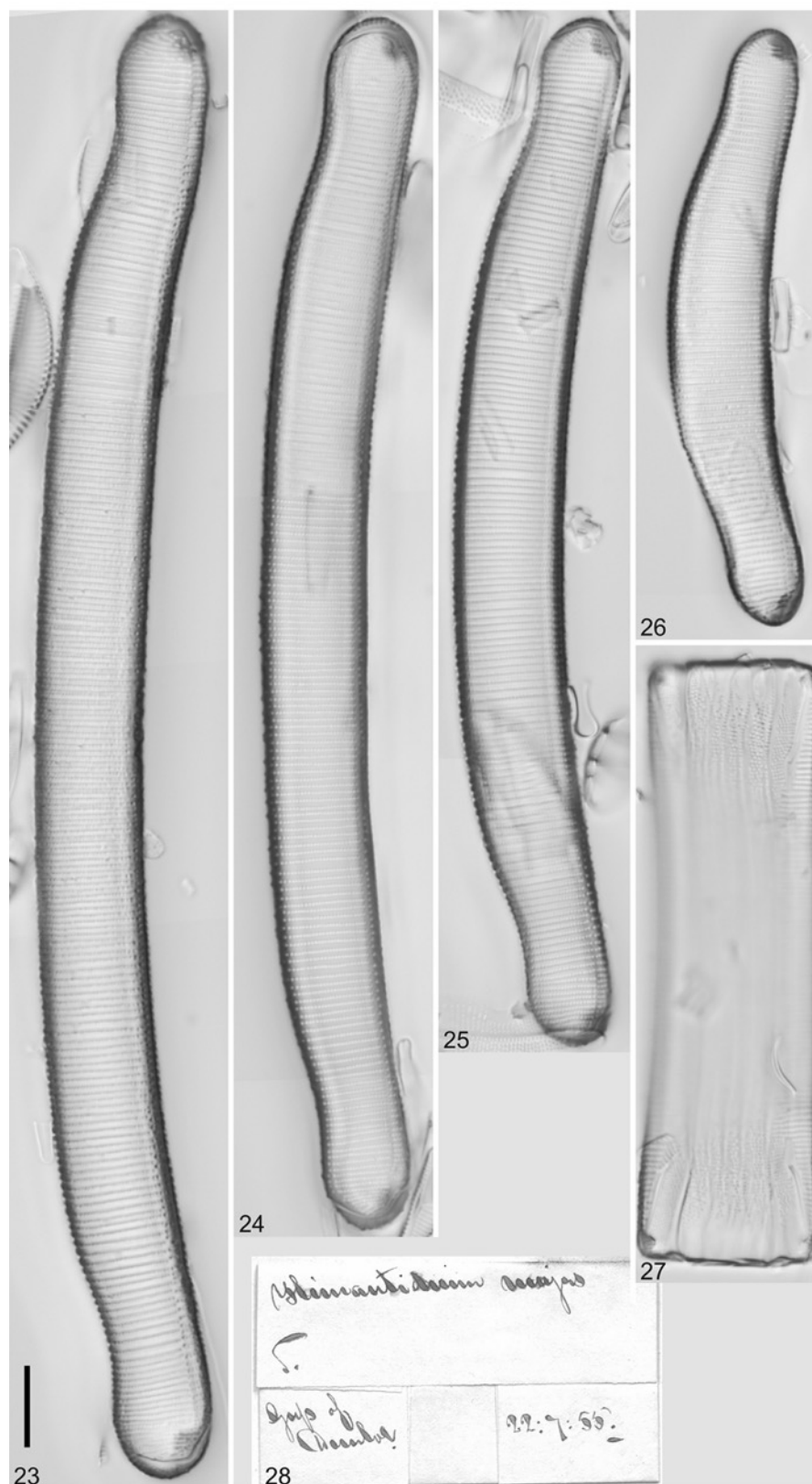
- Allorge, P. & Manguin, E. (1941). Algues d'eau douce des Pyrénées basques. *Bulletin de la Société Botanique de France* 88(1): 159–191.
- Hamilton, P.B. & Siver, P.A. (2010). A morphological investigation of *Eunotia fennica* (Bacillariophyceae) from a freshwater acidic pond in Newfoundland, Canada. *Proceedings of the Academy of Natural Sciences of Philadelphia* 160: 89–98.
- Hoover, R.B. (1976). Henri Van Heurck Museum. Types du Synopsis of British Diatomaceae. Inventory of the original typical collection of the Reverend William Smith (1808–1857). Koninklijke Maatschappij voor Dierkunde van Antwerpen met de medewerking van de Koninklijke Bibliotheek Albert I en het Stadsbestuur van Antwerpen. pp. [I–XLV], 1–106.
