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ORIGINAL ARTICLE

Deep-water Ophiuroidea of the northern Atlantic with descriptions of three new species and taxonomic remarks on certain genera and species

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Abstract

Based on material from the fourth cruise of the RV *Akademik Mstislav Keldysh* and the MAR-ECO cruise of the RV *G.O. Sars*, 31 species of Ophiuroidea were identified from the section of the Mid-Atlantic Ridge between the Reykjanes Ridge and the Azores. The taxonomy of the group of genera with reduced arm comb and tentacle pores restricted only to the proximal arm segments is reviewed. It is suggested that the genera *Homalophiura* H.L. Clark, 1915, *Ophiurolepis* Matsumoto, 1915, *Theodoria* Fell, 1961 and *Homophiura* Paterson, 1985 should be regarded as synonyms of the genus *Ophioplinthus* Lyman, 1878. From examination of the type specimens, it is demonstrated that the six-armed species *Ophiacantha anomala* G.O. Sars, 1871 also includes five-armed specimens previously identified as the separate species *Ophiacantha cuspidata* Lyman, 1878. The latter taxon is considered here as the junior synonym of *O. anomala*. Previously mentioned 'deep-water populations of the common shallow water species *Ophiacantha bidentata* (Retzius, 1805)' represent a separate species, *Ophiacantha fraterna* Verrill, 1885, which is well distinguished by the shape of the spicules of the disk, narrow outer oral papilla and narrower tentacle scale as well as a hermaphroditic nature. Three new species, i.e. *Ophioplinthus pseudotessellata* sp. nov., *Ophiocamax patersoni* sp. nov. and *Ophiophyllum nesisi* sp. nov., are described.

Key words: *Distribution, North Atlantic, Ophiuroidea, Reykjanes Ridge, taxonomy*

Introduction

The North Atlantic deep-water Ophiuroidea have a long history of study. The first deep-water ophiuroid from the North Atlantic was found during sounding of Baffin Bay at a depth of 1460 m in the early 19th century. This species was *Gorgonocephalus eucnemis* (Müller et Troschel, 1842) brought up wound around the plummet (Menzies et al. 1973). Regular collecting of ophiuroids took place during the famous deep-water expeditions, such as *Porcupine* and *Lightning* (Wyville Thomson 1873), Norwegian expeditions (Sars 1871), *Challenger* (Lyman 1878, 1882), *Travailleur* and *Talisman* (Koehler 1906, 1907a), *Albatross* (Verrill 1885a,b, 1894), *Caudan* (Koehler 1895, 1896a), *Princesse Alice* (Koehler 1896b, 1901a, 1909), *L'Hirondelle* (Koehler 1898), *Michael Sars* (Grieg 1921), *Tjalfe*, *Thor*, *Dana*, *Ingolf* (Mortensen 1913, 1933) and others. More recently, ophiuroids of the North Atlantic have been studied by Cherbonnier & Sibuet (1972); cruises of the RV *Jean Charcot*), Gage et al. (1983); mainly RRS *Challenger*), Paterson (1985); campaign BIOGAS), and Bartsch (1987, 1991) (RV *Meteor*). Paterson (1985) summarized scattered data and reviewed all North Atlantic Ophiuroidea. Most recently, a new amphiurid species was described from deep waters around Iceland (Stöhr 2003). Stöhr & Segonzac (2005) described several new species from hydrothermal vents and methane cold seeps of the North Atlantic, including also records from non-vent habitats. Tyler et al. (2005) presented results of a study of Ophiuroidea around the Faeroe Islands, including both shallow- and deep-water species. Preliminary results of the study of the ophiuroid fauna from waters around Iceland were presented by Stöhr (oral communication).

Despite numerous studies, taxonomic problems still remain, even with common species. Species

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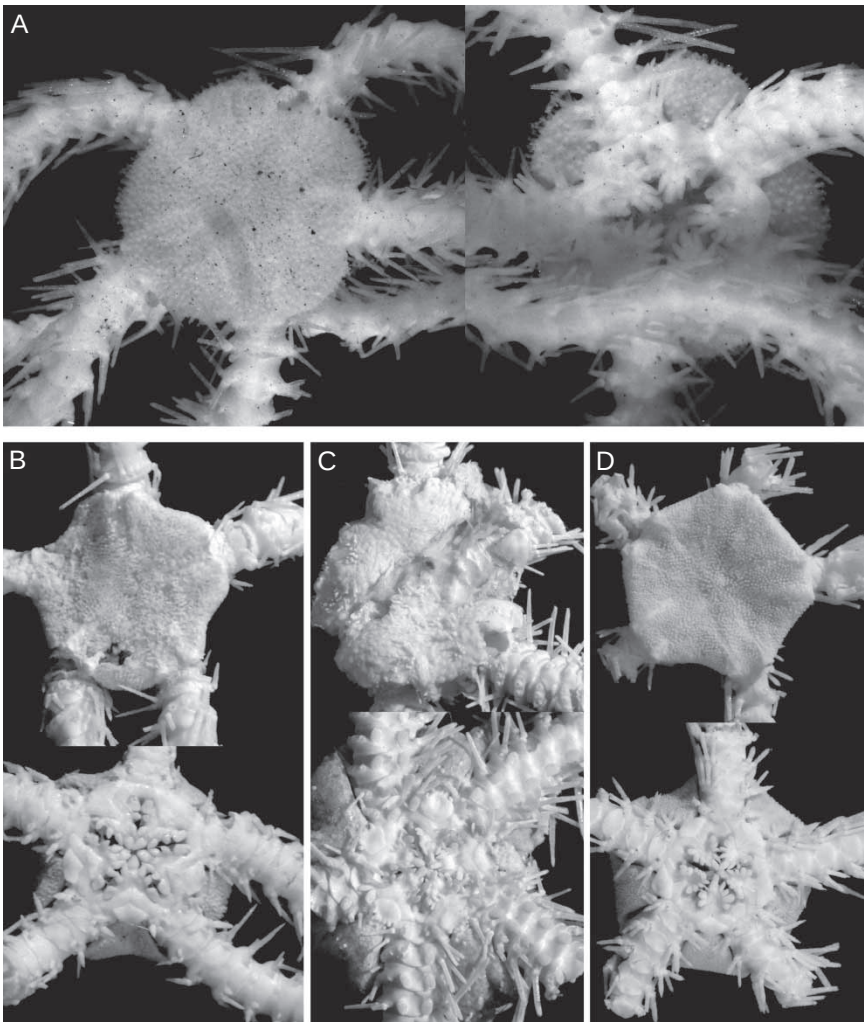

