Valve morphology and typification of *Epithemia eugeniae* W.Smith, a forgotten diatom species described from the Pyrenees Mountains in France (*Rhopalodiaceae, Bacillariophyta*)

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In 1857 the Rev. William Smith described two journeys through France in two short papers (Smith 1855, 1857). His second trip brought him to the Pyrenees Mountains where he collected several samples, including one near Biarritz on the border of France and Spain. Smith described how he had made a freshwater gathering "On the face of the cliff beneath the Villa Eugénie, the new château of the Empress of the French…" (Smith 1857: 5). Smith (1857) ultimately described eight new diatom species from his 1856 collections, including, for instance, *Synedra fontinalis* W.Smith (1857: 9), now transferred to the genus *Fragilaria* as *F. fontinalis* (W.Smith) Van de Vijver & al. (Van de Vijver & al. 2021). Smith prepared a single exsiccata, acquired by Henri Van Heurck, who mentioned the acquisition in both his *Synopsis* (Van Heurck 1885) and his *Traité* (*Treatise*) (1896). Van Heurck wrote in his *Synopsis*: "*M. Smith a également publié une série de préparations faites avec les matériaux récoltés pendant son voyage dans les Pyrénées. Cette collection est, croyons-nous, encore bien plus rare que la précédente, et nous n'en avons jamais vu d'autre exemplaire que celui qui est en notre possession*." [Mr Smith has also published a series of preparations from the materials he collected during his Pyrenees trip. This collection is, and you can believe us, even more rare than the previous one [i.e. a series of slides and samples for the *Synopsis of British Diatomaceae*] and we have not seen another set than the one in our possession.] (Van Heurck 1885: 48). However, Nuttall (2009) reported that some of the slides of the Pyrenees excursion have also been kept in the Okeden collection in the Royal Botanic Garden, Edinburgh (**E**), Scotland. Since 2006, Van Heurck's entire diatom collection is now held as part of the Meise Botanic Garden (**BR**) collection.

Amongst the species Smith described was *Epithemia eugeniae* W.Smith (1857: 9), a species he named in honour of the French empress Eugénie ("[…] in compliment to the locality and its mistress […]", Smith 1857: 5). His description was succinct: "F.V. inflated, with truncated extremities; S.V. lunate, extremities straight, truncate; canaliculi distinct, 8 in .001''; foramina conspicuous. Striae 32 in .001''. Length .0009'' to .0033''. v.v." (Smith 1857: 9). Smith presented four drawings of his new species of *Epithemia* (our Fig. 1), two of girdle view and two showing the septa (Smith 1857: pl. I, fig. 1a-d). Remarkable, the two septa figured were quite different in size and shape, with one being long, and allantoid (sausage-shaped) having broadly rounded apices (Fig. 1a), whereas the other septum was smaller and nearly triangular in shape with more narrowly-rounded apices (Fig. 1b). Of the two girdle views, the specimen in fig. 1c shows a single frustule, the other (Fig. 1d) shows two recently divided cells. Both illustrations have cells with narrow costae bearing small "capitate costae" (in the sense of Patrick in Patrick & Reimer 1975).

The name *Epithemia eugeniae* only sparsely reappears in diatom literature. Van Heurck (1880) did not mention it in his famous Atlas of the *Synopsis des Diatomées de Belgique*, nor did Hustedt (1930) in his overview of the genus *Epithemia*. Ralfs (in Pritchard 1861: 760) included it in his treatment of the genus, echoing Smith's description, and possible similarities to *E. sorex* Kützing and *E. proboscidea* Kützing. Rabenhorst (1864: 68) listed it and suggested it was like *Epithemia ocellata* (Ehrenberg) Kützing ["*praecedenti similis*", similar to the previous one (i.e. *E. ocellata*)]. That interpretation was, however, not followed by De Toni (1892: 782) who listed it as a synonym of *Cystopleura argus* (Ehrenberg) Kuntze (as all *Epithemia* species were transferred by Kuntze

(1891) to the genus *Cystopleura*), the latter interpretation was followed by Mills (1934) and VanLandingham (1969). On the other hand, Guiry & Guiry (2023) indicate, without comment, that *E. eugeniae* is an accepted species name. Though described originally from Europe, *E. eugeniae* was not treated by Krammer & Lange-Bertalot (1988).

It seems apparent that no one has made any direct observations on *E. eugeniae* since it was first described by Smith in 1857, most likely because of its supposed synonymy with *E. argus* Ehrenberg. As stated above, most of the samples Smith collected during his 1856 trip are conserved in Van Heurck's collection. A sample labelled 'Biarritz' was found in the collection and following preparation, proved to contain a small population of *E. eugeniae*.

