European Journal of Taxonomy 870: 46–75
https://doi.org/10.5852/ejt.2023.870.2117
ISSN 2118-9773
www.europeanjournaloftaxonomy.eu
2023 · Calero B. & Ramil F.

Research article

urn:lsid:zoobank.org:pub:3FDD6064-3107-4540-B587-9D02C01DF5B8

Euryalida (Echinodermata, Ophiuroidea) from Northwest Africa

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Abstract. From 2004 to 2012, ten multidisciplinary oceanographic surveys were conducted along the coast of Northwest Africa, between the Strait of Gibraltar and the northern border of Sierra Leone. A total of five species of Euryalida Lamarck, 1816 belonging to three families were captured at 29 of the 1298 stations sampled in the area. Among them, *Astrodendrum juancarlosi* sp. nov. is described and figured in this paper. *Ophiocreas oedipus* Lyman, 1879 is recorded for the first time on West African continental margin and *Gorgonocephalus pustulatum* (H.L. Clark, 1916), an Indo-Pacific species only known from South African coast in the Atlantic, is reported off Guinea-Bissau, greatly extending to the North its Atlantic distribution. In addition, *Asteroschema inornatum* Koehler, 1906, a northeast Atlantic species, is recorded for the first time in African waters, off Western Sahara, extending its range of distribution to the south. Our data also extend the bathymetric distribution of *A. inornatum* to shallower waters and of *G. pustulatum* to deeper waters. The association of some euryalids with certain species of pennatulaceans and gorgonians is also described.

Keywords. Brittle-stars, taxonomy, *Astrodendrum juancarlosi* sp. nov., CCLME region, NW Atlantic.

Calero B. & Ramil F. 2023. Euryalida (Echinodermata, Ophiuroidea) from Northwest Africa. *European Journal of Taxonomy* 870: 46–75. https://doi.org/10.5852/ejt.2023.870.2117

Introduction

Brittle stars are a common and numerically important component of epibenthic assemblages in bathyal and abyssal bottoms, constituting a significant component of the deep-sea megafauna (Metaxas & Giffin 2004). Ophiuroid species are distributed in all oceans inhabiting all types of substrata and are present in most habitats, ranging from intertidal to hadal depths (Stöhr *et al.* 2012). Among the five classes of the phylum Echinodermata Klein, 1878, Ophiuroidea Gray, 1840 – which includes brittle stars, basket stars (euryalids with branching arms) and snake stars (euryalids with non-branching arms) – has the highest diversity, with more than 2200 described species (Stöhr *et al.* 2012, 2021). Despite the remarkable differences in their bathymetric range, shelf (0–200 m) and bathyal (200–3500 m) strata harbour

approximately the same number of species, although there is a clear difference in species composition between both strata. In abyssal depths (3500–6500 m), however, species richness is considerably reduced (Stöhr *et al.* 2012, 2021). In several locations the bathymetric distribution pattern of ophiuroids seems influenced by food availability, concentration of dissolved oxygen and its relative trophic position (Haedrich *et al.* 1980; Summers & Nybakken 2000; García *et al.* 2002; Metaxas & Giffin 2004). In addition, some species have been recorded forming dense aggregations that can reach up to thousands of individuals per square meter – so-called 'ophiuroid seabeds' (Metaxas & Giffin 2004; Calero *et al.* 2018). Nevertheless, how much these patterns are biased by differences in spatial and bathymetric sampling efforts remains unresolved.

Although knowledge about their biology, particularly related to feeding behaviour, is currently quite scarce, ophiuroids display a wide range of selective strategies such as deposit-feeding, scavenging, predation and suspension feeding (Stöhr *et al.* 2012). Suspension feeding has been described in numerous species – mostly families of Ophiotrichidae Ljungman, 1867, Ophiactidae Matsumoto, 1915, Amphiuridae Ljungman, 1867, Ophiocomidae Ljungman, 1867 and Ophiacanthidae Ljungman, 1867 (Warner & Woodley 1975; Metaxas & Giffin 2004). Nevertheless, Stöhr *et al.* (2012) consider that correlating feeding mode with taxonomic levels (genus, family) is problematic, since the systematics of ophiuroids are currently in flux.

Within Ophiuroidea, the order Euryadida Lamarck, 1816 comprises three families: Gorgonocephalidae Ljungman, 1867, Asteronychidae Ljungman, 1867 and Euryalidae Gray, 1840, with Gorgonocephalidae as the largest family, encompassing 33 genera and 94 extant species (Stöhr *et al.* 2021).

Species of Euryalida have simple or branched arms, which can coil on a vertical plane (Mortensen 1927; Hyman 1955; Baker 1980). This feature allows them to wind around corals, living epizoically on gorgonians or antiphatarians, but occasionally also on hard substrates (Baker 1980).

Euryalid species have a worldwide distribution and wide bathymetric ranges, and are found from depths of a few meters to over 4000 m (Baker 1980).

This group is not well known, and available information is less advanced than for other ophiuroids. Currently, most of the studies on Euryalida has been carried out in the Indo-Pacific region (Okanishi *et al.* 2011, 2018, 2020; Kim & Shin 2015; Baker *et al.* 2018; Okanishi & Fujita 2018). In the East Atlantic, they were mainly studied on the European coast and Boreal seas (Mortensen 1927; Madsen 1951; Gage *et al.* 1983; Paterson 1985) and there have been few reports of the group to date along the Northwest African coast (Calero 2017).

The present study represents a new contribution to the knowledge base of Euryalida (Echinodermata: Ophiuroidea) fauna off Northwest Africa.

Material and methods

The study area stretches for more than 5000 km along the Atlantic coast of Northwest Africa, from the Strait of Gibraltar (36º N) to the northern border of Sierra Leone (9º N).

Species of Euryalida were collected at 29 of a total of 1298 stations sampled with commercial bottom trawl over soft bottoms, between 19 and 1888 m depth. The samples were collected during the ten multidisciplinary Spanish and Norwegian surveys conducted, in collaboration with marine research institutes from African countries, in the area between 2004 and 2012 (Fig. 1).

At each station, specimens were sorted on board to morpho-species level; then they were counted, wet weighed and preserved in 80% ethanol for further study in the laboratory.

Specimens were identified in the Marine Zoology laboratory of the University of Vigo. The disc diameter (dd) was measured to the nearest millimetre on the dorsal side of each specimen – from the base of one arm to the opposing disc side in the inter-radius.

Imaging was obtained using a Nikon DS-Fi2 digital camera mounted on a motorized Nikon SMZ25 stereo microscope. The images were computerized using the NIS-Elements Microscope Imaging Software, which included the Extended Depth of Focus (EDF) functionality.

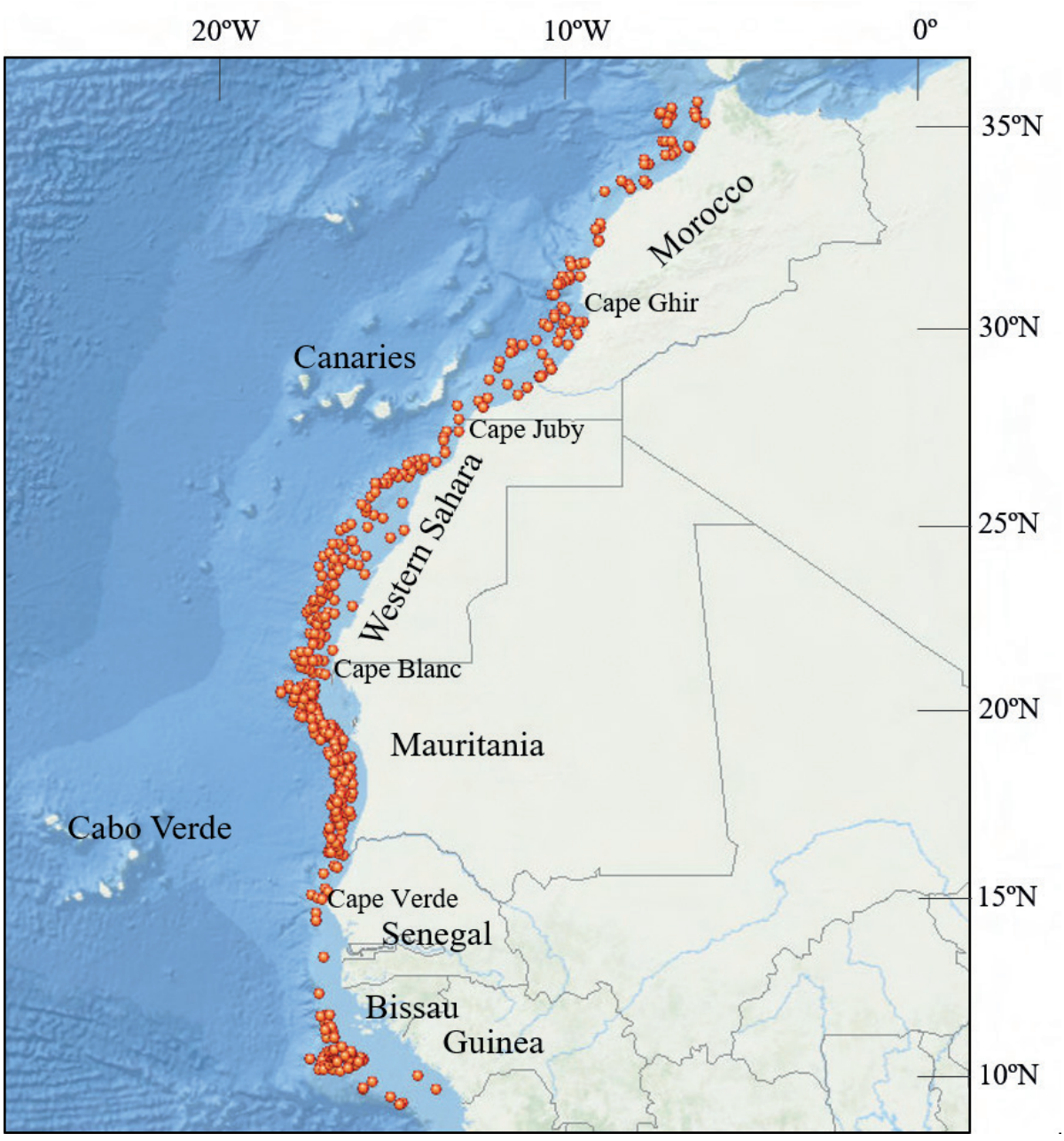

Fig. 1. Map from the study area with the location of the 1298 bottom trawling stations carried out during the ten surveys off Northwest Africa.