Figure 11. (A) *Ophiacantha fraterna* Verrill, 1885, specimen labelled as '*Ophiacantha aculeata*, Type', YPM 7679, Steamer *Albatross*, cruise of 1883, St. 2105, off Delaware Bay, 37°50′00″N, 73°03′50″W, depth 2551 m, disk diameter 6 mm; (B) *Ophiacantha simulans* Koehler, 1896, ZMMU D-640, RV *Akademik Mstislav Keldysh*, St. 464, disk diameter 6 mm; (C) *Ophiacantha spectabilis* G.O. Sars, 1871, ZMMU D-660, RV *Akademik Mstislav Keldysh*, St. 464, disk diameter ca. 11 mm; (D) *Ophiacantha veterna* Koehler, 1907, ZMMU D-657, RV *Akademik Mstislav Keldysh*, St. 464, disk diameter 7.5 mm. Dorsal and ventral views are shown. Photographs: Tanya Korshunova.

Ophiacantha veterna: Koehler 1907b: 41.
Ophiacantha enopla veterna: Paterson 1985: 37, Figure 16.

Material

RV *Akademik Mstislav Keldysh*, fourth cruise, St. 464, three specimens.

Distribution

Prior to this study *O. veterna* was recorded only from the Bay of Biscay and south of the Azores and Madeira at 101–2300 m (Koehler 1907b; Paterson 1985; Stöhr & Segonzac 2005). Now the range is extended to the north to the Reykjanes Ridge, at 1670–1750 m.

Remarks

Paterson (1985) considered *O. veterna* as a subspecies of *O. enopla* Verrill, 1985. We believe that characters distinguishing *O. enopla enopla* from *O. enopla veterna* listed by Paterson are enough to maintain them as separate species. Especially characteristic is the shape of tentacle scales in *O. veterna*: these are very small compared to those of *O. enopla* and are missing on distal arm segments.

Ophiocamax patersoni sp. nov.
(Figures 13D, 14, 15C, F, 16H, I)

Material

RV *G.O. Sars*, MAR-ECO cruise, St. 52/374, holotype (ZMBN 77854, dried), one paratype

(ZMBN 77855, dried), St. 50/373, 10 paratypes (ZMBN 77856, in ethanol), two paratypes (ZMMU D-748, dried), St. 72/386, one paratype (ZMBN 77857, in ethanol).

Etymology

This species is named in honour of Gordon L.J. Paterson (The Natural History Museum, London) for his important contribution in studying North Atlantic Ophiuroidea.

Description of the holotype

The disk has diameter 17.5 mm, is domed and circular, but indented interradially to various degrees – from minor to considerable. The disk plates are numerous, different in size and shape, from small to moderate, irregular-rhomboidal and -polygonal, bearing one or few long spines. Some spines bearing at about mid-length a few irregularly placed short thorns, whereas others lack distinct thorns. Proximal to the radial shields the disk plates are larger and fewer, whereas in the centre of the disk and in the interradii the plates are smaller. Radial shields (2–3 mm in length) are relatively small, about one-sixth of the disk diameter, irregularly triangular in outline, proximally narrowed and obtuse pointed, distally widened, joined at almost their length, but in two interradii have irregular row of spinelets in-between. At the distal border of the radial shields and between the first dorsal arm plate there is a dense irregular row of spines. The interradii are swollen, ventrally covered by spines; close to the oral shields the interradial scales bear short tubercle-like spines or are naked. Each jaw bears two or three irregularly placed narrow spiniform apical papillae. The latter are hardly distinguished from teeth and from adjacent lateral oral papillae. Nevertheless, the first pair of the lateral papillae is quite distinct. Other papillae are placed along jaws in two irregular rows – one internal and one external. At least two pairs placed dorsally in the middle of the jaws. The distal papillae are similar to the proximal ones in shape, differing only in length, but forming a semicircular comb around the second tentacle pore. The first papillae are pointed, narrow. Sometimes additional papillae are placed between apical and first papillae. The shape of the oral shield can be described as wide-arrowhead with straight rather long distal part attached to the interradius and triangular proximal part, completely separated from the first lateral arm plate by the wide adoral shields. The madreporic oral shield is swollen and has lost its usual shape. One to five rough spindle-shaped papillae (in one interradius these papillae probably are lost) are placed on the proximal edge of the madreporite. Two oral shields also have two tubercles at their distal edge. Arm length is about four times the disk diameter. The dorsal arm plates are broad, fan-shaped, rather large, entirely separated by the lateral arm plates, even on most basal segments. The proximal edge of the dorsal arm plate is almost straight throughout the length of the arm, whereas on the basal segments this edge is slightly triangular. The distal edge of the dorsal arm plate is semicircular and distinctly covered with sparse quite long thorns. These thorns are present already on most basal segments and placed in few irregular rows – one more close to the distal edge, whereas others are placed farther from the edge of the dorsal arm plate. The proximal area of the dorsal arm plate is also covered sparsely with short thorns or spiny small tubercles. On the basal segments these proximal thorns are more developed, whereas towards the distal end of the arm they tend to be reduced. The middle area of the dorsal arm plates has few and weakly developed thorns or is fully devoid of them. Most distal dorsal arm plates have ca. five blunt tubercle-shaped distal thorns and few prominent needle-shaped thorns on the middle line of the lateral plates. Arms have distinct nodes and form a strong lateral ridge on which the spine arm articulation ridges are placed. On most proximal segments there are eight or nine spines, in the middle of the arm – six or seven, distally – five or six. The dorsalmost spine is shortest, the second slightly longer and the third is longest and strongest (about four segments in length). The next spine is considerably shorter and following spines are gradually reduced in size. Sparse quite long thorns cover the dorsal spines including the longest, whereas the more ventrally placed spines have a rough surface with some short denticles. The first ventral arm plate is rather small, trapezoid. The second ventral arm plate is very remarkable – distally rhomboid, proximally with two semicircular lateral wings corresponding to the large basal tentacle pore. The third and fourth ventral arm plates are also distally rhomboid (about two times wider than long) and proximally show traces of the above described structure, which disappears towards the middle of the arm and again becomes more developed on more distal segments. Further ventral arm plates towards the middle of the arm have a triangular proximal lobe, while they are polygonal with rounded angles distally. Some segments have nearly ovoid ventral arm plates. The distalmost segments have a rather trapezoid distal part of the ventral arm plate. Ventral plates throughout the length of the arm are separated. The tentacle pores are larger and more conspicuous proximally than towards the distal end

