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Ehrenberg's Radiolarian Collections from Barbados

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Abstract Barbados radiolarians in the Ehrenberg Collections are very important microfossils since the tropical Middle Eocene to Oligocene radiolarians are largely described by Christian Gottfried Ehrenberg. As this collections have safely kept in Museum für Naturkunde, Humboldt University, Berlin, Germany. We reexamined the radiolarians from Barbados which were originally studied by Ehrenberg, and of these 250 species were found from the collection. All the specimens examined in our study are illustrated here.

Key words: Barbados, Classification, Ehrenberg, Legacy Collection, Radiolaria, Taxonomy.

Introduction

The "Barbados Earth" is long known to comprise remarkably beautiful polycystine radiolarians since Schomburgk (1847) offered samples from Barbados to scientists, and these sediments have been the subject of numerous studies since. Ehrenberg (1846) examined samples from Schomburgk, and reported the presence of 282 species although in this paper he did not provide a species list. Ehrenberg (1847) illustrated 11 species, of which 9 specimens were re-figured on pages 560 and 561 of Schomburgk (1847). The majority of the species which were named by Ehrenberg were not formally published until the 1870's. Ehrenberg (1854) illustrated a few species from Barbados, as part of copper plates showing 70 polycystine radiolarian species. Barbados samples were examined not only by Ehrenberg but also many other persons. Haeckel did not examine Barbados samples in (1862), although he had received some of Schomburgk's Barbados samples from Thomas H. Huxley in reply for a complimentary copy of Haeckel (1862) (p. 73 in Di Gregorio, 2005). P.S. Bury (1862) obtained samples of "Barbados chalk deposit" from Dr. Davy in July 1846. Microscopic slides were prepared from these by C. Johnson in 1860 and 1861, and Bury drew the specimens. This publication consists almost solely of photographic reproductions of Bury's original drawings. Since little was known about the species composition of Barbados samples at that time, despite the reported presence of 282 species by Ehrenberg (1846), Bury (1862) identified few species names. Haeckel (1887) cited her figures to propose new species (pl. 1, fig. 1 for *Lithostrobus acuminatus* Haeckel 1887; pl. 3, figs. 4 for *Xiphostylus anhinga* Haeckel 1887; pl. 4, fig. 4 for *Staurosphaera simonis* Haeckel 1887; pl. 5, fig. 2 for *Dicty-*

ocephalus urceolus Haeckel 1887, pl. 5, fig. 3 for *Podocyrtis urceolata* Haeckel 1887; pl. 17, fig. 7 for *Stichopilium macropterum* Haeckel 1887; pl. 19, figs. 4–6 for *Tetrahedrina quadricornis* Haeckel 1887; pl. 19, fig. 7 for *Cyrtocapsa pila* Haeckel 1887; and pl. 20, fig. 2 for *Saturnalis trchoides* Haeckel 1887) so that Bury (1862) is still important for taxonomic purposes. Although Ehrenberg (1846) reported the presence of 282 species from Barbados samples, only 265 species were described in Ehrenberg (1874) and 85 species were subsequently illustrated in Ehrenberg (1876). The remaining approximately 180 species were not illustrated by Ehrenberg. Haeckel examined Barbados samples in (1887). He found and described approximately 200 species from his samples, but more than 80 species were not associated with any illustrations, and subsequent studies generally ignored these un-illustrated species by Ehrenberg and Haeckel. Bütschli (1882) studied Haeckel's Barbados samples and described the detailed internal structures of nassellarian radiolarians. His study contributed to a new higher classification of Nassellaria in the middle 20th century (e.g. Petrushevskaya, 1971). Otherwise, fragmentary studies of polycystine radiolarians from Barbados were reported (Carter, 1893, 1895, 1896a, 1896b 1896c, 1896d, 1896e, 1896f; Sutton, 1896a, 1896b, 1896c, 1896d). These numerous papers, however, describe a single species or genus each by each. Earland (1900) made a list of equivalent names of Ehrenberg's and Haeckel's species from Barbados. In the 20th century, other than a new genus and new species described by Deflandre (1964), new species was not described any longer from Barbados samples. All these studies since the first report of Schomburgk (1847) had a problem owing to the lack of precies knowledge of stratigraphic distributions and the exact localities. Saunders *et al.*, (1984) first published a modern multidisciplinary biostratigraphic study of Barbados material from the Bath Cliff section, and identified the stratigraphic range as the Middle Eocene to the Lower Oligocene.