Table 1 (continued on next page). Table of stations where Euryalida Lamarck, 1816 were collected during the ten surveys conducted off Northwest Africa, including date, zone, start and end coordinates and depths, and species of Euryalida recorded in each station.

survey	code station	date	zone	latitud (N) longitud (W) start	latitud (N) longitud (W) end	depth range (m)	species
Maroc-0511	MO162	5 Dec. 2005	Sahara	26°40′20″–14°33′14″	26°40′59″–14°29′55″	1294–1151	*Asteroschema inornatum* Koehler, 1906
Maroc-0511	MO169	7 Dec. 2005	Sahara	26°33′21″–14°33′16″	26°35′04″–14°36′07″	1313–1469	*Asteroschema inornatum* Koehler, 1906
Maroc-0511	MO171	8 Dec. 2005	Sahara	26°39′46″–14°45′20″	26°41′48″–14°42′44″	1593–1588	*Asteroschema inornatum* Koehler, 1906, *Ophiocreas oedipus* Lyman, 1879
Maroc-0511	MO172	8 Dec. 2005	Sahara	26°32′37″–14°46′45″	26°30′44″–14°49′31″	1004–1031	*Asteroschema inornatum* Koehler, 1906
Maroc-0511	MO181	11 Dec. 2005	Sahara	26°23′25″–15°17′44″	26°26′32″–15°18′14″	1615–1755	*Ophiocreas oedipus* Lyman, 1879
Maroc-0511	MO184	12 Dec. 2005	Sahara	26°12′42″–15°27′44″	26°10′34″–15°25′15″	1371–1250	*Asteroschema inornatu* Koehler, 1906
Maroc-0611	MO198	17 Dec. 2006	Sahara	21°33′13″–18°07′26″	21°36′08″–18°07′09″	1860–1820	*Asteronyx loveni* Müller &Troschel, 1842
Maroc-0611	MO217	22 Dec. 2006	Sahara	22°25′08″–17°32′05″	22°27′14″–17°29′31″	1543–1540	*Ophiocreas oedipus* Lyman, 1879
Maroc-0611	MO230	26 Nov. 2006	Sahara	22°59′13″–17°37′30″	22°56′19″–17°38′12″	1562–1577	*Asteronyx loveni* Müller &Troschel, 1842
Maroc-0611	MO235	27 Nov. 2006	Sahara	23°12′00″–17°11′16″	23°14′27″–17°12′27″	909–913	*Ophiocreas oedipus* Lyman, 1879
Maroc-0611	MO237	27 Nov. 2006	Sahara	23°15′08″–17°23′29″	23°18′11″–17°24′17″	1341–1338	*Asteroschema inornatu* Koehler, 1906
Maurit-1107	MU22	23 Nov. 2007	Mauritania	19°34′14″–17°31′44″	19°31′34″–17°30′21″	1689–1628	*Asteronyx loveni* Müller &Troschel, 1842
Maurit-1107	MU31	26 Nov. 2007	Mauritania	19°25′29″–17°33′17″	19°22′44″–17°32′11″	1778–1811	*Asteronyx loveni* Müller &Troschel, 1842
Bissau-0810	BS149	26 Oct. 2008	Bissau	11°06′46″–17°06′23″	11°07′39″–17°06′40″	71–71	Gorgonocephalidae indet
Bissau-0810	BS151	26 Oct. 2008	Bissau	11°05′09″–17°03′15″	11°04′15″–17°03′10″	46–47	*Astrodendrum juancarlosi* sp. nov.
Bissau-0810	BS156	27 Oct. 2008	Bissau	10°22′50″–17°19′08″	10°23′40″–17°19′08″	940–849	*Asteronyx loveni* Müller &Troschel, 1842
Bissau-0810	BS166	29 Oct. 2008	Bissau	10°01′18″–17°24′56″	10°00′24″–17°25′05″	902–908	*Gorgonocephalus pustulatum* H.L. Clark, 1916, *Asteronyx loveni* Müller &Troschel, 1842
Bissau-0810	BS200	4 Nov. 2008	Bissau	10°18′55″–16°25′07″	–	79	*Astrodendrum juancarlosi* sp. nov.
Maurit-0811	MU92	21 Nov. 2008	Mauritania	19°55′41″–18°01′07″	19°53′05″–18°02′01″	1808–1862	*Asteronyx loveni* Müller &Troschel, 1842
Maurit-0811	MU92	21 Nov. 2008	Mauritania	19°55′41″–18°01′07″	19°53′05″–18°02′01″	1808–1862	*Asteronyx loveni* Müller &Troschel, 1842
Maurit-0811	MU93	21 Nov. 2008	Mauritania	19°51′02″–17°55′33″	19°49′33″–17°53′00″	1740–1769	*Asteronyx loveni* Müller &Troschel, 1842
Maurit-0811	MU94	21 Nov. 2008	Mauritania	19°35′15″–17°35′13″	19°32′43″–17°33′37″	1720–1734	*Asteronyx loveni* Müller &Troschel, 1842

Table 1 (continued).

survey	code station	date	zone	latitud (N) longitud (W) start	latitud (N) longitud (W) end	depth range (m)	species
Maurit-0911	MU193	22 Nov. 2009	Mauritania	19°59′28″–17°57′28″	19°59′01″–17°59′07″	1746–1749	*Asteronyx loveni* Müller &Troschel, 1842
Maurit-1011	MU274	6 Dec. 2010	Mauritania	16°08′44″–17°10′08″	16°11′14″–17°08′40″	1590–1599	*Asteronyx loveni* Müller &Troschel, 1842
CCLME-1110	BT53	29 Oct. 2011	Bissau	11°08′07″–17°15′20″	11°09′33″–17°15′44″	109–109	*Astrodendrum juancarlosi* sp. nov.
CCLME-1110	BT105	8 Nov. 2011	Senegal	16°03′15″–16°43′59″	16°01′50″–16°44′15″	76–75	Gorgonocephalidae indet
CCLME-1110	BT215	29 Nov. 2011	Sahara	26°26′23″–14°25′30″	26°25′06″–14°26′23″	67–58	*Astrodendrum juancarlosi* sp. nov.
CCLME-1110	BT216	2 Dec. 2011	Sahara	26°39′31″–14°03′42″	26°39′09″–14°04′03″	73–72	Gorgonocephalidae indet
CCLME-1205	BT368	27 May 2012	Senegal	14°57′00″–17°39′08″	14°58′09″–17°38′13″	797–797	*Astrodendrum juancarlosi* sp. nov.
CCLME-1205	BT492	22 Jun. 2012	Sahara	26°51′57″–13°47′12″	26°51′01″–13°48′38″	96–94	Gorgonocephalidae indet

Ossicles from the new species *Astrodendrum juancarlosi* sp. nov. were isolated by immersion in sodium hypochlorite (NaOCl). Subsequently they were washed with ethanol 96% and deionized water, and air-dried. Dried ossicles were mounted on SEM stubs using double-sided conductive tape. Finally, the ossicles were sputter-coated with gold-palladium and examined with a JEOL JEM 2010 F SEM and digitally photographed.

The station data where Euryalida were collected, including date, zone, start and end coordinates and depths, as well as the species recorded in each station are summarized in Table 1.

The samples collected during these cruises were labelled (”survey”-XXXX) and sent to the zoological collections of the Marine Zoology Laboratory at University of Vigo, Spain (LZM-UV), for conservation and curation. Type material of the new species was deposited in the Nacional Natural Sciences Museum of Madrid (MNCN). Besides, paratypes were deposited in the zoological collections of the Marine Zoology Laboratory at University of Vigo, Spain (LZM-UV), in the Collection of Marine Fauna from the Oceanographic Centre of Málaga of the Spanish Institute of Oceanography, Spain (CFM-IEOMA) and the Natural History Museum of the University of Santiago de Compostela, Spain (MHN-USC).

Institutional abbreviations

CFM-IEOMA = Collection of Marine Fauna from the Oceanographic Centre of Málaga of the Spanish Institute of Oceanography, Spain
LZM-UV = Zoological collections of the Marine Zoology Laboratory at University of Vigo, Spain
MHN-USC = Natural History Museum of the University of Santiago de Compostela, Spain
MNCN = Museo Nacional de Ciencias Naturales de Madrid, Spain
MNHN = Muséum national d'histoire naturelle, Paris, France

Further abbreviations

dd = disc diameter
stn = station
VIA = ventral interbrachial arcs

Results

Taxonomy

Class Ophiuroidea Gray, 1840
Order Euryalida Lamarck, 1816
Family Asteronychidae Ljungman, 1867
Genus *Asteronyx* Müller & Troschel, 1842

Asteronyx loveni Müller & Troschel, 1842
Figs 2, 3A–B, 4A, D–E

Asteronyx loveni Müller & Troschel, 1842: 119, pl. X figs 3–5.
Ophiuropsis lymani Studer, 1884: 55, pl. V figs 12a–d.
Asteronyx locardi Koehler, 1895: 470–471, fig. 10

Asteronyx loveni – Clark 1923: 314–315. — Mortensen 1927: 158–160, fig. 90 — Paterson, 1985: 13–15, fig. 15.
Asteronyx locardi – Koehler 1896: 88–89, pl. 3 fig. 25.

Material examined

MAURITANIA • 1 spec., 25.22 mm dd; 19°34′14″–19°31′34″ N, 17°31′44″–17°30′21″ W; depth 1689–1628 m; 23 Nov. 2007; Maurit-1107 exped.; stn MU22; Maurit-1107-04528; LZM-UV • 12 specs, 6.08–21.71 mm dd; 19°25′29″–19°22′44″ N, 17°33′17″–17°32′11″ W; depth 1778–1811 m; 26 Nov. 2007; Maurit-1107 exped.; stn MU31; Maurit-1107-05231; LZM-UV • 10 specs, 6.83–19.28 mm dd; 19°55′41″–19°53′05″ N, 18°01′07″–18°02′01″ W; depth 1808–1862 m; 21 Nov. 2008; Maurit-0811 exped.; stn MU92; Maurit-0811-03931; LZM-UV • 4 specs, 64.90–22.98 mm dd; 19°51′02″–19°49′33″ N, 17°55′33″–17°53′00″ W; depth 1740–1769 m; 21 Nov. 2008; Maurit-0811 exped.; stn MU93; Maurit-0811-03725; LZM-UV • 2 specs, 9.60–12.56 mm dd; 19°35′15″–19°32′43″ N, 17°35′13″–