of the arm, where they become small and inconspicuous. Basally around the tentacle pores at least four tentacle scales are placed. The basal tentacle scales are large, narrowly conical, with widened base and gradually sloped towards top. Towards the distal end of the arm the number of tentacle scales reduced to two and then to one. About at mid-length of the arm the tentacle scales became spindle-shaped, and at the distalmost segments they turn into a rather short tubercle.

Paratype variations

The smallest paratype with disk diameter 8.5 mm (radial shields approximately 0.8–0.9 mm) is different compared to the large specimen disk spine structure. These spines, both in the centre and periphery have a well-developed basal rosette of four or five long thorns and several also have long denticles towards the top of the spine. At the distal border of the radial shields similar spines are placed, with a basal rosette of denticles. The radial shields are very short and irregularly square in outline, entirely joined in some radii, whereas in others slightly divergent proximally. The dorsal arm plates, especially on the seven or eight proximal segments at their distal edge heavily covered by long spines (15–20 spines on the mentioned segments), which are arranged in two irregular rows. Towards the middle of the arm the spines become more tubercle-shaped and reduced in number. The oral papillae are more irregular than in the holotype, the single large, and small additional rows of papillae encircling the second tentacle pores are especially well developed. The additional papillae are placed on the adoral shields instead of on the oral shield, and the shape of the papillae are approaching the shape of the disk spines but more massive and with lesser developed rosette of denticles. The oral shields are more or less hourglass-shaped. The tentacle scales on all segments, including the proximalmost, are spiniform and not massive conical. At least one tentacle scale has a wide base contrasting with its narrow remaining part. The tentacle scales are rough, some have distinct thorns. Proximally there are seven to nine spines, five or six towards the distal end of the arm. The largest paratype of 19.5 mm disk diameter (radial shields 3–4 mm in length) has disk spines that are roughly spiniform but without thorns. Only a few spines in the interradii have two or three blunt thorns. The radial shields are triangular, some with obtuse proximal angle, whereas others have an acute angle. The radial shields are in contact for most of their length, but in two radii there is a distinct narrow insertion plate in-between. Proximally the radial shields are divergent. All dorsal arm plates bear on their distal edge a set of, to a various degree developed, blunt short spines (on proximal segments) or tubercles, 15–20 in number on proximal segments. Few short sharp spines or tubercles are placed also proximally on the dorsal arm plate. The dorsal arm plates are rhomboidal, wider than long. Towards the middle of the arm the dorsal plates became wider and shorter. All dorsal arm plates are not contiguous but the basalmost plates lie very close to each other due to somewhat dorsally shifted arms.

The oral papillae have a more irregular appearance than in the holotype, but they also have two distinct irregular rows around the tentacle pore (laterally they are adjoining true tentacle scales). The tentacle scales at the second and third segments are very long, narrow, up to five in number, with a smooth surface. The oral shield is shaped with a proximal wide triangular part with slightly convex sides, and a triangular lobe of considerable size. At the lateral sides of the distal edge of the triangular lobe there are usually one or two pairs of long narrow papillae. The distal part of the oral shield is short and wide.

Distribution

The Charlie-Gibbs Fracture Zone, the Mid-Atlantic Ridge north of the Azores, 2522–2979 m.

Remarks

For comparative purposes we studied type material of various species of the genus *Ophiocamax* as well as non-type specimens of *O. dominans* Koehler, 1906 identified by Ilse Bartsch. Since species of the genus *Ophiocamax* are difficult to distinguish, we illustrate here the above-mentioned material. From the geographically closest species *O. dominans* Koehler, 1906 (known presently only off Sahara, and never reported from the Reykjanes Ridge), *Ophiocamax patersoni* sp. nov. clearly differs in the following characters. Disk plates are more numerous, radial shields are relatively small (from one-fifth to one-tenth of the disk diameter in *Ophiocamax patersoni* sp. nov. and from one-half to three-quarters in *O. dominans*; the latter according to Paterson (1985) (compare Figures 12A, 15A and 13D, 14A, B, 15C, F). In the specimens identified by Bartsch we found the length of the radial shield to the disk diameter to be one-third to one-fifth, thus not considerably different from *Ophiocamax patersoni* sp. nov. Disk spines of *Ophiocamax patersoni* sp. nov are narrow elongated cones, almost devoid of the long thorns in large specimens (few can be found in the interradial area), whereas in large specimens of *O. dominans* most disk spines presented massive spines with