Reexamination of both Ehrenberg's and Haeckel's species from Barbados is expected to help clarify the polycystine radiolarian diversity from the Middle Eocene to the Lower Oligocene in the equatorial regions, and more generally will help us to correctly identify other Eocene-Oligocene polycystine radiolarians. The polycystine radiolarian specimens that were examined by Ehrenberg have kept in the Museum für Naturkunde, Humboldt University, Berlin, Germany, and the Ehrenberg Collection is well curated (Lazarus and Jahn, 1998; Lazarus, 1998; Lazarus and Suzuki, 2009, this volume). To find the actual specimens we used the database of this museum (http://onlinedb.naturkundemuseum-berlin.de/v1/default.asp) and the original source materials, curated originally by Clara Ehrenberg, the youngest daughter of Christian Gottfried Ehrenberg. Using these sources, we successfully identified which specimens were found from which samples. Almost all the specimens examined by Ehrenberg, according to the specimen location ID on his original drawings, were recognized in our project. Our paper illustrates all polycystine radiolarian specimens that were digitally imaged from samples Barbados 1 (pl. 1 in our paper), 43 (pls. 1–2), 94 (pls. 3–8), 16 (pls. 9–10), 25 (pls. 11–25), 30 (pls. 26–60), 14 (pl. 61) and 15 (pls. 62–98), following our cross-references (see Suzuki *et al.*, 2009a, this volume). The specific relationships between the actual specimens and samples is first published in our paper because Ehrenberg (1846, 1847, 1854, 1874, 1876) and Schomburgk (1847) did not indicate such information. The faunal assemblage of Ehrenberg's Barbados radiolarians is also useful to decide their approximate geologic ages.

Methods

An Olympus BAX51 microscope with 10, 20, 40, and special long distance 80x dry objectives were used. Photos were digitally captured with an old digital camera (2776×2074 pixels) in the years of 2004 and 2005, Olympus CAMEDIA(R) C5060WZ (2048×1536 pixels) in 2006, and Canon PowerShot(R) A640 (2548×2736 pixels) in 2007. By using Corel Photo-Paint X3 (R) for Windows, these images were transferred to grayscale images and the image resolution were adjusted and cut as appropriate file sizes for publication.

Results

Suzuki *et al.* (2009b) digitally recorded the Neogene polycystine radiolarians in the Ehrenberg Collection using two selection rules: (1) All polycystine radiolarians encountered in their examination were captured in complete scans of all mica strips for Davisstraße, Caltanisetta, Zante and Aegina, and (2) All polycystine radiolarians regardless of published or not were searched to record as digital images from his mica strips of samples from the Philippinischer Ozean and Californischer Stiller Ozean. Differing from the first rule, the second rule was concerned only specimens that are indicated by Ehrenberg. By contrast, the Barbados Earth is lithologically a radiolarian ooze so that uncountable polycystine radiolarians are embedded in mica strips. Ehrenberg also recorded so many working species names on the mica trays that we concentrated on finding only the specimens that are recorded on Ehrenberg's drawings. The arrangement of plates in our paper follows the arrangement order of mica strips in the collection, from K16B01 to K16B05 (K16B01 is the tray ID in the Ehrenberg Collection). Ehrenberg (1876) listed 16 samples as containing polycystine radiolarians. We did not find polycystine radiolarians from Barbados 3, 26, 51, 60, 74, 81 and 95.

Barbados 1 (K16B01): Plate 1

Only four specimens (pl. 1, figs. 1a–4d) were marked on Ehrenberg's drawings. *Pterocanium barbadense* Ehrenberg 1874 was only found from Barbados 1.

Barbados 43 (K16B01): Plates 1 and 2

Thyrsocyrtis anthophora Ehrenberg 1874 (pl. 1, figs. 7a–7e) is found only from Barbados 43. *Haliomma entactinia* Ehrenberg 1874 (pl. 1, figs. 5a–5d), *Eucyrtidium montiparum* Ehrenberg 1874 (pl. 1, figs. 6a–6e), *Eucyrtidium versipellis* Ehrenberg 1874 (pl. 2, figs. 1a–1d) and *Anthocyrtis hispida* Ehrenberg 1874 (pl. 2, figs. 8a–8c) are found from several Barbados samples, but the published illustration of these species are derived from Barbados 43.