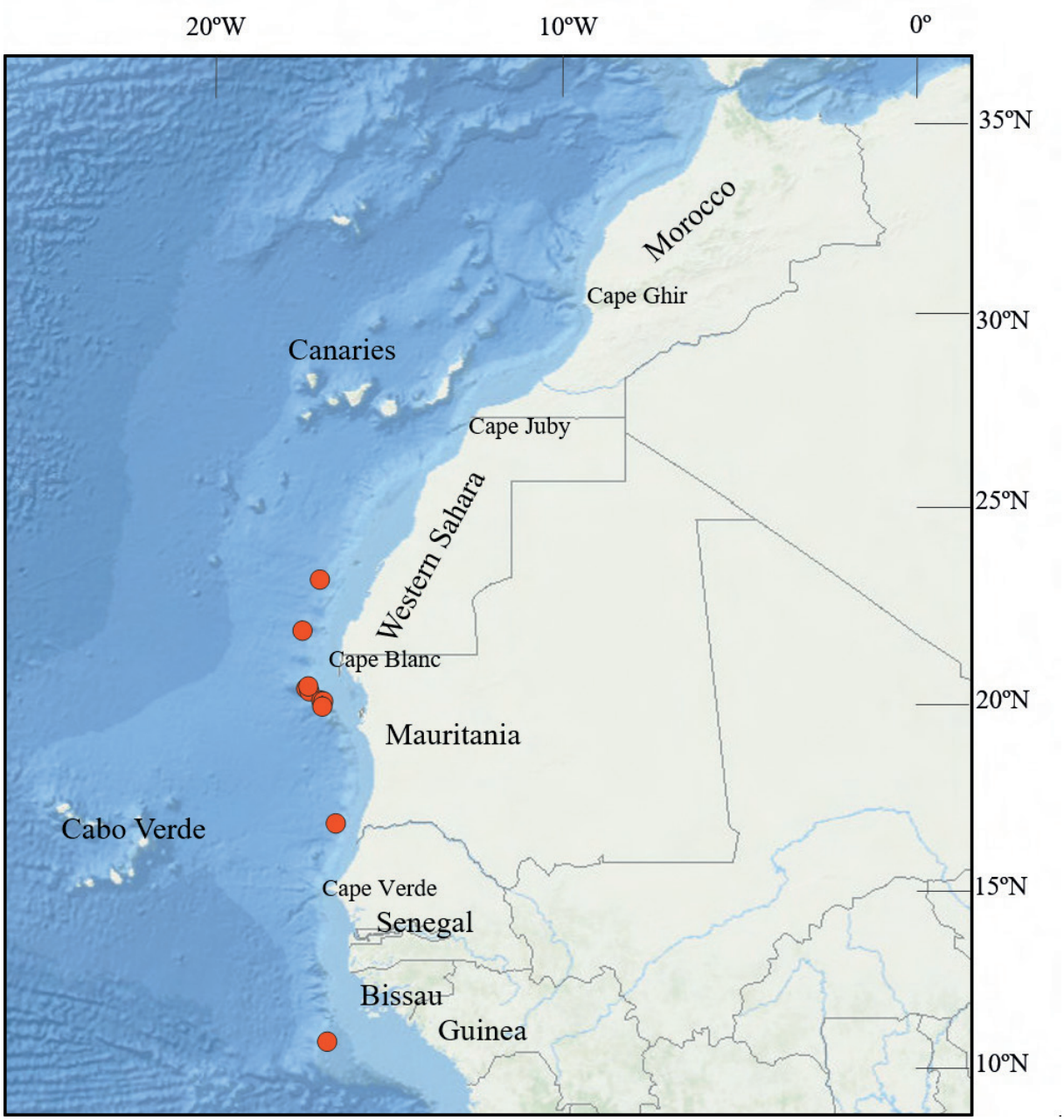

Fig. 2. Map from the study area with the location of the stations where specimens of *Asteronyx loveni* Müller & Troschel, 1842 were collected during the ten surveys off Northwest Africa.

17°33′37″ W; depth 1720–1734 m; 21 Nov. 2008; Maurit-0811 exped.; stn MU94; Maurit-0811-03928; LZM-UV • 1 spec., 11.07 mm dd; 19°59′28″–19°59′01″ N, 17°57′28″–17°59′07″ W; depth 1746–1749 m; 22 Nov. 2009; Maurit-0911 exped.; stn MU193; Maurit-0911-03154; LZM-UV • 1 spec., 25.74 mm dd; 16°08′44″–16°11′14″ N, 17°10′08″–17°08′40″ W; depth 1595 m; 6 Dec. 2010; Maurit-1011 exped.; stn MU274; Maurit-1011-02982; LZM-UV.

WESTERN SAHARA •1 spec., 11.01 mm dd; 21°33′13″–21°36′08″ N, 18°07′26″–18°07′09″ W; depth 1860–1820 m; 17 Nov. 2006; Maroc-0611 exped.; stn MO198; Maroc-0611-16135; LZM-UV • 1 spec., 5.81 mm dd; 22°59′13″–22°56′19″ N, 17°37′30″–17°38′12″ W; depth 1562–1577 m; 26 Nov. 2006; Maroc-0611 exped.; stn MO230; Maroc-0611-16155; LZM-UV.

GUINEA BISSAU • 2 specs, 13.24–18.81 mm dd; 10°01′18″–10°00′24″ N, 17°24′56″–17°25′05″ W; depth 902–908 m; 29 Oct. 2008; Bissau-0810 exp.; stn BS166; Bissau-0811-06529; LZM-UV.

Distribution

Asteronyx loveni Müller & Troschel, 1842 is a circumglobal species, widely distributed across the three major oceans (Indian, Pacific and Atlantic). In the Atlantic Ocean, it has been recorded on both sides: in the West Atlantic, from North USA to West Indies (Hernández-Herrejón *et al.* 2008), and in the East Atlantic, from Norway (Döderlein 1911) to South Africa (Mortensen 1933). It also has a wide bathymetric distribution, ranging from 100 to 4721 m (Smirnov *et al.* 2014).

We collected the species at eleven stations from Western Sahara, Mauritania and Guinea-Bissau waters, between 902 and 1862 m.

Remarks

This is a deep-sea-water species generally associated with gorgonians and pennatularians (Mortensen 1927). Our specimens were always associated with pennatularians *Distichoptilum gracile* Verrill, 1882 and *Anthoptilum murrayi* Kölliker, 1880. Living colour of the species is cream or pinkish orange, more intense in the central part of the disc. The innermost arm spine much larger than the other spines and a hooked arm spine at the tip of the arm are the most distinctive characteristic for this species.

Family Asteroschematidae Verrill, 1899
Genus *Asteroschema* Örstedt & Lütken, 1899

Asteroschema inornatum Koehler, 1906
Figs 3C, 4B, F–G, 5

Asteroschema inornatum – Koehler, 1906: 30–31, pl. III figs 45, 47.

Asteroschema inornatum – Koehler, 1906b: 303–304, pl. XXI figs 46–47; 1909: 205, pl. VII fig. 1. — Gage *et al.,* 1983: 288 — Paterson, 1985: 16, fig. 10.

Material examined

WESTERN SAHARA • 6 specs, 7.36–9.91 mm dd; 26°40′20″–26°40′59″ N, 14°33′14″–14°29′55″ W; depth 1294–1151 m; 5 Dec. 2005; Maroc-0511 exped.; stn MO162; Maroc-0511-16532; LZM-UV • 3 specs, 5.62–11.09 mm dd; 26°33′21″–26°35′04″ N, 14°33′16″–14°36′07″ W; depth 1313–1469 m; 7 Dec. 2005; Maroc-0511 exped.; stn MO169; Maroc-0511-16716; LZM-UV • 10 specs, 5.61–9.71 mm dd; 26°39′46″–26°41′48″ N, 14°45′20″–14°42′44″ W; depth 1593–1588 m; 8 Dec. 2005; Maroc-0511 exped.; stn MO171; Maroc-0511-16767; LZM-UV • 1 spec., 4.76 mm dd; 26°32′37″–26°30′44″ N, 14°46′45″–14°49′31″ W; depth 1004–1031 m; 8 Dec. 2005; Maroc-0511 exped.; stn MO172; Maroc-0511-16711;

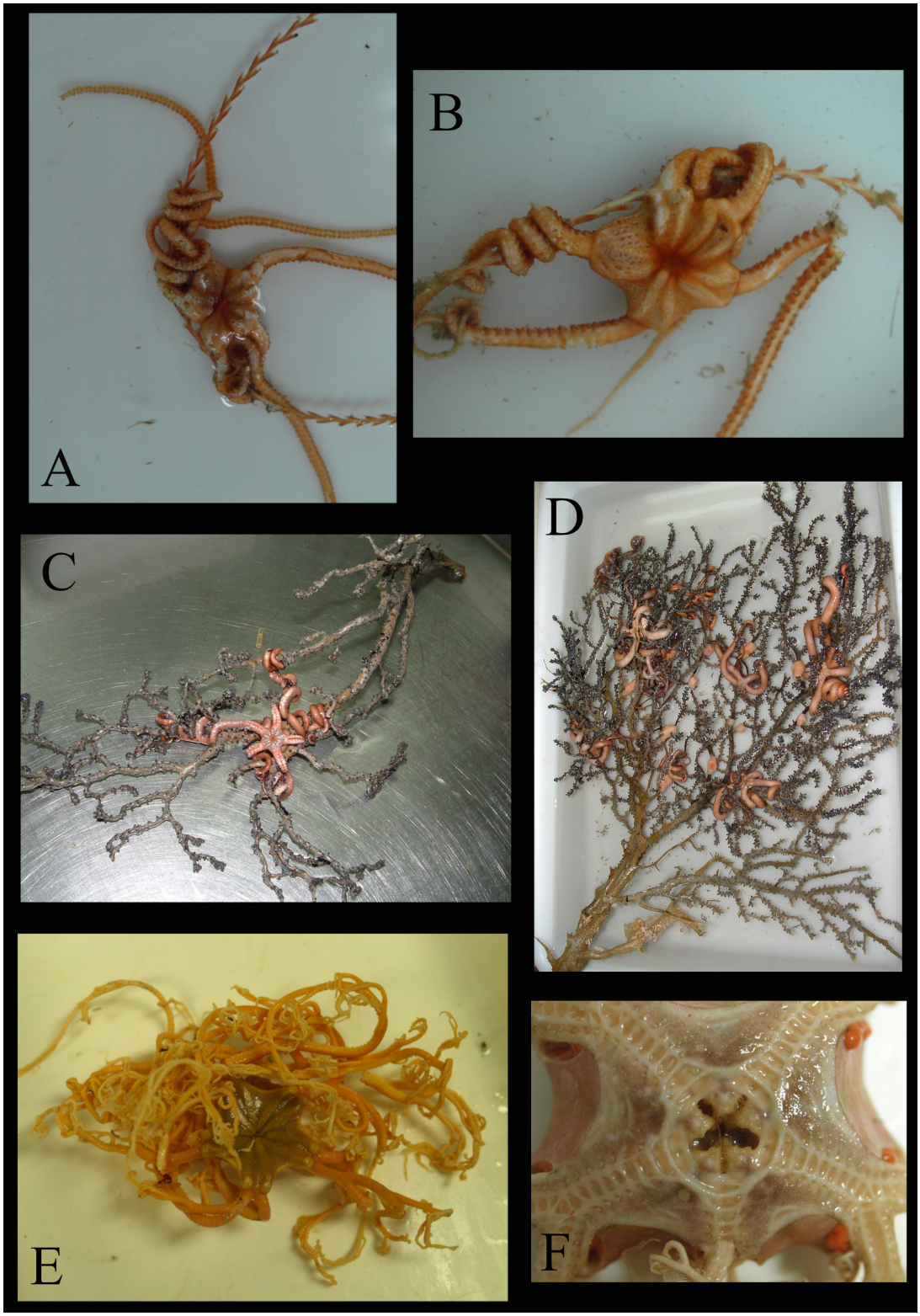

Fig. 3. A–B. *Asteronyx loveni* Müller & Troschel, 1842 collected from Mauritanian waters on *Distichoptilum gracile* Verrill, 1882. **C**. *Asterochema inornatum* Koehler, 1906 collected from Western Sahara waters on *Paramuricea* sp. Koelliker, 1865. **D**. *Ophiocreas oedipus* Lyman, 1879 collected from Western Sahara waters, on Acanthogorgiidae indet. **E–F**. *Astrodendrum juancarlosi* sp. nov. (LZM-UV Bissau-0810-06146), specimens collected from Guinea Bissau waters. Not to scale.