conspicuous thorns. The distal edges of the radial shields of *Ophiocamax patersoni* sp. nov. are heavily covered with long spines (Figure 15C), whereas *O. dominans* has radial shields almost devoid of spines at their distal edge (Figure 15A). The dorsal arm plates of *Ophiocamax patersoni* sp. nov. are rhomboidal, slightly convex at their proximal edge, and form an obtuse angle at the distal edge, wider than long, not contiguous even on most basal segments (Figures 13D, 14A–C, 15C, F) (*O. dominans* has dorsal arm plates clearly triangular, distal edge convex, proximal edge represented by an acute angle, clearly contiguous at the basal segments and still nearly in contact (Figures 12A, 15A).) In *Ophiocamax patersoni* sp. nov. most dorsal arm plates have distal edges heavily covered with relatively long spines or obtuse tubercles (Figures 14C–E, 15C, F), whereas in *O. dominans* they are entirely devoid of spines (Figure 15A), except for the distal part of the arms where two tiny spines appear (according to Bartsch 1987). The shape of the oral shield of *Ophiocamax patersoni* sp. nov. is an arrow-head (proximal part is large, acutely triangular with slightly concave lateral sides) (Figure 16H, I), whereas *O. dominans* has the oral shield irregularly hour-glass-shaped (Figure 16A). Another Atlantic species, *O. fasciculata* Lyman, 1883 from the Caribbean region, also differs considerably from *Ophiocamax patersoni* sp. nov. by a number of features: dorsal arm plates clearly triangular, distal edge convex, proximal edge represented by an acute angle, clearly contiguous on the basal segments and still nearly in contact, most dorsal arm plates entirely devoid of spines (Figures 12B, 15B), oral shields with large ovoid proximal part with small triangular lobe and short wide distal edge (Figure 16B), apical and oral papillae are very irregular, tentacle scales with considerably widened base (Figures 12B, 16B). The only other Caribbean species, *O. hystrix* Lyman, 1878 (and very similar to this species *Ophiocamax austera* Verrill, 1899), has slightly rugose dorsal and lateral arm plates (Figure 15D), but in other characters it differs greatly from *Ophiocamax patersoni* sp. nov.: distinctly lobed disk, deeply notched interradially thus forming a very small central area (Figure 12C), disk covered with short massive conical stumps or blunt tubercles, trapezoid dorsal arm plates contiguous basally (Figure 15D), oral papillae placed proximally in two distinct clusters (Figure 16C), ovoid proximal part of the oral shield with small triangular proximal lobe and distinct swollen tubercle on distal edge (Figure 16C). The North Atlantic *Ophiocamax patersoni* sp. nov. is by general appearance and shape and structure of the dorsal arm plates even more similar to Antarctic species of the genus – *O. gigas* Koehler, 1901 and especially to *O. drygalskii* Hertz, 1927. *Ophiocamax gigas* differs from *Ophiocamax patersoni* sp. nov. in the numerous short spinelets of the disk having few thorns at the top (Figure 13A), dorsal arm plates with convex proximal edge and distal edge forming an obtuse angle covered by a single regular row of rounded tubercles (Figure 15E), the oral shield heavily covered with thorny spines (Figure 16E) and tentacle scales with few denticles at the top. *Ophiocamax drygalskii* Hertz, 1927 differs from *Ophiocamax patersoni* sp. nov. in the numerous short spinelets of the disk having few denticles at the top or along their sides (even in large specimens) (Figure 13B, C), proximal edge of the dorsal arm plate distinctly triangular – from acute to obtuse angle, nearly contiguous on basal segments (Figures 13B, C, 15G, H), oral shield hour-glass-shaped or with very elongated proximal part (Figure 16F, G). It is necessary to note that in the studied type specimens of *O. drygalskii* the shape of the oral shield is quite variable. Different shapes of the oral shields were observed even within single specimen (madreporic oral shield is not considered). At the same time, *Ophiocamax patersoni* sp. nov. does not display such polymorphism and all studied large specimens have essentially the same shape of the oral shield, well distinguished from *O. drygalskii* by this character. *Ophiocamax applicatus* Koehler, 1922 described off Tasmania, Australia is considerably larger than *Ophiocamax patersoni* sp. nov. and has proximally contiguous triangular dorsal arm plates. *Ophiocamax brevicetra* Baker, 1974, off Otago, New Zealand, differs from *Ophiocamax patersoni* sp. nov. in shape of disk spinelets, structure of spines, shape of thorns at distal edge of the dorsal arm plates and in shape of the oral shield.

Finally, the common Indo-West Pacific deep-water species *O. vitrea*, which was recently shown as being very polymorphic (O'Hara & Stöhr 2006), is well distinguished from *Ophiocamax patersoni* sp. nov. by the shape and structure of the disk spines and spines of the arm (Figures 12D, 15I), numerous irregular oral papillae and the shape of the oral shield (Figure 16D).

Thus, in the North and Middle Atlantic there are several locally distributed, but well-distinguished species – in the Caribbean region *O. fasciculata* and *O. hystrix*; off Northern Africa *O. dominans*; and on the Charlie-Gibbs Fracture Zone and the Mid-Atlantic Ridge north of the Azores *Ophiocamax patersoni* sp. nov.

Ophiolimna bairdi (Lyman, 1883)
(Figure 17A)