Barbados 94 (K16B02): Plates 3 to 8

We show 47 specimens from Barbados 94, and confirmed that 22 specimens were published. The precision of Ehrenberg's drawing can be evaluated with *Lithobotrys ornata* Ehrenberg 1874 (pl. 4, figs. 1a–1d), *Lophophaena lynx* Ehrenberg 1874 (pl. 3, figs. 4a–4e), *Lophophaena radians* Ehrenberg 1874 (pl. 3, figs. 3a–3e, 5a–5d), and *Stylodictya hastata* Ehrenberg 1874 (pl. 5, figs. 1a–1c). These specimens have incomplete shells, and these imperfections are well shown on Ehrenberg's drawings. The drawing of *Lithomelissa corythium* Ehrenberg 1874 (pl. 4, fig. 5b) showed a lateral line near the base of the cephalis, but this line is erroneously recognized as being on the surface but not the internal cephalic structure, based on the actual specimen (pl. 4, figs. 5c–5e). Ehrenberg (1876) shows two horizontal spines extending from the thorax of *Pterocodon apis* Ehrenberg 1874 (pl. 5, fig. 8a). We also recognized them with the actual specimen (pl. 5, figs. 8b–8d), but were unable to clarify whether they are actually a part of this specimen or not.

The drawing of *Cornutella cucullaris* Ehrenberg 1874 (pl. 6, fig. 1a) is flipped horizontal in comparison with the appearance of the actual specimens (pl. 6, figs. 1b–1d) under the modern microscope. *Lychnocanium tetrapodium* Ehrenberg 1874 (pl. 7, figs. 9a–9c) is also flipped between the drawing and the actual specimen. The broken short feet of this specimen appear to be emerging from the back side of the thorax in the drawing (pl. 7, fig. 9a) but emerged from the front side of the thorax in the actual specimen (pl. 7, fig. 9b). We infer from this that Ehrenberg drew this specimen from the back side of the mica strip. These two species are located on the same strip, Strip 160207, but the other specimens on the same strips were drawn as normal illustrations. We don't know why a few specimens are flipped but this may have occurred if when Ehrenberg attached the newly examined loose mica to the strip for storage he inadvertently reversed the sides.

Barbados 16 (K16B03): Plates 9 and 10

A total of 14 specimens are shown in plates 9 and 10. We also recognized the actual specimens of the unpublished drawings (*Histiastrum quaternarium* Ehrenberg 1874, pl. 9, figs. 4a–4b; *Podocyrtis bicornis* Ehrenberg 1874, pl. 9, figs. 8a–8d; and *Podocyrtis argus* Ehrenberg 1874, pl. 10, figs. 6a–6c). The specimen of *Ceratospyris setigera* Ehrenberg 1874 (pl. 9, figs. 3a–3c) is cracked. The specimen of *Pod. bicornis* (pl. 10, figs. 8a–8d) is flipped horizontally between the drawing and the actual specimen on the basis of the orientation of the feet.

Barbados 25 (K16B03): Plates 11 to 25

We figured 97 specimens from Barbados 25. Cracks are relatively strongly developed on the Canada balsam of the mica strips of Barbados 25, and they split *Haliomma apertum* Ehrenberg 1874 (pl. 11, figs. 1a–1c), *Stylodictya clavata* Ehrenberg 1874 (pl. 14, figs. 4a–4c) and *Stylodictya dimidiata* Ehrenberg 1874 (pl. 17, figs. 3a–3b). Only one specimen of *Hal. apertum* and *Sty. clavata* is marked on the Ehrenberg's drawings, respectively, so that reference specimens are shown in pl. 11, figs. 2a–2b for *Hal. apertum* and in pl. 14, figs. 2a–2b for *Sty. clavata* from the type material. The drawing of *Haliomma triactis* Ehrenberg 1874 (pl. 11, fig. 3a) differs from the actual specimen (pl. 11, figs. 3b–3c) in having two shorter radial spines, but this is the only specimen which is identical with this drawing by the location ID on the Ehrenberg's drawing and his working names on the mica tray. The directions of the bi-polar spines of *Stylosphaera flexuosa* are different between the drawing (pl. 11, fig. 4d) and the actual specimen (pl. 11, figs. 4b–4f). This species bears similarity to *Dorcadospyris*-species (Nassellaria) but a morphologically similar specimen shown in pl. 11, figs. 5a–5f has a macrosphere so that the latter is Spumellaria. We did not determine whether *Sty. flexuosa* belongs to Nassellaria or Spumellaria. Ehrenberg tends not to draw the internal structure of spherical radiolarians. The Ehrenberg drawings of *Hal. triactis* (pl. 11, figs. 3a–3c), *Stylosphaera coronata* Ehrenberg 1874 (pl. 12, figs. 1a–1d), *Stylosphaera sulcata* Ehrenberg 1874 (pl. 12, figs. 3a–3d) and *Stylosphaera liostylus* Ehrenberg 1874 (pl. 12, figs. 6a–6f) only show an ambiguous grey area for the internal shells and did not show radial beams between the cortical shell and medually shell, but the actual specimens have such structures.