Here, we detail observations on specimens of *E. eugeniae* from the Biarritz sample using light and scanning electron microscopy. We offer the first LM and SEM micrographs of valves of *Epithemia eugeniae*, allowing us to: 1) provide an emended description of William Smith's taxon (see below); 2) compare this diatom to other species with which it has been compared or proposed to be in synonymy; and 3) assign this species to a morphological group within *Epithemia* based upon its valve and girdle band features.

As no type was indicated, the Biarritz sample kept in **BR**, is therefore formally designated as lectotype for this species in accordance with ICN Art. 9.3 (Turland *et al.* 2018).

Epithemia eugeniae W.Smith emend. Kociolek & Van de Vijver (Figs 1–16)

Original description: Smith (1857) *Annals and Magazine of Natural History, Series 2*, vol. 19: 7, 1857

Homotypic synonym: *Cystopleura eugeniae* (W.Smith) Kuntze 1891: 891

Lectotype (here designated): BR 4807! (Meise Botanic Garden, Belgium); BM 1037, BM 3706, BM 21477, BM 49442, BM 67054, ANSP Febiger 2482, isolectotypes

Registration (of above lectotypification): http://phycobank.org/103980

Type locality: Face of the cliff below the "villa Eugénie" at Biarritz (France), leg. W. Smith, coll. date 3.vii.1856, sample housed at **BR**.

Emended description: LM: Valves with convex dorsal margins and slightly concave ventral margins. Apices rounded, not set off from the valve. Valve dimensions (n=15): length 25–65 µm, width 9–13 µm. Raphe at the apices beginning almost halfway between the dorsal and ventral margins, curved slightly and extending to the dorsal margin of the valve at the center. Raphe distinct. Costae extending across the valve face, 2–3 in 10 µm. Areolae distinct, formed into curved (rarely straight) striae. Striae ca. 3–6 between each costa, numbering 10–12 in 10 µm. Girdle band with robust siliceous extensions from both the dorsal and ventral margins, separating from one another close to the ventral margin. SEM: highly arched valves showing on the valve exterior radiate striae, with two rows of areolae between thin, unornamented strips running across the valve face. Striae and hyaline strips extending onto the mantle. Raphe contained in a hyaline axial area, running from about the middle of the apices, weakly arched and terminating at the dorsal margin. At the margins, raphe extending onto valve mantle, appearing to be slightly elevated from the valve face into a very short keel along its path. Dense pattern of small, acute spines visible along the ventral valve margin. Internally, large septum present, interrupted towards the ventral margin. Separation of the strong extensions from the margins appearing jagged on both edges. Vertical extensions on one side of the septum smooth, while on the other side running along the costae, extensions grooved, clasping the costae. Primary costae on the valve face extending across the valve. Canal raphe with round, distinct portules, being larger than the round areola openings. Three-four striae located between adjacent costae. Central area showing the central raphe ends to be discontinuous. Terminal raphe fissures apparently not terminating onto helictoglossae.

Figure 1a in Smith (1857) shows a rather oddly positioned specimen and seems not to resemble those found in the original material. The overall general outline of that figure, which is a drawing of the septum and not the valve, might be suggestive of the outline in valves of *E. argus*, and hence the suggestions by Ralfs (1861) and Rabenhorst (1864), that Smith's *E. eugeniae* is synonymous with *E. argus*. Nevertheless, at least one specimen was photographed in the original material (Fig. 3). *Epithemia argus* has a biarcuate raphe that, near the middle of the valve, extends from nearly the ventral margin to nearly the dorsal margin, a raphe configuration quite unlike *E. eugeniae*. The course of the raphe in *E. eugeniae* is more reminiscent of *E. cistula* (Ehrenberg) Ralfs and its allies, with the raphe barely curved and nearly straight, extending from the apices to the dorsal margin (Krammer & Lange-Bertalot 1988, Vigneshwaran & al. 2021). It is possible that *E. eugeniae* is synonymous with *E. cistula* (basionym: *Eunotia cistula* Ehrenberg 1854), a species originally described from "Jastraba" (now in Slovakia) (Ehrenberg 1854). Both *E. eugeniae* and *E. cistula* appear similar in outline, have a similar structure to the raphe system and have been reported from France (Hustedt 1939). However, while *E. eugeniae* has septa that are separated near the ventral margin, Krammer & Lange-Bertalot (1988: 151) indicate for *E. cistula*, "*Die recht kräftigen Septensprossen besitzen Nähte auf ihrer Dorsalseite*….". Patrick & Reimer (1975) have used the position of separation of the septal extensions (as being either dorsal or ventral) as one distinguishing feature of species in *Epithemia*. The identity and distribution of *E. cistula* has been debated (Hustedt 1938, Lange-Bertalot & Krammer 1987, Krammer & Lange-Bertalot 1988), thus further work on that species is necessary to determine its identity and, thus, whether it is conspecific with *E. eugeniae* or if the latter is a distinct, unique taxon.