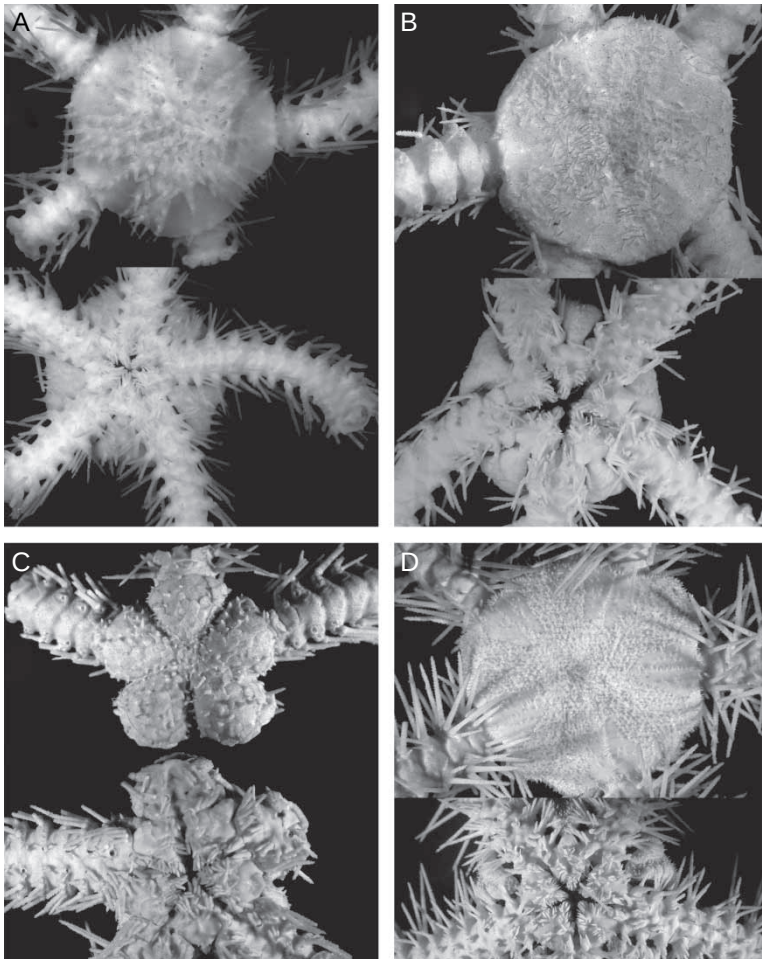

Figure 12. (A) *Ophiocamax dominans* Koehler, 1906, ZSM 20043260, RV *Meteor*, Cruise 36, St. 98/ES 148, off Spanish Sahara, 25°40.8′N, 16°02.0′W, depth 883–992 m, disk diameter 11.1 mm; (B) *Ophiocamax fasciculata* Lyman, 1883, holotype MCZ 2082, *Blake*, St. 209, off Martinique, depth ca. 344 m, disk diameter 14 mm; (C) *Ophiocamax hystrix* Lyman, 1878, holotype MCZ 2084, *Blake*, off Havana, Cuba, depth ca. 318 m, disk diameter 13 mm; (D) *Ophiocamax vitrea* Lyman, 1878, syntype MCZ 2096, *Challenger*, St. 219, off Admiralty Is., depth ca. 273 m, disk diameter 17 mm. Dorsal and ventral views are shown. Photographs: Tanya Korshunova (A); Alexander Martynov (B–D).

Ophiacantha bairdi: Lyman 1883: 256, Plate 5, Figures 70–72.
Ophiolimna bairdi: Verrill 1899: 40, 44; Paterson 1985: 60, Figure 24.

Material

RV *Akademik Mstislav Keldysh*, fourth cruise, St. 316-5, 56 specimens; St. 415, one specimen; St. 445, three specimens; St. 478, one specimen; St. 499, 10 specimens.

Distribution

Arctic Ocean; North Atlantic: in the west – south of Martha's Vineyard, east – from the Rockall Trough to south of Portugal, at 620–2600 (Dyakonov 1954; Paterson 1985). Present study: the Reykjanes Ridge, at 1535–2440 m.

Family Ophiactidae

Histampica duplicata (Lyman, 1875)
(Figure 17B)

Amphiura duplicata: Lyman 1875: 19–20, Text figure 87, Plate 5, Figure 78.
Ophiactis duplicata: Lütken & Mortensen 1899: 142–3, Plate 6, Figures 1–3.
Amphiactis duplicata: Matsumoto 1915: 66–7.
Histampica duplicata: A.M. Clark 1970: 73–4.

Material

RV *Akademik Mstislav Keldysh*, fourth cruise, St. 418, two specimens.

Distribution

The Caribbean, the Pacific Ocean. North Atlantic records: Bay of Biscay to north Africa, at 125–2870 m

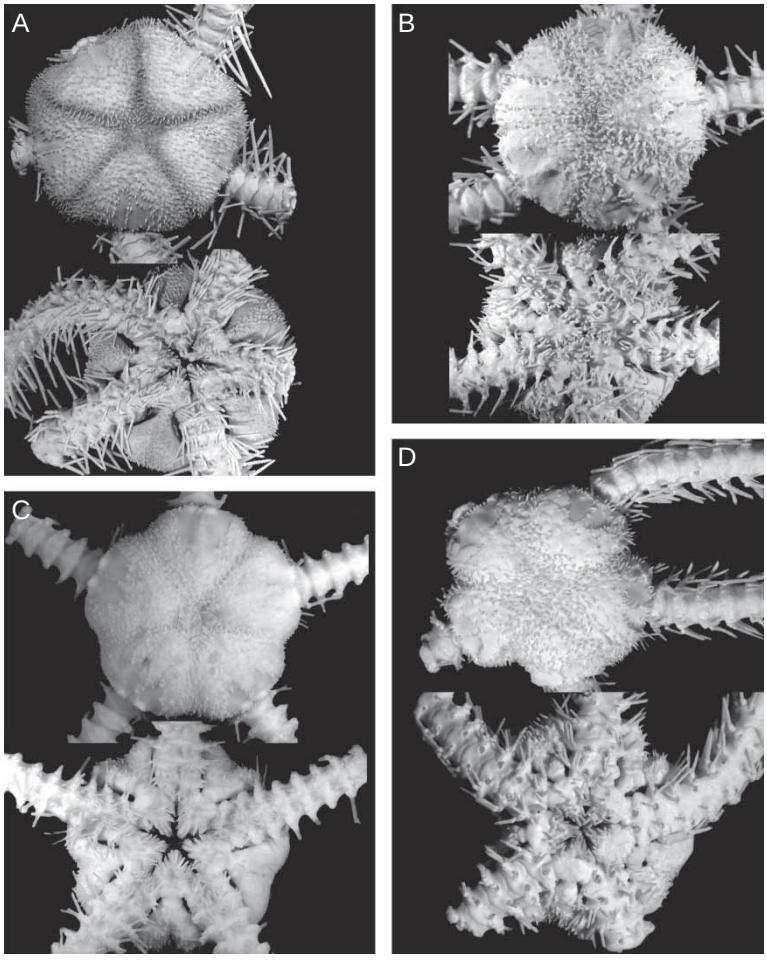

Figure 13. (A) *Ophiocamax gigas* Koehler, 1901, IORAS 5.1, RV *Akademik Kurchatov*, Cruise 11, St. 881, 57°8′S, 26°42′W, depth 932 m, disk diameter 34 mm; (B) *Ophiocamax drygalskii* Hertz, 1927, syntype ZSM 20001015/2, Deutsche Südpolar-Expedition, 65°31′S, 85°14′W, depth 2450 m, disk diameter 19.8 mm; (C) *Ophiocamax drygalskii* Hertz, 1927, syntype ZSM 20001015/1, 65°31′S, 85°14′W, depth 2450 m, disk diameter 20.1 mm; (D) *Ophiocamax patersoni* sp. nov., holotype ZMBN 77854, MAR-ECO St. 52/374, disk diameter 17.5 mm. Dorsal and ventral views are shown. Photographs: Alexander Martynov (A, D); Tanya Korshunova (B, C).