The drawings of *Haliomma helianthus* Ehrenberg 1874 (pl. 15, figs. 1a–1e) and *Stylodictya dimidiata* Ehrenberg (pl. 17, figs. 1a–2c) are very rough sketches, but the actual specimens were nonetheless easily identified. The drawing of *Eucyrtidium coronata* Ehrenberg 1874 (pl. 19, fig. 4a) has a strange flare-like top on the cephalis, which was confirmed on the actual specimen (pl. 19, figs. 4b–4c). A bizarre four-fold opening in the cephalis is drawn for *Lithocorythium oxylophos* Ehrenberg 1847 (pl. 20, figs. 7a–7d, 9a–c) and *Lithocorythium platylophos* Ehrenberg

1854 (pl. 20, figs. 10a–10c). These images are obliquely developed initial structures of the cephalis from a ventral or dorsal view which are magnified by the lens effect of the convex cephalic wall. A similar four-fold cephalic opening is shown for *Lithopera oxystauros* Ehrenberg 1874 (pl. 20, fig. 11a), but the lower part of the openings correspond to the cephalic neck on the basis of the actual specimen (pl 20, figs. 11b–11d).

Barbados 30 (K16B04): Plates 26 to 60

A total of 151 specimens are shown in plates 26 to 60. The drawing of *Cenosphaera megapora* Ehrenberg 1874 (pl. 26, fig. 1a) shows four cylindrical radial spines and does not show any internal structure. The actual specimen of this species (pl. 26, figs. 1b–1c) has more than eight, triradiate radial spines and consists of three concentric shells. The internal structure is often missing for other specimens of *Cen. megapora* (pl. 27, figs. 1a–1b, pl. 28, figs. 1a–2b). The original drawings of *Haliomma oculatum* Ehrenberg 1874 (pl. 28, fig. 3a) and *Haliomma echinatum* Ehrenberg 1874 (pl. 30, figs. 1a–1c) were not informative as to whether this species is spherical or has a flattened test, but the actual specimen (pl. 28, figs. 3b–3c) has a discoidal cortical shell, with a pear-shaped internal shell located in the equatorial plane of the test. The internal structure of *Stylodictya carduus* Ehrenberg 1874 was ambiguously drawn by Ehrenberg (pl. 29, fig. 1a in our paper). The actual specimen of this species (pl. 29, figs. 1b–1d) has a thick-walled cortical shell and double medullary shells. The drawing and actual specimens of *Stylosphaera laevis* Ehrenberg 1874 (pl. 29, figs. 3a–3c) are at first confusing. The drawing indicates with grey shading the presence of some internal structure, but the actual specimen internal structures appear to be absent. This actual appearance is supported by the other specimen of the representative species (pl. 29, figs. 4a–4b) but is not supported by ambigous structures inside another specimen (pl. 29, figs. 6a–6b). This is clarified by the specimen from Barbados 14 (pl. 61, figs. 2a–2c), which has a pear-shaped internal shell. Similar problems may arise in other bipolar spherical radiolarians. The image of *Stylosphaera sulcata* Ehrenberg 1874 (pl. 29, figs. 5a–5b) does not have internal structures, but additional specimens should be examined for confirmation of this issue. Ehrenberg identified the specimen shown in pl. 31, figs. 4a–4b in our paper as *Cycladophora discoides* Ehrenberg 1874 on his original drawing, but the concentric peripheral structure and probable hollow space inside the test are identical with a half shell, split along the equatorial plane, of *Stylodictya dimidiata* Ehrenberg 1874 (See, pl. 32, figs. 1a–1c), *Lithocyclia ocellus* Ehrenberg 1854 (See pl. 32, figs. 2a–2b) or *Lithocyclia stella* Ehrenberg 1874 (See pl. 32, figs. 4a–4c). The drawing of *Thyrsocyrtis pristis* Ehrenberg 1874 (pl. 35, fig. 4a) could not be matched to any polycystine radiolarian individuals, but the actual specimen (pl. 35, figs. 4b–4d) is easily identifiable as an approximately one-third fragment of *Cladospyris tribrachiata* Ehrenberg 1874 (pl. 35, figs. 2a–2c). Ehrenberg (1874) described *Cenosphaera spinulosa* Ehrenberg 1874 (pl. 38, figs. 3a–4d in our paper). In the original drawings of this species it is difficult to recognize specific skeletal characters. The actual specimens look appears to belong to the family Acanthodesmidae. *Ceratospyris longibarba* Ehrenberg 1874 (pl. 38, figs. 8a–8d) seems to have an elongated cephalis on the basis of pl. 38, fig. 8a, but this appearance is simply interpreted as a lateral view because the D ring is shown in pl. 38, figs. 8b–8c. *Lychnocanium falciferum* Ehrenberg 1854 (pl. 43, figs 1a–1c) is split by a crack in the Canada balsam. We compared several two chambered nassellarians bearing three-feet (pls. 41 to 43) to understand the skeletal structure of *Lyc. falciferum* (e.g. pl. 43, figs. 2a–2c). The drawing of *Halicalyptra galea* Ehrenberg 1874 (pl. 44, fig. 2a) is a rough sketch with no clearly marked segmentation. The actual specimen (pl. 44, figs. 2b–2g) shows two segments. *Pterocanium contiguum* Ehrenberg 1874 (pl. 47, figs. 8a–8d) is difficult to observe in detail owing to the roughness of the embedded Canada balsam. Alternate specimens should be chosen when a lectotype or neotype is designated.