- Hustedt, F. (1930). Bacillariophyta. Die Süßwasserflora von Mitteleuropa Heft 10. [I–VIII], 1–466. Jena: Verlag von Gustav Fischer.
- Hustedt, F. (1932). Die Kieselalgen Deutschlands, Österreichs und der Schweiz unter Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete. In: Rabenhorst L. *Kryptogamen-Flora von Deutschland, Österreich und der Schweiz* VII. Band, 2. Teil, Lieferung 2, 177–320. Leipzig: Akademische Verlagsgesellschaft.
- Krammer, K. & Lange-Bertalot, H. (1991). *Bacillariophyceae. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae*. In: *Süßwasserflora von Mitteleuropa*, Band 2/3 (Ettl, H., Gerloff, J., Heynig, H. & Mollenhauer, D. Eds) pp. [V–XIII], [1]–576. Stuttgart, Jena: Gustav Fischer Verlag.
- Kützing, F.T. (1849). *Species Algarum*. pp. [I–VI], [1]–922. Lipsiae, F.A. Brockhaus.
- Lange-Bertalot, H. (1993). 85 Neue Taxa und über 100 weitere neu definierte Taxa ergänzend zur Süßwasserflora von Mitteleuropa Vol. 2/1–4. *Bibliotheca Diatomologica* Vol. 27. pp. [I–XXIII], 1–454.
- Lange-Bertalot, H., Båk, M. & Witkowski, A. (2011). *Eunotia* and some related genera. *Diatoms of Europe* Vol. 6. pp. [1]–747. Ruggell: A.R.G. Gantner Verlag K.G.
- Rabenhorst, L. (1864). *Flora Europaea algarum aquae dulcis et submarinae. Sectio I. Algas Diatomaceas complectens*. pp. 1–417. Lipsiae [Leipzig]: Eduardum Kummerum.
- Simonsen, R. (1987). Atlas and catalogue of the diatom types of Friedrich Hustedt. Vol. 1: pp. ix–x, [1]–525, Vol. 2: 395 pls. Berlin, Stuttgart: J. Cramer.
- Werum, M. & Lange-Bertalot, H. (2004). Diatoms in Springs from Central Europe and elsewhere under the influence of hydrology and anthropogenic impacts. *Iconographia Diatomologica* Vol. 1. pp. 1–417. Ruggell: A.R.G. Gantner Verlag K.G.



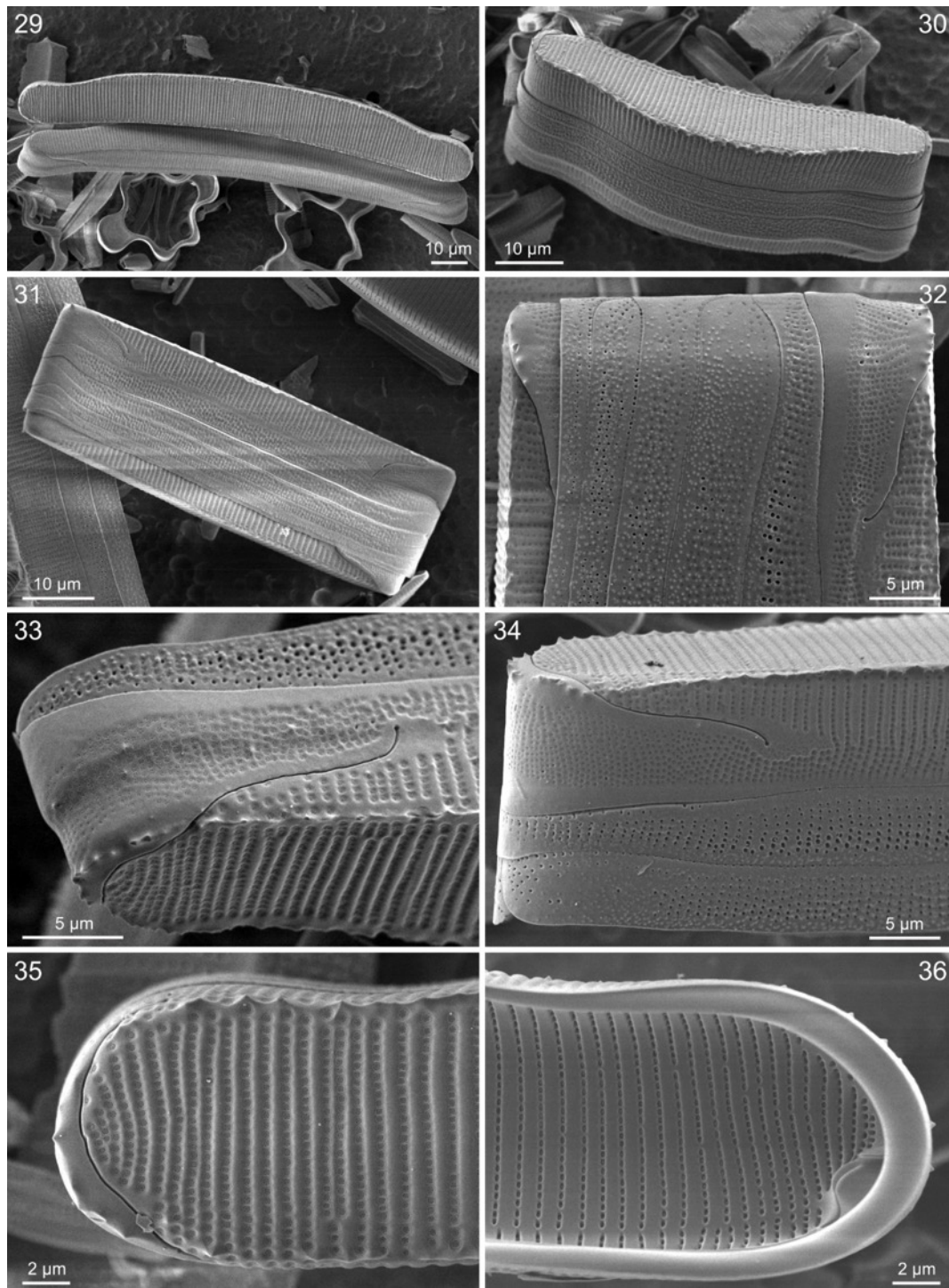
Figs 1–14. *Eunotia denticulata* (Brébisson ex Kützing) Rabenhorst. LM pictures from the lectotype material (BR-4724, La Trappe, France, Figs 1–7) and the Falaise material (BR-4726, Falaise, France, Figs 8–14). **Fig. 1.** Packet of material from La Trappe, kept at Meise Botanic Garden (BR). **Figs 2–3.** Two frustules in girdle view, ventrally (Fig. 2) and dorsally (Fig. 3). **Figs 4–7.** Four specimens from the lectotype in decreasing length. **Figs 8–9.** Two frustules in girdle view, ventrally (Fig. 8) and dorsally (Fig. 9). **Figs 10–14.** Five specimens from the Falaise material in decreasing length. Scale bar = 10 µm.