(Paterson 1985). Present study: the Reykjanes Ridge, at 1815–1915 m.

Ophiactis abyssicola (M. Sars, 1861)
(Figure 17C–E)

Amphiura abyssicola: M. Sars 1861: 18.
Ophiactis abyssicola: Ljungman 1867: 324; Paterson 1985: 76–8, Figure 32.
Ophiactis poa: Lyman 1882: 119.
Ophiactis echinata: Koehler 1898: 48.
Ophiactis corallicola: Koehler 1896a: 75.

Material

RV *G.O. Sars*, MAR-ECO cruise, St. 42/368, one specimen; St. 53/375, one specimen; St. 60/379, 25 specimens; St. 62/380, 13 specimens; St. 65/382, five specimens; St. 70/385, seven specimens; RV *Akademik Mstislav Keldysh*, fourth cruise, St. 319, 13 specimens; St. 364, five specimens; St. 385, 56 specimens; St. 415, three specimens; St. 418, one specimen; St. 445, 40 specimens; St. 446, three specimens; St. 464, one specimen; St. 465, 65 specimens; St. 478, one specimen; St. 489, 15 specimens.

Distribution

North Atlantic: Davis Strait, off Iceland, Faeroe Islands, from Norway to southern Africa, at 121–4721 m (Paterson 1985). Present study: the Reykjanes Ridge, at 607–2107 m.

Remarks

Mortensen (1933) recorded six- and seven-armed specimens of this species as a rare abnormality. This feature was confirmed in the present study (Figure 17C–E). Other characters are essentially the same as in common five-armed specimens. In our material

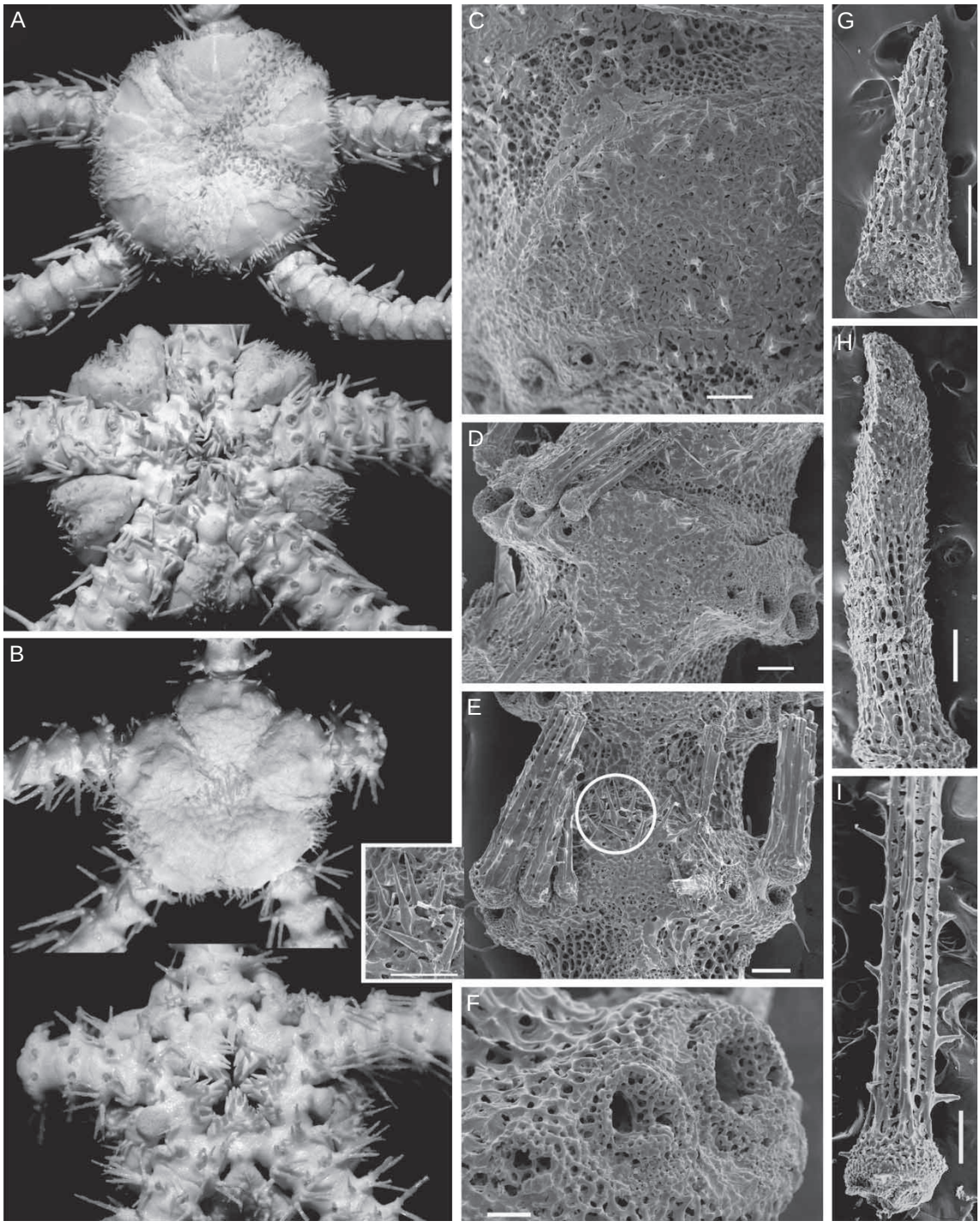

Figure 14. *Ophiocamax patersoni* sp. nov. (A) Paratype ZMMU D-748, MAR-ECO St. 50/373, disk diameter 19.5 mm, dorsal and ventral views; (B) paratype ZMMU D-748, MAR-ECO St. 50/373, disk diameter 8.5 mm, dorsal and ventral views; (C) holotype ZMBN 77854, scanning electron micrograph of dorsal arm plate, basal segments; (D) holotype ZMBN 77854, scanning electron micrograph of dorsal arm plate, distal segments; (E) paratype ZMMU D-748, disk diameter 8.5 mm, scanning electron micrograph of dorsal arm plate, basal segments (enlarged view of spines also shown); (F) paratype ZMMU D-748, disk diameter 8.5 mm, scanning electron micrograph of arm spine articulation ridges, middle segments; (G) paratype ZMMU D-748, disk diameter 19.5 mm, scanning electron micrograph of tentacle scale, basal segments; (H) paratype ZMMU D-748, disk diameter 19.5 mm, scanning electron micrograph of ventral arm spine, middle segments; (I) paratype ZMMU D-748, disk diameter 19.5 mm, scanning electron micrograph of basal part of third arm spine, middle segments. Scale bars: 300 μm (C–E, G–I); 100 μm (F). Photographs: Alexander Martynov.