Eucyrtidium argus Ehrenberg 1874 (pl. 48, figs. 8a–8f) has a constriction between the cephalo-thorax part and thorax, differing from the original drawing. This species also has a cylindrical opening on the basal part of the apical horn (pl. 48, fig. 8d). This opening seems to be connected with the A rod of the cephalic internal structure (pl. 48, figs. 8e–if). The relationship between a basal opening on the apical horn and an A rod is recognized in many species. *Podocyrtis princeps* Ehrenberg 1874 (pl. 54, figs. 1a–1f) has a short opening which starts from the tip of the A rod (pl. 54, fig. 1f) and vents at the left side of the proximal apical horn, 50 μm above the boundary of cephalis and apical horn (the concave part on the apical horn in pl. 54, fig. 1e). The specimen of pl. 59, figs. 1a–1c in our paper has also a typical opening inside the apical horn.

Differing from the species having a penetration, *Eucyrtidium alauda* Ehrenberg 1874 (pl. 49, figs. 1a–1e), *Eucyrtidium scolopax* Ehrenberg (pl. 58, figs. 3a–3f), *Podocyrtis attenuata* Ehrenberg 1874 (pl. 56, figs. 2a–3d), *Podocyrtis bicornis* Ehrenberg 1874 (pl. 55, figs. 2a–2e) and *Podocyrtis papalis* Ehrenberg 1847 (pl. 58, figs. 1a–1f) have a branched basal portion of the apical horn. One of branches is always connected with the A rod of the cephalic internal structure. In the case of *Anthocyrtis serrulata* Ehrenberg 1874 (pl. 51, figs. 1a–1f), a triradiate short apical horn is encased within the thickened siliceous wall above the cephalis (pl. 51, fig. 1d).

Ehrenberg (1876) showed a very long apical horn for *Podocyrtis princeps* Ehrenberg 1874 (pl. 54, fig. 1a in our paper) and *Podocyrtis cothurnata* Ehrenberg 1874 (pl. 55, fig. 1a), which is confirmed by the actual specimen (pl. 54, figs. 1b–1f). Another specimen of *Pod. princeps* (pl. 54, figs. 2a–2c) also possesses a very long apical horn.

Barbados 14 (K16B05): Plate 61

Six specimens are shown in pl. 61 of our paper. The published drawings of *Lithobotrys adspera* (pl. 61, figs. 5a–5d) and *Lithochytris pyramidalis* Ehrenberg 1874 (pl. 61, figs. 6a–6c) were found from Barbados 14.