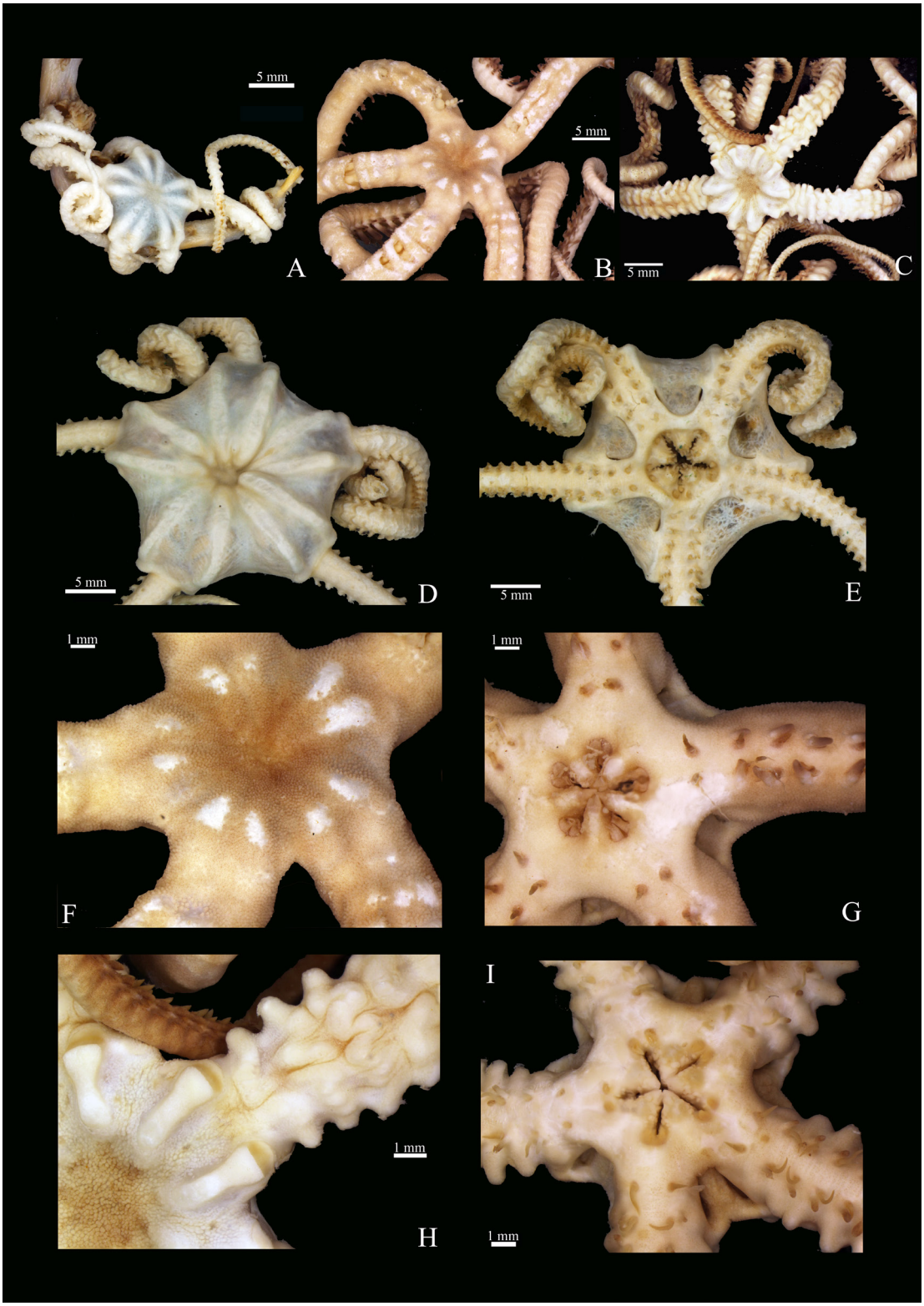

Fig. 4. A, D–E. *Asteronyx loveni* Müller & Troschel, 1842 (LZM-UV Maurit-1107-04528). **A**. One specimen collected over *Anthoptilum murrayi* Kölliker, 1880. **D**. Dorsal view. **E**. Ventral view. **B, F–G**. *Asterochema inornatum* Koehler, 1906 (LZM-UV Maroc-0511-16532). **B**. Dorsal view. **F**. Detail of dorsal disc. **G**. Ventral view. **C, H–I**. *Ophiocreas oedipus* Lyman, 1879 (LZM-UV Maroc-0611-07763). **C**. Dorsal view. **H**. Detail of dorsal disc. **I**. Ventral view.

LZM-UV • 1 spec., 7.75 mm dd; 26°12′42″–26°10′34″ N, 15°27′44″–15°25′15″ W; depth 1371–1250 m; 12 Dec. 2005; Maroc-0511 exped.; stn MO184; Maroc-0511-16703; LZM-UV • 1 spec., 14.23 mm dd; 23°15′08″–23°18′11″ N, 17°23′29″–17°24′17″ W; depth 1341–1338 m; 27 Nov. 2006; Maroc-0611 exped.; stn MO237; Maroc-0611-07763; LZM-UV.

Distribution

Asteroschema inornatum Koehler, 1906 is considered as an endemic species for the Northeast Atlantic (Paterson 1985). The species was recorded from the Reykjanes Ridge and Mid-Atlantic Ridge, south-

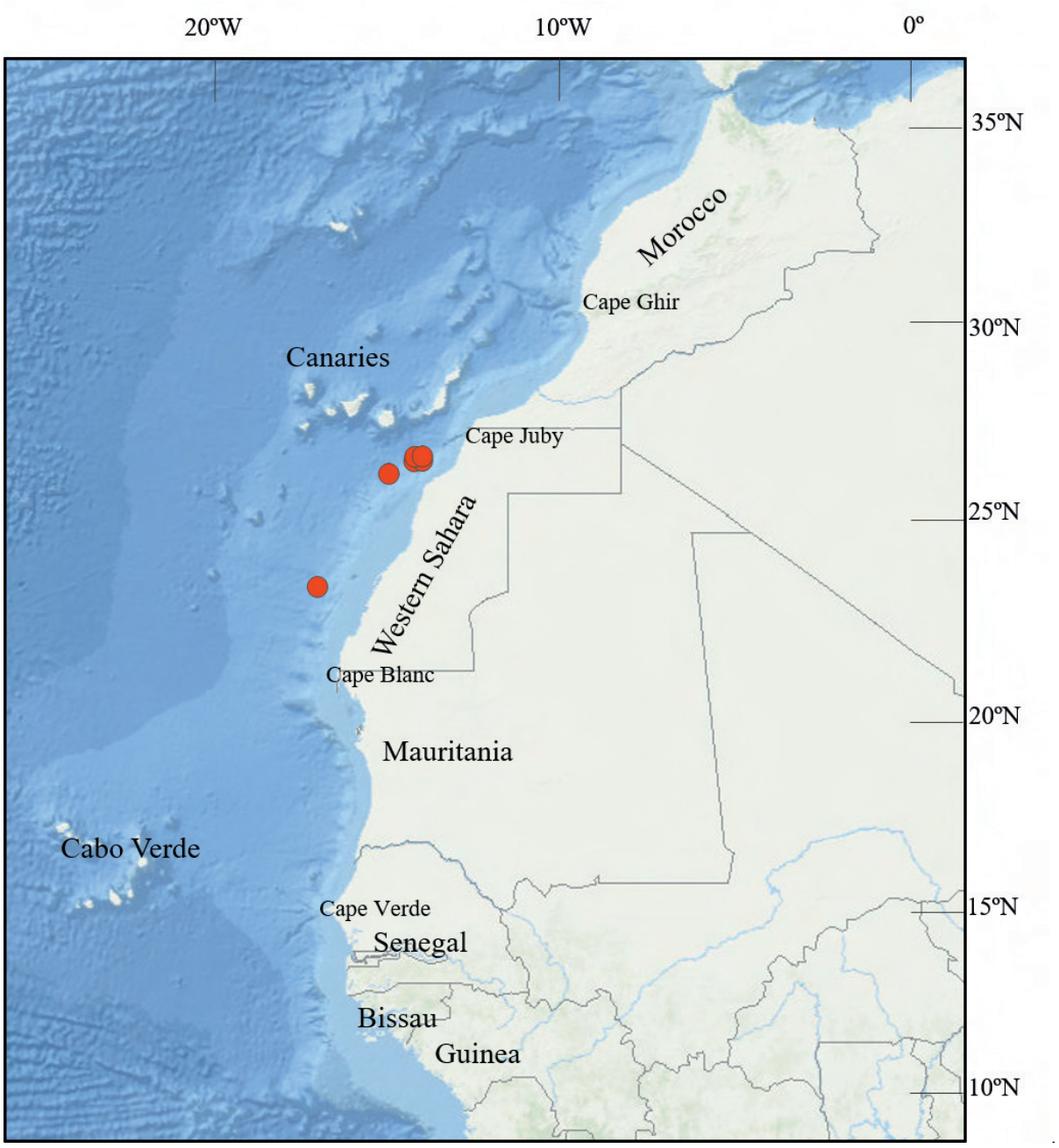

Fig. 5. Map from the study area with the location of the stations where specimens of *Asteroschema inornatum* Koehler, 1906 were collected during the ten surveys off Northwest Africa.

east of the Charlie-Gibbs Fracture Zone (Martynov & Litvinova 2008), from 36°32.26′ N to 33°27.40′ W (Stöhr & Segonzac 2006), Rockall Trough (Gage *et al.* 1983), Bay of Biscay (Paterson 1985), Northwest Spain (Paterson 1985), off Azores (Koehler 1909; Paterson 1985) and off Madeira (Berry 1938; Smirnov *et al.* 2014). Its bathymetric distribution extends from 1300 (Martynov & Litvinova 2008) to 4140 m (Madsen 1951).

We collected the species at six stations located off Western Sahara, between 1004 and 1593 m, normally associated with gorgonians.