Figs 15–22. *Eunotia denticulata* (Brébisson ex Kützinger) Rabenhorst. SEM pictures from the lectotype material (BR-4724, La Trappe, France). **Fig. 15.** Oblique view of the valve face, rows of spines at the valve face/mantle junction, and of the dorsal mantle and valvocopula. **Fig. 16.** View of the valve face and rows of spines at the valve face/mantle junction. **Fig. 17.** View of the dorsal side of a frustule showing the epivalve, epicingulum and hypovalve. **Fig. 18.** Oblique view of the valve pole. **Fig. 19.** View of the ventral side of a frustule showing mantle and raphe of the epi- and hypovalve and the cingulum. **Fig. 20.** View of the ventral side of a valve, valvocopula and copula. **Fig. 21.** Internal view of a valve. **Fig. 22.** Internal view of the pole with distal raphe and helictoglossa.



Figs 23–28. *Eunotia major* (W.Smith) Rabenhorst, LM pictures taken from the lectotype material (BR-4725, Gap of Dunloe, Killarney, July 22, 1855, leg. W. Smith). **Figs 23–26.** LM pictures of valves in decreasing length. **Fig. 27.** Frustule in girdle view showing the raphe slits on the ventral mantle and the cingulum. **Fig. 28.** Packet of material from the Gap of Dunloe, held at Meise Botanic Garden (BR). Scale bar = 10 μ m.



Figs 29–36. *Eunotia major* (W.Smith) Rabenhorst, SEM pictures taken from the lectotype material (BR-4725, Gap of Dunloe, Killarney, July 22 1855, leg. W. Smith). **Fig. 29.** Upper valve showing *E. major* in valve view. **Fig. 30.** Oblique view of a frustule showing the dorsal mantle of the hypovalve and the cingulum. **Fig. 31.** View of the frustule showing the ventral mantle of the epivalve, the epicingulum and the hypovalve. **Fig. 32.** Partial view of a frustule showing the raphe and the epicingulum. **Fig. 33.** Oblique view showing the raphe at the valve pole and on the mantle. **Fig. 34.** View of the mantle and raphe on the valve pole with raphe, valvocopula and copula. **Fig. 35.** Valve view of the pole and terminal raphe fissure. **Fig. 36.** Internal view of the pole with helictoglossa and rimoportula.