Mrs Myriam de Haan is thanked for her help with the SEM observations. This study was supported in part by Grant No. 2222944 from the National Science Foundation (United States).

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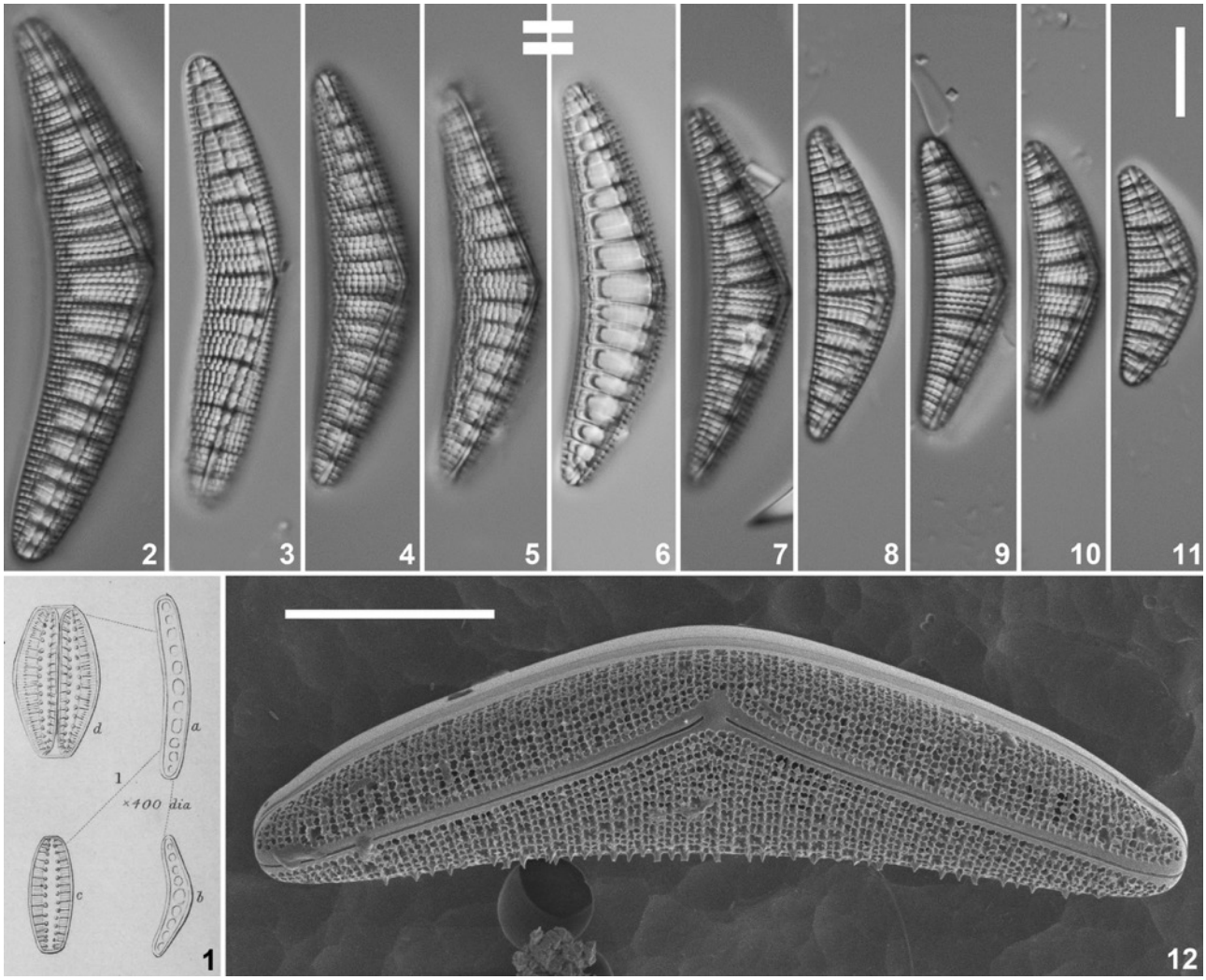
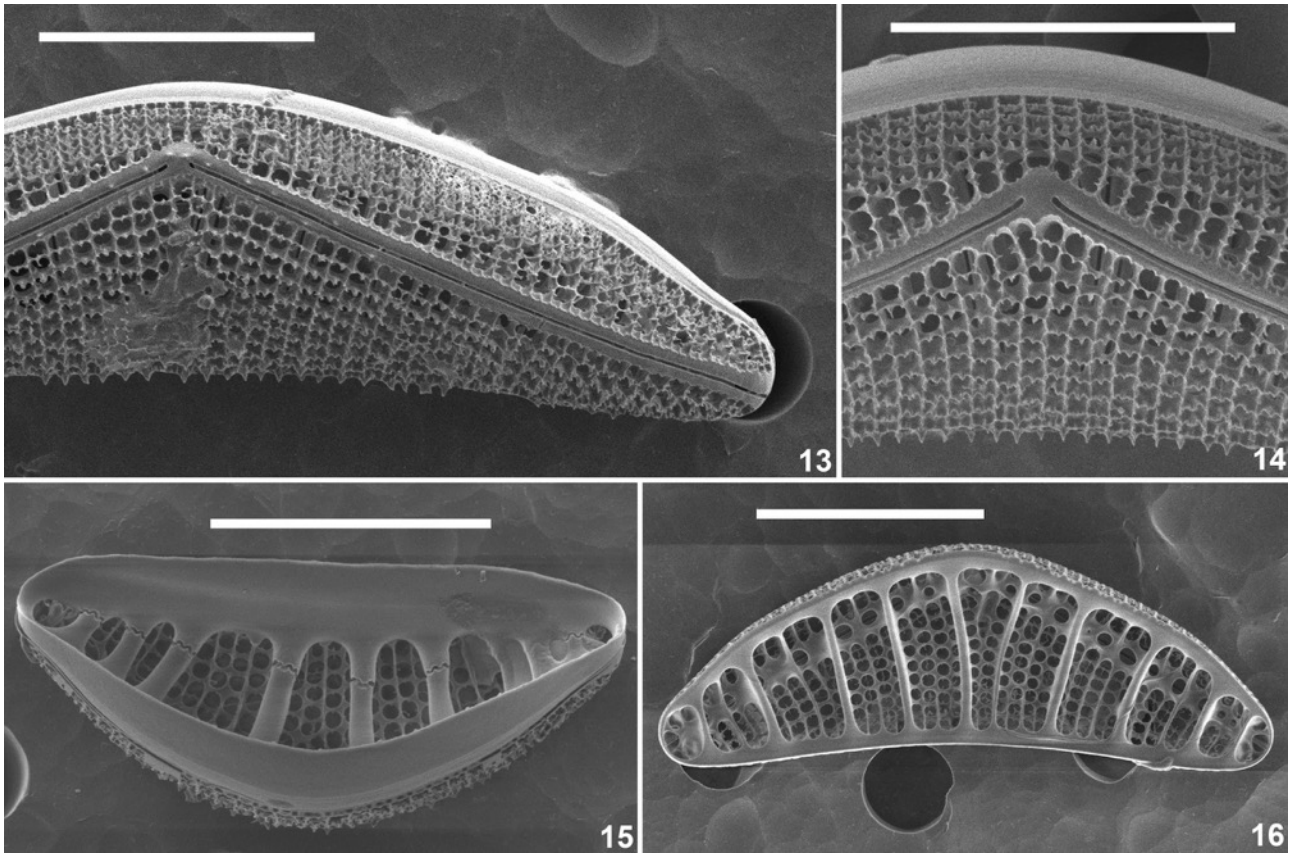


Figs 1–12. *Epithemia eugeniae* W.Smith. LM and SEM pictures taken from the lectotype material (BR-4807, Biarritz, France, leg. William Smith, 03.VII.1856, sample housed at **BR**.). **Fig. 1.** Original drawing taken from Smith (1857, plate 1, fig. 1a–d). **Figs 2–11.** LM valve face views showing the cell diminution series. Figs 5 & 6 represent the same specimen with Fig. 5 showing the valve face and Fig. 6 focusing on the septum. **Fig. 12.** SEM external view of an entire valve. Note the numerous spines scattered over the valve face. Scale bar represents 10 µm.



Figs 13–16. *Epithemia eugeniae* W.Smith. SEM pictures taken from the lectotype material (BR-4807, Biarritz, France, leg. William Smith, 03.VII.1856, sample housed at **BR**.). **Fig. 13.** SEM external view of part of a valve. **Fig. 14.** SEM external detail of the central area. **Fig. 15.** SEM internal view of an entire valve with the septum still in place. **Fig. 16.** SEM internal view of an entire valve without the septum. Scale bars represent 10 µm.