Remarks

The records in waters of Western Sahara extend the geographical distribution of the species to the south and represent the first report of *A. inornatum* in African waters. Our record at 1004–1031 m depth (Stn MO172) also increase its bathymetric range to shallower waters. Living colour of the species is orange pink and grayish in the interadial areas of the disc.

Genus *Ophiocreas* Lyman, 1879

Ophiocreas oedipus Lyman, 1879
Figs 3D, 4C, H–I, 6

Ophiocreas oedipus – Lyman, 1879: 65, pl. XVI figs 443–446.

Ophiocreas oedipus – Lyman, 1882: 283, pl. XXXI figs 5–8, pl. XLVI fig. 1. — Koehler, 1909: 206, pl. VII fig. 2. — Clark, 1911: 283. — Paterson 1985: 18, fig. 10. — McKnight, 1993: 174.

Material examined

WESTERN SAHARA • 1 spec., 10.42 mm dd; 26°39′46″–26°41′48″ N, 14°45′20″–14°42′44″ W; depth 1593–1588 m; 8 Dec. 2005; Maroc-0511 exped.; stn MO171; Maroc-0511-16715; LZM-UV • 1 spec., 10.88 mm dd; 26°23′25″–26°26′32″ N, 15°17′44″–15°18′14″ W; depth 1615–1755 m; 11 Dec. 2005; Maroc-0511 exped.; stn MO181; Maroc-051107632; LZM-UV.

Distribution

Ophiocreas oedipus Lyman, 1879 has a wide geographical distribution in warm and temperate waters. It has been recorded in the Indo-Pacific area (New Zealand to Japan) (Koehler 1904; Clark 1911; Baker 1980; McKnight 1993), between 350 (material deposited in MNHN) and 1994 m (Koehler 1904). In the Atlantic Ocean, it was reported from Ascension Island between 756 and 778 m (Lyman 1882), Madeira from 1500 to 1968 m (Koehler 1909) and from several Northwest Atlantic seamounts (Mosher & Watling 2009; Cho & Shank 2010).

We collected this species at only four stations in Western Sahara, between 909 and 1755 m depth, representing the first record on West African continental margin.

Remarks

Ophiocreas oedipus and *Asteroschema inornatum* are very similar species. Nevertheless, they can be distinguished chiefly by several characters. In *A. inornatum*, both dorsal and ventral surfaces are more densely covered by granules, even in juveniles. However, the dorsal granulation on the disc seems to be a slightly variable character in *O. oedipus*, with different densities of coverage among specimens. Radial shields are quite parallel and aligned with the arms in *A. inornatum*, giving continuity between the disc and arms; however, in *O. oedipus*, the radial shields are divergent – closer in the proximal part – and with a marked ridge, forming a border between the disc and arms. Finally, in *O. oedipus*, the tooth line (not

the ventral-most teeth) is truncated, while that of *A. inornatum* is more pointed. Besides, we found other slight differences between the species: genital slits are smaller and triangular-shaped in *A. inornatum* and longer and parallel in *O. oedipus*. In both species, oral papillae are granule-shaped, but these papillae are bigger in *A. inornatum*. Moreover, in *O. oedipus*, the arms have well-marked ridges, mostly proximally, and the proximal segments are widened dorsally, creating a median groove along the arm. However, *A. inornatum* does not have a well-marked ridge, but some specimens show the medial groove along the arm. According to Paterson (1985), these grooves can be related to gonadal development. Living colour of the species is orange-pink with purple hues on the dorsal part, dark underparts, almost black. This species was found, sometimes in large numbers, living on Acanthogorgiidae gorgonians.

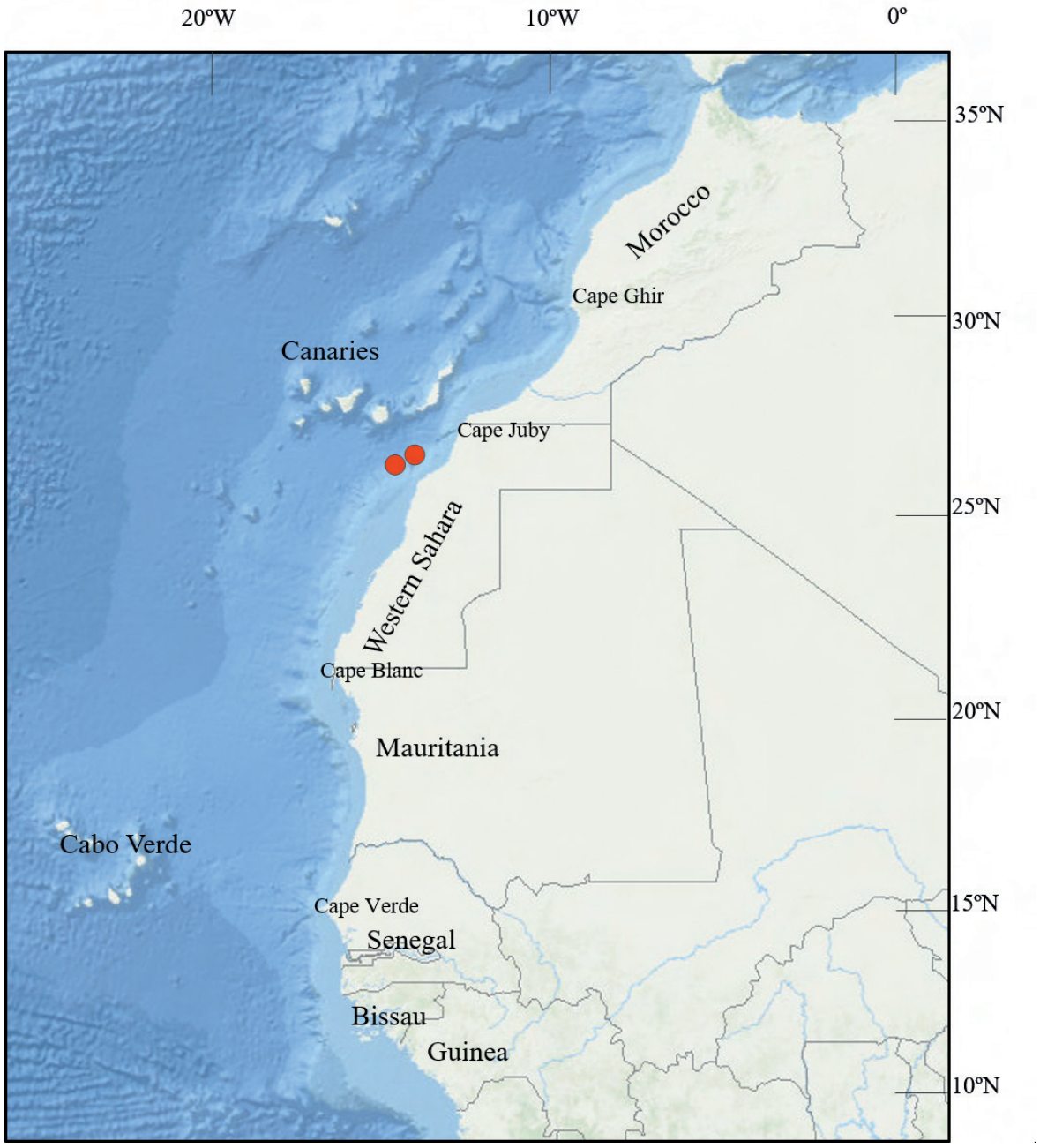

Fig. 6. Map from the study area with the location of the stations where specimens of *Ophiocreas oedipus* Lyman, 1879 were collected during the ten surveys off Northwest Africa.

Family Gorgonocephalidae Ljungmanm, 1867
Genus *Astrodendrum* Döderlein, 1911

Astrodendrum juancarlosi sp. nov.
urn:lsid:zoobank.org:act:ECD0622E-6FAF-4C72-B102-F1B94D8ECBFB
Figs 3E–F, 7–9

Diagnosis

Species with small granule-like external ossicles, ending in a crystalline point, covering the dorsal and lateral interradial areas of the disc. Ventral disc areas and arms covered by domed granule-like external ossicles without any crystalline point. Two or three terminal projections on each arm spine; one secondary teeth on each valve.

Etymology

The specific epithet '*juancarlosi*' was chosen as a tribute to Mr Juan Carlos Calero, father of the first author.

Material examined

Holotype

GUINEA BISSAU • 2 specs, 40.43–56.81 mm dd; 10°18′55″ N, 16°25′07″ W; depth 79 m; 4 Nov. 2008; Bissau-0810 exped.; stn BS200; Bissau-0810-06403; MNCN 29.02/1534.

Paratypes

GUINEA BISSAU • 2 specs, 28.20–51.16 mm dd; 11°08′07″–11°09′33″ N, 17°15′20″–17°15′44″ W; depth 109 m; 29 Oct. 2011; CCLME-1110 exped.; CCLME-1110 exped.; stn BT53; MHN USC-10132-1 and 2 • 1 spec., 40.43 mm dd; 10°18′55″ N, 16°25′07″ W; depth 79 m; 4 Nov. 2008; Bissau-0810 exped.; Bissau-0810 exped.; stn BS200; MNCN 29.02/1535.

WESTERN SAHARA • 1 spec., 44.62 mm dd; 26°26′23″–26°25′06″ N, 14°25′30″–14°26′23″ W; depth 67–58 m; 29 Nov. 2011; CCLME-1110 exped.; CCLME-1110 exped.; stn BT215; CFM-IEOMA-7776. • 1 spec., 46.70 mm dd; 14°57′00″–14°58′09″ N, 17°39′08″–17°38′13″ W; depth 797 m; 25 May 2012; CCLME-1205 exped.; CCLME-1205 exped.; stn BT368; CCLME-1205-03248; LZM-UV.

Additional material

GUINEA BISSAU • 1 spec., 10.07 mm dd; 11°05′09″–17°03′15″ N, 11°04′15″–17°03′10″ W; depth 46–47 m; 26 Oct. 2008; Bissau-0810 exped.; stn BS151; Bissau-0810-06146; LZM-UV.

Description (holotype)

Disc. Five-lobed in shape, slightly excavated inter-radially (Fig. 8A), with no peripheral calcareous plates on rim. Radial shields tumid, long (almost raising the centre of disc) and narrow, which is deeply sunken (Fig. 8C). Radial shields completely concealed by external ossicles, bar-shaped, as wide proximally as distally, but more separated distally, converging towards centre of disc. Distally, radial shields end on enlarged, slightly concave and oval-shaped plate covered by minute granules (Fig. 8C–D). Dorsal disc covered by small granule-like external ossicles (Fig. 8A, C–D), each one ending in terminal crystalline point. At edge of disc, ossicles more densely packed and without crystalline point (Fig. 8C), and bigger in size between radial shields (Fig. 8C–D). Ossicles concealing radial shields similar to those from dorsal disc but more densely packed.Ventral inter-radial areas densely covered by mosaic of small irregular flat plates with granule-like external ossicles without terminal point. Oral shield, adoral shield, oral plates, along edge of mouth frame and ventral arm plates more densely covered by similar external ossicles. Mouth frame sunken (Fig. 8E). Interradial surface of lateral disc covered by external ossicles similar

but smaller than those covering dorsal disc. Two large genital slits on each interradius running almost vertically along first five or six brachial segments after first fork (Fig. 8F). Conical external ossicles with terminal crystalline point more developed on adradial edge of genital slits. One oval-shaped and well-developed madreporite located just outside mouth frame (Fig. 8E). Both, tooth and oral papillae spiniform, especially larger apical ones. Mouth and infradental papillae form continuous series along mouth frame (Fig. 8E). Teeth varying in position and size, being irregular in outline and more or less irregularly disposed.