Barbados 15 (K16B05): Plates 62 to 98

A total of 172 specimens were illustrated from pl. 62 to pl. 98. As for Barbados 15, many specimens were drawn by Ehrenberg.

The drawing of *Cenosphaera micropora* Ehrenberg 1874 (pl. 61, fig. 1a) did not show any internal structure, but the actual specimen (pl. 61, figs. 1b–1e) has one medullary shell at least. Although we searched better preserved specimens of this species in the type mica slides from Barbados 15, specimens adequate to examine the internal structure were not found. *Stylosphaera liostylus* Ehrenberg 1874 (pl. 63, figs. 1a–1e) was drawn with two long bipolar spines, but the actual specimen doesn't have so long bipolar spines. The detailed structure of the internal shell cannot be documented precisely due to poor optical quality. The drawing of *Stylodictya setigera* Ehrenberg 1874 (pl. 63, fig. 4c) was not detailed enough to determine whether this species has a spherical or flattened shape. The actual specimen of this species (pl. 63, figs. 4a–4b, 4d–4e) can be precisely focused on the nearly whole area of the upper surface at once so that it has a somewhat flattened spherical test. The drawing shows double spiral structure, but the details of three dimensional structure were not determined because we did not examine other specimens of this species. Similarly, the drawing of *Stylodictya echinastrum* (pl. 64, fig. 1a) can be interpreted as either a spherical or flattened shape. In our examination this species has a spherical form (pl. 64, figs. 1b–1c). This is supported by the other specimens identified as this species by Ehrenberg (see pl. 64, figs. 2a–3b).

Stylodictya gracilis Ehrenberg 1854 (pl. 65, figs. 1a–1c) is the type species of the genus *Stylodictya*. The detailed morphological description and taxonomic reexamination of this species using this specimen was published in Ogane *et al.* (2009). As Suzuki *et al.* (2009a, this volume) point out in the inclination of his drawing, the outline of a specimen tends to become narrowed. This inclination has a strong effect on the drawing of *Stylodictya perichlamydium* Ehrenberg 1874 (pl. 65, figs. 2a–2e). The drawing of this species shown in our pl. 65, fig. 2a was rotated at an angle of 90 degrees to be fixed with the orientation of the actual specimen shown in pl. 65, figs. 2a–2b and 2d–2e. The actual specimen of this species is more elliptical than indicated in the drawing. The location of *Stylodictya ocellata* Ehrenberg 1874 is recorded at "15.1.b.w", relevant to Strip 160505.b.w on the Ehrenberg's drawing and is also written at this location on the mica tray. However, this specimen was found from a different location (Strip 160508 r et bl, meaning between paper rings "r" and "bl", following Ehrenberg's indication rule). This specimen (pl. 65, figs. 3a–3f) is partly broken off, and the preservation is relatively poor. An alternative specimen for designating a neotype should be found from the topotype material of Barbados 15. *Astromma pentactis* Ehrenberg 1874 (pl. 69, figs. 1a–1c) and *Histiastrum quaternarium* Ehrenberg 1874 (pl. 69, figs. 2a–2c) were found from Barbados 15, but were poorly preserved. The specimen of *His. quaternarium* illustrated in pl. 69, figs. 2a–2c was subsequently designated as the lectotype of this species by Ogane *et al.* (2009) because this is the type species of the genus *Histiastrum*. One arm of *Astromma pythagorae* Ehrenberg 1854 was drawn with a lighter grey color (pl. 70, fig. 3a). The light colored part is a partially lost portion of the arm in the actual specimen (pl. 70, figs. 3b–3c). The drawing of *Dictyospyris spinulosa* Ehrenberg 1874 (pl. 76, fig. 5a) have short spinules around the test, but the actual specimen (pl. 76, figs. 5b–5e) has more robust, longer spines. The drawing of *Ceratospyris triomma* (pl. 78, fig. 2a) does not seem to correspond to the actual specimen (pl. 78, figs. 2b–2d). However, only one specimen identified as this species on the mica labels was found from the exact location. *Pterocodon campanella* Ehrenberg 1874 was drawn to have two lateral spines from the upper part of the thorax (pl. 80, fig. 3a), but we did not confirm the presence of two lateral spines in the actual specimen (pl. 80, figs. 3b–3c). The drawing of *Cornutella cucullaris* Ehrenberg 1874 (pl. 81, fig. 3a) is horizontally flipped in comparison with the appearance of the actual specimen (pl. 81, figs. 3b–3g), and furthermore, this specimen was drawn as being much narrower than the actual specimen. The drawing of *Cornutella mitra* Ehrenberg 1874 (pl. 82, fig. 3a) was not clear on the presence of cephalis. The actual specimen of this species (pl. 82, figs. 3b–3d) consists of very small cephalis and large thorax. The published image of *Eucyrtidium barbadense* Ehrenberg 1874 (pl. 9, fig. 7 in the original paper = pl. 85, fig. 7a in our paper) appears to be a well preserved specimen to understand the morphological characters. By contrast, the optical image of the actual specimen (pl. 85, figs. 7b–7c) is extremely poor due to the rough surface of the Canada balsam.