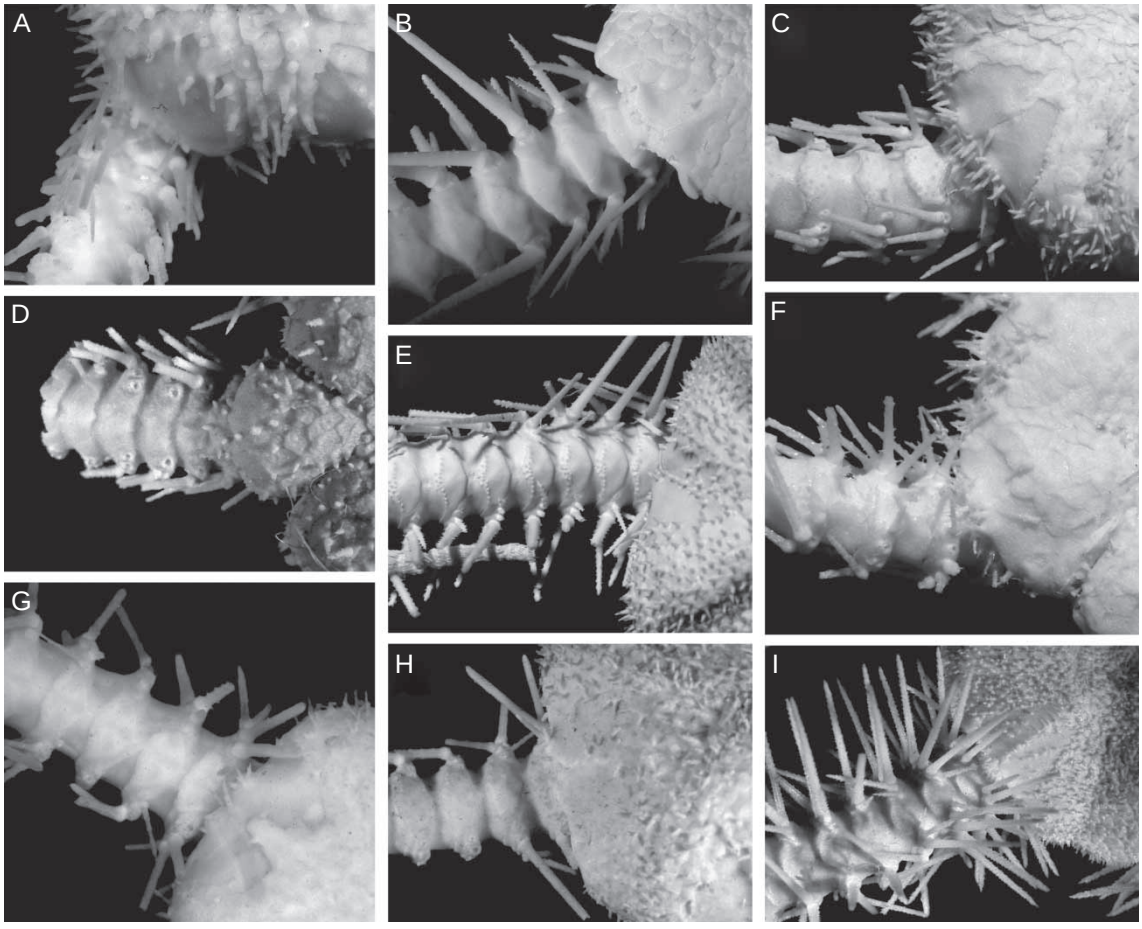

Figure 15. Segment of the disk and basal part of the arm of various *Ophiocamax* species. (A) *Ophiocamax dominans* Koehler, 1906, ZSM 20043261, RV *Meteor*, Cruise 36, St. 98/AT 149, off Spanish Sahara, 25°31′05″N, 16°02′00″W, depth 658–888 m, disk diameter 16.5 mm; (B) *Ophiocamax fasciculata* Lyman, 1883, paratype MCZ 4613, *Blake*, St. 145, 147, 148, off St Kitts, 378–491 m, disk diameter 18 mm; (C) *Ophiocamax patersoni* sp. nov., paratype ZMMU D-748, MAR-ECO St. 50/373, disk diameter 19.5 mm; (D) *Ophiocamax hystrix* Lyman, 1878, holotype MCZ 2084, *Blake*, off Havana, Cuba, depth ca. 318 m, disk diameter 13 mm; (E) *Ophiocamax gigas* Koehler, 1901, RV *Akademik Kurchatov*, Cruise 11, St. 881, 57°8′S, 26°42′W, depth 932 m, disk diameter 34 mm; (F) *Ophiocamax patersoni* sp. nov., paratype ZMMU D-748, MAR-ECO St. 50/373, disk diameter 8.5 mm; (G) *Ophiocamax drygalskii* Hertz, 1927, syntype ZSM 20001015/1, 65°31′S, 85°14′W, depth 2450 m, disk diameter 18.1 mm; (H) *Ophiocamax drygalskii* Hertz, 1927, syntype ZSM 20001015/2, Deutsche Südpolar-Expedition, 65°31′S, 85°14′W, depth 2450 m, disk diameter 20.9 mm; (I) *Ophiocamax vitrea* Lyman, 1878, syntype MCZ 2096, *Challenger*, St. 219, off Admiralty Is., depth ca. 273 m, disk diameter 17 mm. Photographs: Tanya Korshunova (A, G, H); Alexander Martynov (B–F, I).

this species was found associated with the sponge *Hertwigia falcifera* Schmidt, 1880.

Ophiothamnus chariis H.L. Clark, 1915
(Figure 17F, G)

Ophiacantha gracilis Verrill 1885b: 548.
Ophiothamnus gracilis: Verrill 1899: 41.
Ophiothamnus chariis H.L. Clark 1915: 208; Mortensen 1933: 44–5, Figure 27.