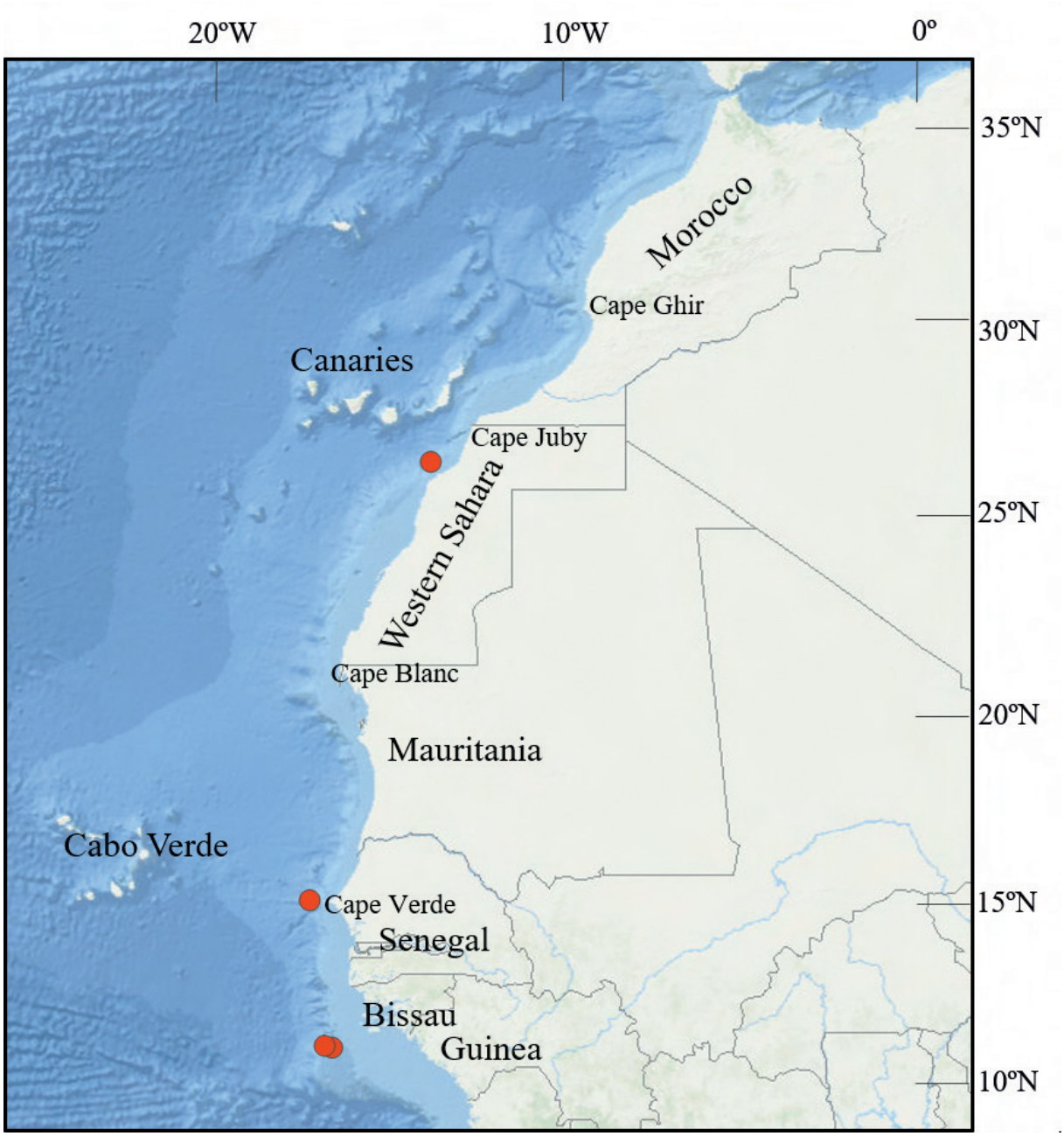

Fig. 7. Map from the study area with the location of the stations where *Astrodendrum juancarlosi* sp. nov. were collected during the ten surveys off Northwest Africa.

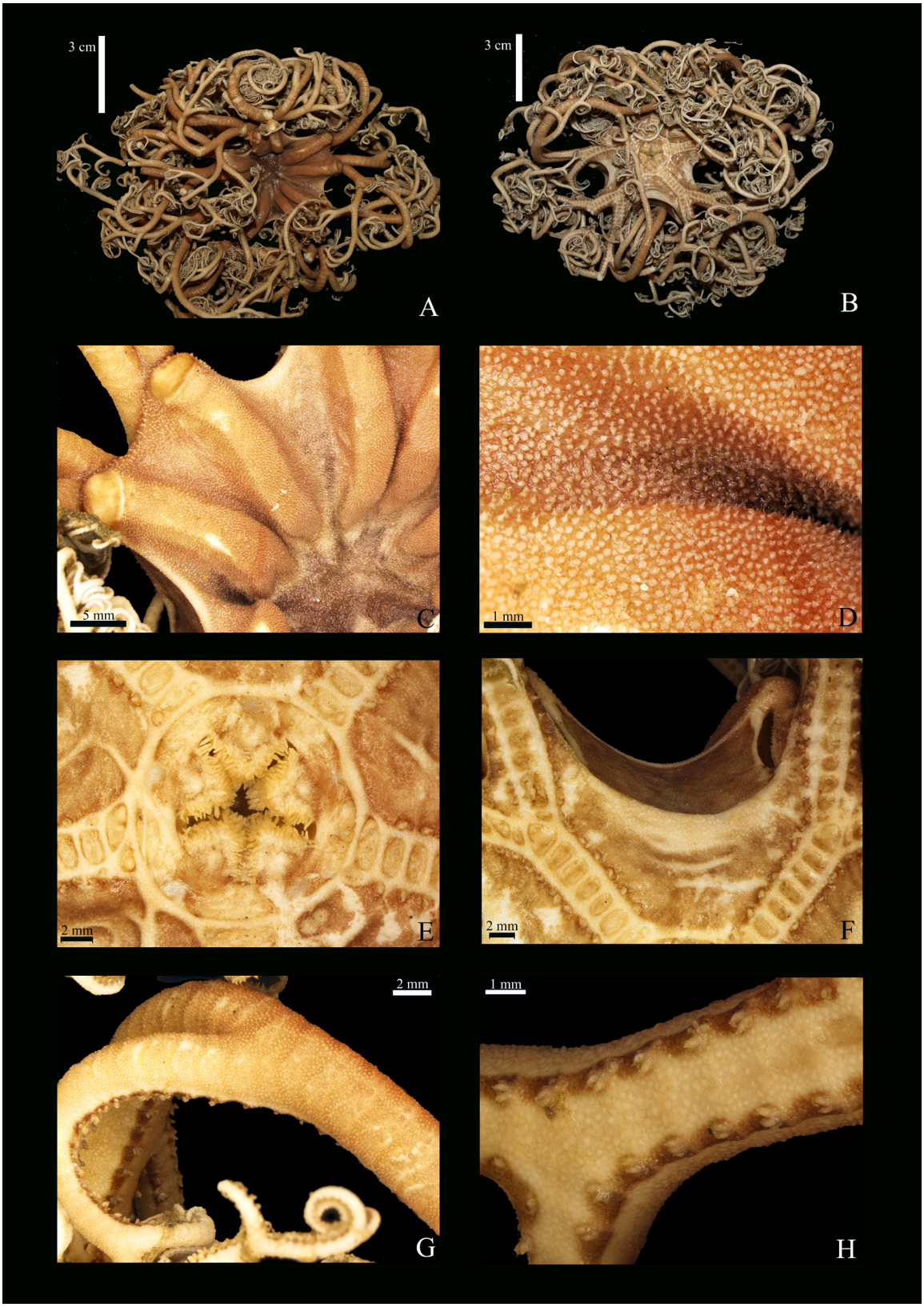

Fig. 8. *Astrodendrum juancarlosi* sp. nov. (MNCN 29.02/1534). A. Dorsal view. **B**. Ventral view. **C**. Detail of dorsal view. **D**. Detail of disc granules. **E**. Detail of ventral view. **F**. Interradial surface of lateral disc and genital slits. **G**. Arm. **H**. Arm, ventral view.