The actual specimens of *Podocyrtis nana* Ehrenberg 1874 (pl. 89, figs. 2a–2c), *Eucyrtidium sphaerophilum* Ehrenberg 1874 (pl. 89, figs. 1a–1c), *Podocyrtis brevipes* Ehrenberg 1874 (pl. 89, figs. 3a–3c) appear to have rough surface texture, probably owing to the rough surface of the Canada balsam, although the drawings of these specimens show their characteristic morphology very well. These specimens are nearly completely preserved individuals, but a neotype should probably be selected for these species. The actual specimen of *Podocyrtis ventricosa* Ehrenberg 1874 (pl. 92, figs. 4a–4b) is identical to the drawing, but we were unable to take photographs the upper portion of the specimen because the focal depth is insufficient to image this part of the specimen, even if we used 10X objective lens. This specimen should be also replaced with other specimen when the type specimen is selected for defining the species.

The drawing of *Podocyrtis pentacantha* Ehrenberg 1874 (pl. 93, fig. 1a in our paper) shows the both sides of the specimen, indicating that Ehrenberg examined some specimens from the both sides of the mica strip because two images of the same specimen in his drawing are flipped horizontally. *Dictyopodium eurylophos* Ehrenberg 1874 is also flipped horizontally between the drawing (pl. 93, fig. 3a) and the actual specimen (pl. 93, figs. 3b–3f), indicating that this specimen was observed by Ehrenberg from the backside of the mica stip because the base of the single foot arises from the other side of the abdomen.

The drawing of *Lithomelissa ventricosa* Ehrenberg 1874 (pl. 96, fig. 1a) shows very short feet extending from the lower portion of the final segment, but we did not recognize these feet in the actual specimen (pl. 96, figs. 1b–1d): Instead, a weak constriction is recognized on the upper portion of the "final segment" in the sense of Ehrenberg's drawing, and this species may actually have three segmentations. The lack of feet and presence of the weak constriction is confirmed by the other specimen of the species (pl. 96, figs. 2a–2d).

Concluding remarks

Ehrenberg generally recorded the location ID of his examined specimens on his drawings, but we did not choose the specimens illustrated here solely by relying on his drawing ID or location reference from published sources. We successfully located almost all the actual specimens by these procedures. Many details of the skeletal morphological characters of spheroidal spumellarians (pl. 11, figs. 1a–3c, pls. 12, 26, 27, 28, 29, 64), discoidal spumellarians (pl. 5, figs. 1a–1c, pls. 14–17, 30, 65, 66, 69) and the larger cephalis-bearing and small nassellarians (pl. 3, figs. 3a–5d, pls. 4, 19, 20, pl. 34, figs. 2a–3c, pl. 62, 79,) from Barbados have not been recognizable from Ehrenberg's drawings. These characters are for the most part easily recognizable on the actual specimens. Although several species will probably be synonymized with well-known species, rules on the priority of species names under the ICZN will raise issues of taxonomic stability which must be taken into account.

The actual specimens of potential lectotypes were identified by comparison to the drawings, but some of the specimens so identified are unsuitable to use as lectotypes due to the state of preservation. *Ceratospyris setigera* (pl. 9, figs. 3a–3c), *Haliomma apertum* (pl. 11, figs. 1a–1c), *Stylodictya clavata* (pl. 14, figs. 4a–4c), *Podocyrtis cothurnata* (pl. 55, figs. 1a–1e), *Podocyrtis schomburgkii* (pl. 57, figs. 1a–1f) and *Haliomma triactis* (pl. 67, figs. 2a–2d) are cracked in the Canada balsam so that the type designation of these specimens would be problematic due to preparation aging. Other specimens are partly broken or ambiguous for other reasons, but not due to problems with their mica's preservation.

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