Material

RV *G.O. Sars*, MAR-ECO cruise, St. 60/379, one specimen.

Distribution

Off Nova Scotia, 400–1561 m (Verrill 1885b) and Davis Strait, at 700–1055 m (Mortensen 1933). Present study: the Reykjanes Ridge, at 1237–1296 m. This species was omitted by Paterson (1985) and recorded here for the first time after 70 years.

Family Ophiochitonidae

Ophiochiton ternispinus Lyman, 1883
(Figure 17H)
Ophiochiton ternispinus Lyman 1883: 255–6, Plate 5, Figures 67–69; Paterson 1985: 96–7, Figure 39.

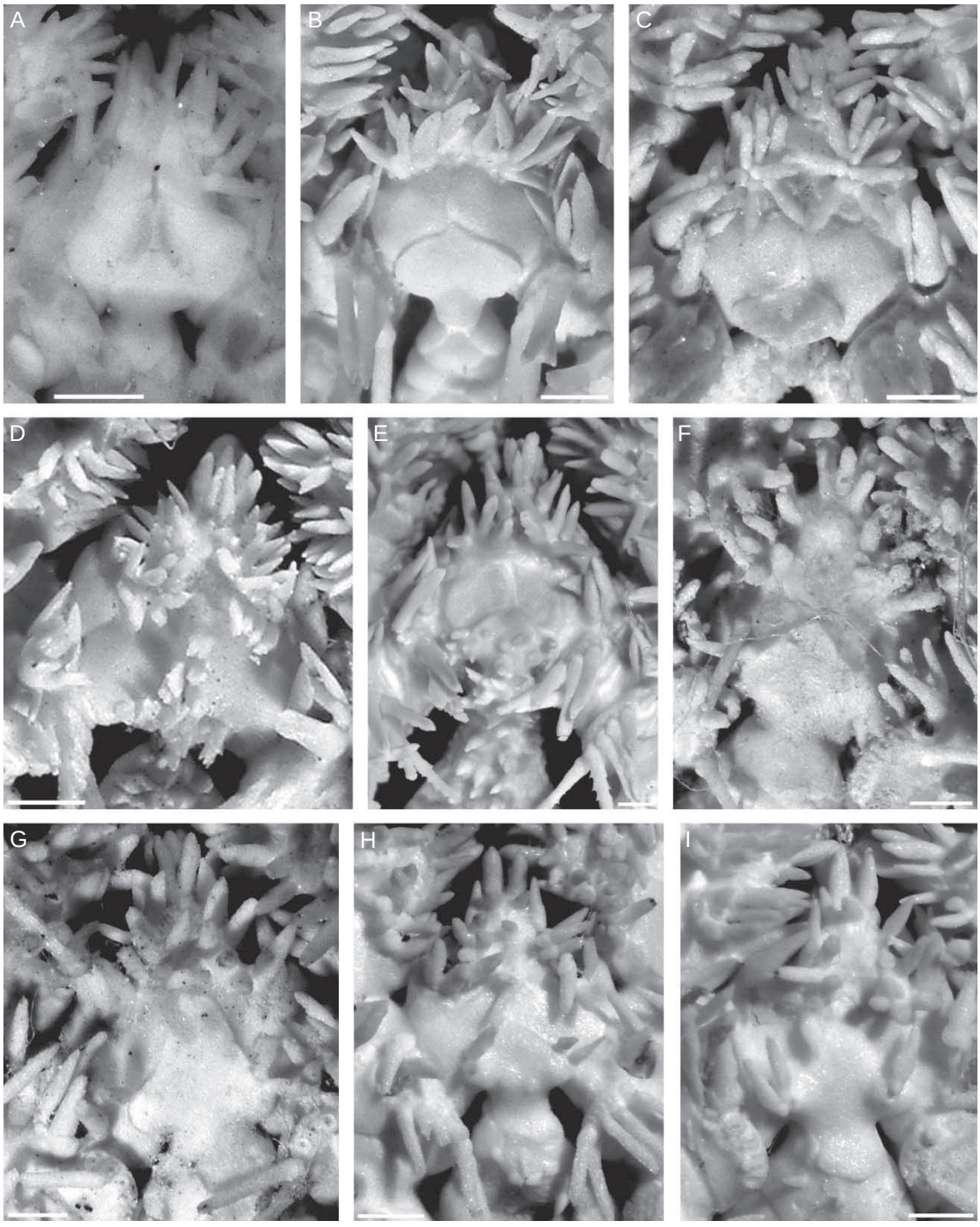

Figure 16. Oral frame showing shape of the oral shield of various *Ophiocamax* species. (A) *Ophiocamax dominans* Koehler, 1906, ZSM 20043261, RV *Meteor*, Cruise 36, St. 98/AT 149, off Spanish Sahara, 25°31.5′N, 16°02.0′W, depth 658–888 m. (B) *Ophiocamax fasciculata* Lyman, 1883, paratype MCZ 2083, *Blake*, St. 295, off Barbados, ca. 328 m. (C) *Ophiocamax hystrix* Lyman, 1878, holotype MCZ 2084, *Blake*, off Havana, Cuba, depth ca. 318 m. (D) *Ophiocamax vitrea* Lyman, 1878, syntype MCZ 2096, *Challenger*, St. 219, off Admiralty Is., depth ca. 273 m. (E) *Ophiocamax gigas* Koehler, 1901, RV *Akademik Kurchatov*, Cruise 11, St. 881, 57°08′S, 26°42′W, depth 932 m. (F, G) *Ophiocamax drygalskii* Hertz, 1927, syntype ZSM 20001015/2, Deutsche Südpolar-Expedition, 65°31′S, 85°14′W, depth 2450 m. (H, I) *Ophiocamax patersoni* sp. nov.: (H) holotype ZMBN 77854, MAR-ECO St. 52/374; (I) paratype ZMMU D-748, MAR-ECO St. 50/373, disk diameter 19.5 mm. Scale bars: 1 mm. Photographs: Tanya Korshunova (A, F, G); Alexander Martynov (B–E, H, I).

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