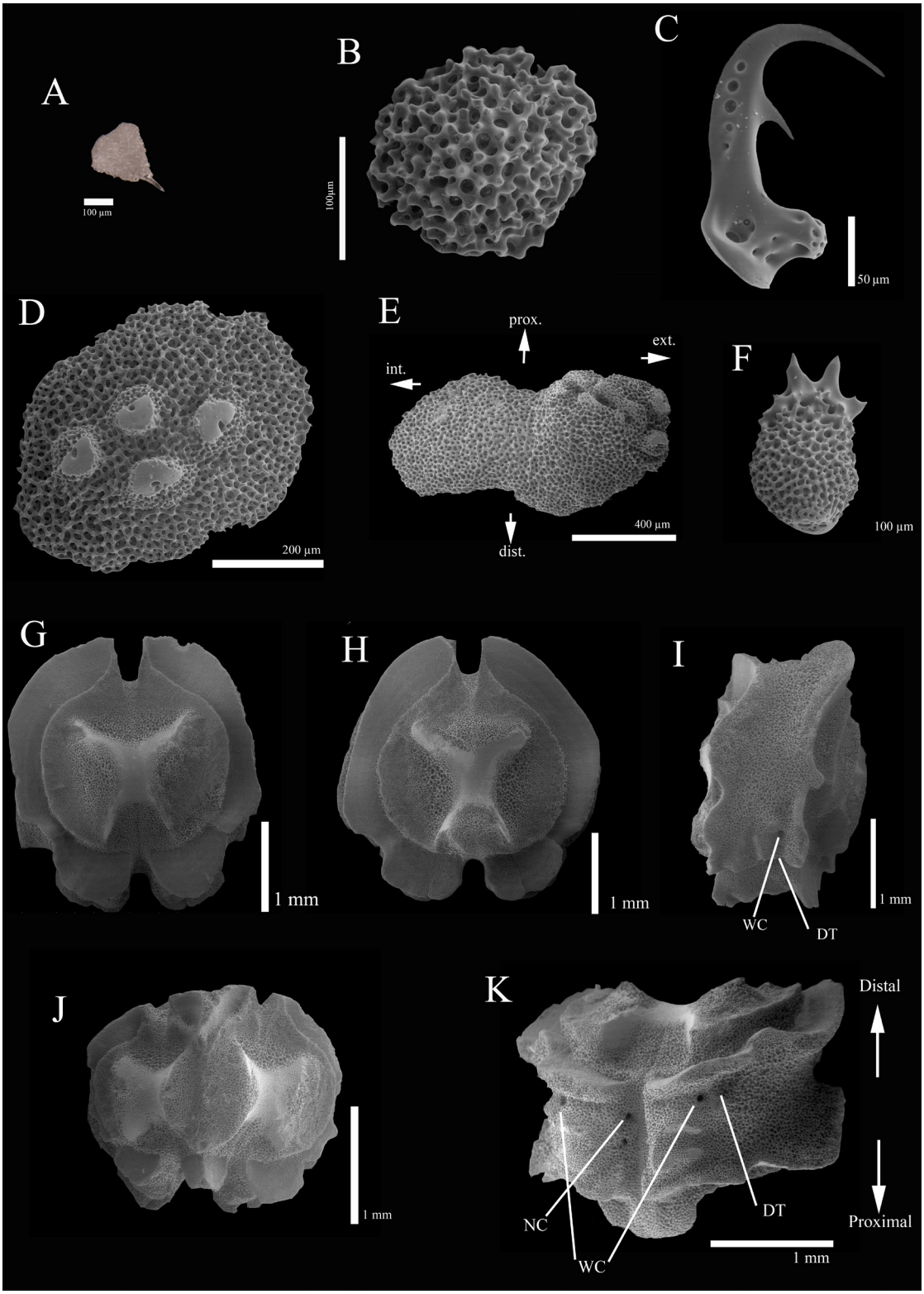

Fig. 9. SEM photographs of internal skeletal characters of specimens of *Astrodendrum juancarlosi* sp. nov. (MNCN 29.02/1534). A. Granule-shaped ossicles from disc. **B**. Ossicle from baseplates. **C**. Valve. **D**. Baseplate. **E**. Lateral arm plate. **F**. Arm spines. **G**. Distal view of vertebrae. **H**. Proximal view of vertebrae. **I**. Ventral view of vertebrae. **J**. Lateral view of vertebrae. **K**. Dorsal view of vertebrae. Abberviations: DT = depression for tentacle; NC = nerve canal; WC = water canal.

Arms. Arms branching, with first fork before disc margin and second one located at margin. Nevertheless, in smaller specimens (juvenile), first fork located on margin of disc. Arms tapering gradually towards tips, completely covered, both, dorsally and ventrally, by domed granule-like external ossicles (Fig. 9A); these granules somewhat bigger than disc ones and without any crystalline point. Dorsal side of arms carry pedicellarial bands along whole arms. Valves with one secondary tooth downwardly curved (Fig. 9C). Some sunken transverse furrow between segments, giving arms an annulated appearance. Indication observed of median furrow along arm (Fig. 8G). Ventral side of arms with noticeable transverse naked furrows between segments until second fork; afterwards, furrows become smaller, disappearing after third fork. First two pores without arm spine. Arm spines beginning at third pair of pores with only one small spine at third and fourth pair of pores, two arm spines (sometimes one) afterwards and three arm spines (sometimes two) after second fork. Arm spines short and wide, ending in two or three hyaline points (Fig. 9F). Vertebrae streptospondylous (Fig. 9G–K).

Colour. Living specimens showing varying colours, from creamish-pink to dark orange and brown to gray (Fig. 3E–F) with clear ventral part; preserved specimens are white.

Ossicle morphology. External ossicles on dorsal surface of disc, including radial shields, are granule-shaped and ending in a crystalline point (Fig. 9A). Baseplates oval-shaped with three to five tubercle-shaped articulations for pedicellarial (Fig. 9D). External ossicles on baseplates granule-like shaped, approximately 200 μm in length and 100 μm in height (Fig. 9B). Valves with single inner tooth downwardly directed, and reticular structure (Fig. 9C). Lateral arm plates long, bar-like, with tuberculous stereom, spines placed in external lobe of plate (Fig. 9E). Arm spines ovoid-shaped with two or three small projections, not transforming into hook-shaped spines on distal portion (Fig. 9F). Vertebrae with hourglass-shaped streptospondylous articulations (Fig. 9G–K). Branching vertebra wider and with two surfaces for articulation.

Distribution

This species has been recorded in the Northwest African coast, from the Western Sahara to Guinea-Bissau waters. Its bathymetric distribution ranges between 47 and 797 m.

Remarks

The genus *Astrodendrum* was established by Döderlein (1911) for *Gornocephalus sagaminus* Döderlein, 1902. He realised that all species that belong to *Gorgonocephalus* Leach 1815 are characterised by the presence of a well-developed belt of calcareous plates at the margins of the disc. However, species of *Astrodendrum* have no ring of calcareous plates at the rim. Additionally, the arm spines appear before the first fork, as in *Gorgonocephalus*; however, in *Astrodendrum* Döderlein, 1911, these arm spines are much smaller, hardly reaching ⅓ of the segment length, and their number is reduced: with three (or rarely four) on each side. Taxonomic studies dealing with this genus are scarce, and we have only found a revision of the genus recently published by Okanishi & Fujita (2018). According to these authors, the genus is characterised by having five branching arms, with less than six segments before the first fork; lack of calcareous plates on the edge of the disc margin; variously shaped external ossicles or no ossicles on the disc; a madreporite placed on the innermost part of the interradial lateral disc; and valves from the dorsal arms with one secondary tooth.

Currently, only six species have been assigned to this genus. Among them, only *Astrodendrum capense* (Mortensen, 1933), described from Durban, South Africa (Mortensen 1933; Clark & Courtman-Stock 1976), has been found in the Atlantic Ocean – Namibia (Alva & Vadon 1989). *Astrodendrum elingamita* Baker, 1974 has been reported in New Zealand and Philippines (Baker 1974; Okanishi & Fujita 2018); *Astrodendrum galapagense* A.H. Clark, 1916 from Galapagos Islands; *Astrodendrum laevigatum* (Koehler, 1897) from Colombo (Sri Lanka); and *Astrodendrum sagaminum* (Döderlein, 1902) from

Japan, East China Sea and Sri Lanka (Döderlein 1902, 1911; Clark 1911; Bomford 1913; Matsumoto 1917; Irimura & Kubodera 1998); and the recently described *Astrodendrum spinulosum* Okanashi & Fujita, 2018 also from Japan.

In addition to the shape, size and arrangement of external ossicles – widely used as an important specific taxonomic character (Baker 1974, 1980; McKnight 2000) – Okanishi and Fujita (2018) included the possibility of the lack of external ossicles (as in the case of *A. laevigatum*), and they also proposed three new taxonomic characters to distinguish species of *Astrodendrum*:

- absence / presence of bulges on lateral ridges of proximal portion of arm
- number of terminal projections of arm spines on proximal portion of arm
- number of secondary teeth of hook-shaped arm spines on distal portion of the arm

The main morphological features of all known species of *Astrodendrum*, including *A. juancarlosi* sp. nov., are summarized in Table 2.

Astrodendrum spinulosum differs from the rest of species by the presence of bulges on lateral ridges of proximal portion of the arm.

The new species here described, also differs from *A. spinulosum* by the number of terminal projections of arm spines on the proximal portion of the arm (three in the case of the new species and one in *A. spinulosum*). In addition, *A. spinulosun* has cone-shaped external ossicles, while *A. juancarlosi* sp. nov. has granule like ossicles ending in a crystalline point at the dorsal surface of the disc.

Astrodendrum juancarlosi sp. nov. is more similar to *A. elingamita* in the shape of the ventral coverage and the lack of a scale in the first tentacle pore. Nevertheless, *A. elingamita* has the first fork in the margin of the disc, while it is located before the margin in our species. The polygonal plates of the ventral covering are closer in the *A. elingamita* than in our specimen. Our specimens also differ from *A. elingamita* by having one type of dome-shaped granules with 1–2 hyaline terminal points rather than two smooth types. *Astrodendrum sagaminum* differs from *Astrodendrum juancarlosi* sp. nov. in also having two types of granules and naked arms and ventral disk.

Astrodendrum capense has several medium-sized conical tubercles along the radial shields; it also has some smaller conical tubercles along the inter-radial disc margin, both ending in small thorns. Moreover, the disc is closely covered with minute and smooth plates.

Astrodendrum galapagense has a dorsal coarse armament on the disc and arms. The external ossicles on the aboral disc are plate-shaped at periphery and conical at center, both slightly in contact, while on the oral surface has a few small widely scattered granules, except in the ventral interbrachial areas.

Astrodendrum laevigatum is covered by a thin, transparent, soft and perfectly smooth tegument without any granules or spines. According to the description of this species in the literature, there are some doubts about the inclusion of this species in the genus *Astrodendrum*. We consider necessary to review the type material before we can reach a conclusion on this issue. Therefore, in this paper we follow Okanishi & Fujita (2018) and keep the species within the genus *Astrodendrum*.

Finally, our specimen has marked rectangular furrows that are absent in the rest of the species of *Astrodendrum*. Even though Mortensen (1933) described the underside of the arms of *A. capense* as flat and without any grooves, he pointed out that this "may be an indication of a transverse furrow between the segments from the first forking onwards" (Mortensen 1933: 286).

Table 2 (continued on next page). Key features for species of *Astrodendrum* Döderlein, 1911 mainly based on the original descriptions; references included in the Table indicated different sources. "–" means no data.

	A. capense (Mortensen, 1933)	*A. elingamita* Baker, 1974	*A. galapagense* A.H. Clark, 1916	*A. laevigatum* (Koehler, 1897)	*A. sagaminum* (Döderlein, 1902)	*A. spinulosum* Okanashi & Fujita, 2018	*A. juancarlosi* sp. nov.
disc armament	closely covered with small granular external ossicles, fully in contact	closely packed with dome-shaped granules of two distinct sizes	mostly naked integument, but with widely scattered coarse granules	no ornamentation	widely covered with small granules	covered by conical external ossicles, but separated and scattered at periphery of the disc	covered by small granule-like external ossicles ending in a crystalline point.
radial shields	covered with large conical external ossicles, separated and scattered, ending in a number of small thorns	distinct, narrow at proximal end, widening distally	bar-like, covered by skin and external ossicles, almost reaching the centre of disc (Okanishi & Fujita 2018)	smooth, large and narrow	well-differentiated	bar like, completely concealed by external ossicles, not reaching disc centre	bar-shaped and densely covered by granule-like ossicles ending in a crystalline point.
VIA	closely covered by small flat polygonal plate-shaped ossicles together with some scattered large conical ossicles ending in a number of small thorns, on lateral marginal edge of the disc	covered with granule-like ossicles of two distinct sizes	covered by sub-equal granule-like ossicles.	covered by a thin and smooth tegument	oral disc surface covered by flat, polygonal external ossicles, fully in contact on oral plate; slightly tumid, round and slightly in contact on adoral plates (Okanishi & Fujita 2018)	the oral surface of disc covered by polygonal plate-shaped external ossicles, fully in contact; interradial surface of lateral disc covered by conical external ossicles and skin	densely covered by small granule-like external ossicles
mouth frame	covered by irregularly polygonal flat plates	closely covered with slightly domed polygonal granule-like plates; adoral plates without this covering	only a few small and widely scattered granules	–	oral shields, adoral shields, oral plates and ventral arm plates completely concealed by external ossicles (Okanishi & Fujita 2018)	oral shields, adoral shields, oral plates and ventral arm plates completely concealed by external ossicles	covered by small granules
jaw	small plates granule-like	–	only a few small and widely scattered granules	–	–	–	sunken; jaw covered with small granules

Table 2 (continued).

	A. capense (Mortensen, 1933)	*A. elingamita* Baker, 1974	*A. galapagense* A.H. Clark, 1916	*A. laevigatum* (Koehler, 1897)	*A. sagaminum* (Döderlein, 1902)	*A. spinulosum* Okanashi & Fujita, 2018	*A. juancarlosi* sp. nov.
arms	dorsally smooth, with small tubercle-like plates; Conspicuous medicn furrow, sunken transverse furrows between the segments; ventrally, irregular polygonal, flat plates	prominent belts dorsally, more noticeable distally; fully covered with polygonal or rounded, slightly domed granules	only a few small and widely scattered granules	broad at the base, with a longitudinal dorsal furrow; ventrally, quite smooth	small vaulted plates with a fine-hunched surface dorsally; ventrally, with flat, polygonal plates of unequal size	tapering gradually toward arm tip; on aboral and lateral surface, each arm segment covered by single annular row of large oblong plates	dorsally and ventrally covered by granules; noticeable transverse furrows between the segments ventrally
arm spines	spiniform, beginning at the 2nd pore with 2 scales, 3 scales from the first fork and 2 again distally; spines simple, pointed proximally, further out ending in 2–3 hyaline thorns and distally hook-shaped	spiniform, beginning at 2nd pore, with 1–2 terminal, glassy teeth; 2–3 scales by pore proximally; 1–2 hook-shaped spines distally	scales start at fourth pair of pores, 2 in proximal and 3 in the middle-distal part of arm proximal scales ovoid, up to 2 terminal projections and hook-shaped with a single secondary tooth distally	first 3–4 pairs of pores without papillae scales, 5th – 6th pairs with 1, 7th pair with 2 and after the 2nd fork with 3; spiniform scales elongated and cylindrical, with blunt end	beginning at the 2nd pore with 2–3 spines proximally and further apart usually 2; spiniform scales short and weak, only about ⅓ to ¼ as long as an arm segment	first to sixth tentacle pore with single arm spine; eighth and subsequent pore with 2 or 3 spines; arm spines approximately one-third to one-fourth of length of corresponding arm segment, and covered by thin integument	beginning at the 3rd pore, with 1 small spine proximally, then 2 and further out 3 arm spines; scales short and wide, ending in 2 or 3 hyaline points
madreporite	almost inconspicuous, at the edge of the mouth frame, encroaching a little upon the inter-radius	one small madreporite	invisible in external view; completely covered by skin and external ossicles (Okanishi & Fujita 2018)	indistinguishable	at the adoral angle of a soft interbrachial space; fragmented into several parts	one large, elliptical madreporite situated on oral interradius	one well-developed oval-shaped madreporite located just outside the mouth frame

See Table 2 for comparison of main morphological characteristics among species.

Genus Gorgonocephalus Leach, 1815

Gorgocephalus pustulatum (H.L. Clark, 1916)
Figs 10–11

Astrodendrum pustulatum Clark, 1916: 84–85, pl. XXXIV figs 1–2.
Gorgonocephalus pustulatum Baker, 1980: 54–56, figs 18B, 20, 30.
Gorgonocephalus pectinatus Mortensen, 1933: 281–285, figs. 16–17, pl. XVIII figs. 1–2.

Gorgonocephalus pustulatum – Rowe & Gates 1995: 368. — Calero et al. 2018: 3, 8.
Gorgonocephalus pectinatus – Clark & Courtman-Stock 1976: 133.

Material examined

GUINEA BISSAU • 1 spec., 30.45 mm dd; 10°01′18″–10°00′24″ N, 17°24′56″–17°25′05″ W; depth 902–908 m; 24 Oct. 2008; Bissau-0810 exped.; stn BS166; Bissau-0810-18012; LZM-UV.

Distribution

This species has an Indo-Pacific distribution. It has been recorded in South Africa from Cape Province to East London (Mortensen 1933), the Indonesian region (Döderlein 1927) and Flinders Islands (Bass Strait, Australia) (Clark 1916); its bathymetric range extends from 182 (Clark 1916) to 860 m (Clark & Courtman-Stock 1976).

Our material was recorded in one station in Guinea-Bissau waters, between 902 and 908 m. This material is the same as that reported by Calero *et al.* (2018).

Description

The dorsal side of disc covered by a skin with some scattered tubercles, ending in some small thorns. The same type of tubercles were found on the marginal belt of plates.

Radial shields long and bar-shaped, nearly reaching the centre of the disc (Fig. 11A). They are almost completely covered by tubercles similar to those from the interradial areas but slightly bigger (Fig. 11C). The ventral interradial areas are almost fully covered by small granules.

Plates of the oral frame swollen and obscured by a thick skin. Oral shields with some scattered small granules. There is a cluster of slender apical papillae flanked on each side by smaller oral papillae.

Arms also covered by a skin concealing the plates. First pair of tentacle pores outside the mouth edge, without arm spines. Two arm spines from the second to fifth or sixth pores; afterwards, from the first fork on, three spines. Arm spines are small, less than one arm segment, and with some thorny ends.

First fork within the edge of the disc. Dorsally, arms covered by flat granules, and with a longitudinal median furrow (Fig. 11F). Pedicellarial bands along the arms, appearing from the first segments.

Remarks

Even though the single specimen collected was badly damaged, the presence of the main distinctive features of *Gorgonocephalus pustulatum* (H.L. Clark, 1916), like the number of spines (max. 4), disc coverage (sparse and low tubercles) or the thin peripheral ring, legitimate our identification to species level.

Our finding in Guinea-Bissau represents the first record of *G. pustulatum* in the Tropical East Atlantic Ocean, extending its geographical distribution to the north, from south Africa to Guinea-Bissau. This station also represents the deepest record for this species (908 m).

Discussion

Twelve species belonging to the order Euryalida have been identified along the East Atlantic. The Euryalida fauna from this region is mainly composed by Atlantic species (9 species), with a minor component of widely distributed species (Fig. 12). The latter group includes *Asteronyx loveni* with

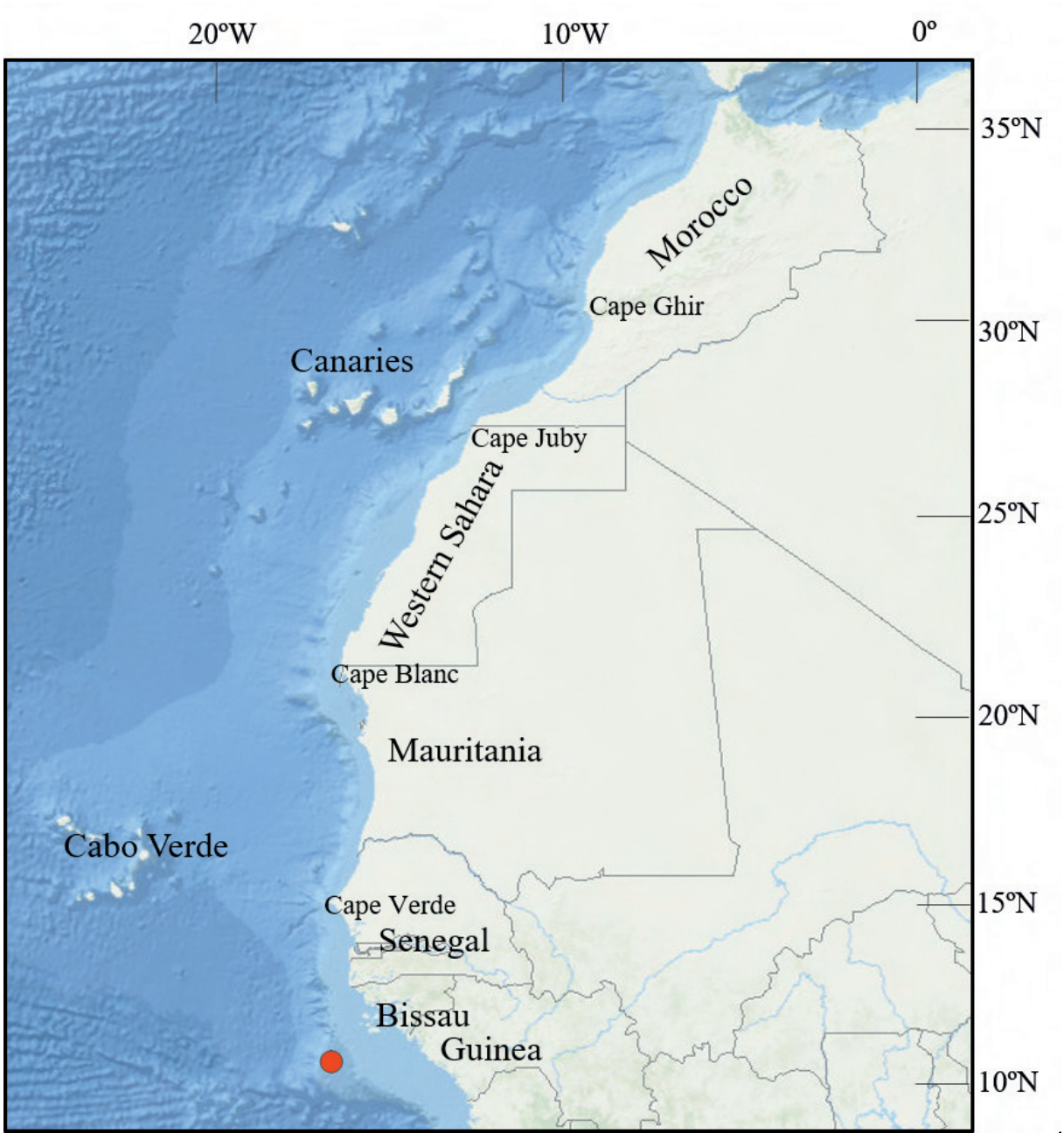

Fig. 10. Map from the study area with the location of the stations where specimen of *Gorgonocephalus pustulatum* (H.L. Clark, 1916) was collected during the ten surveys off Northwest Africa.

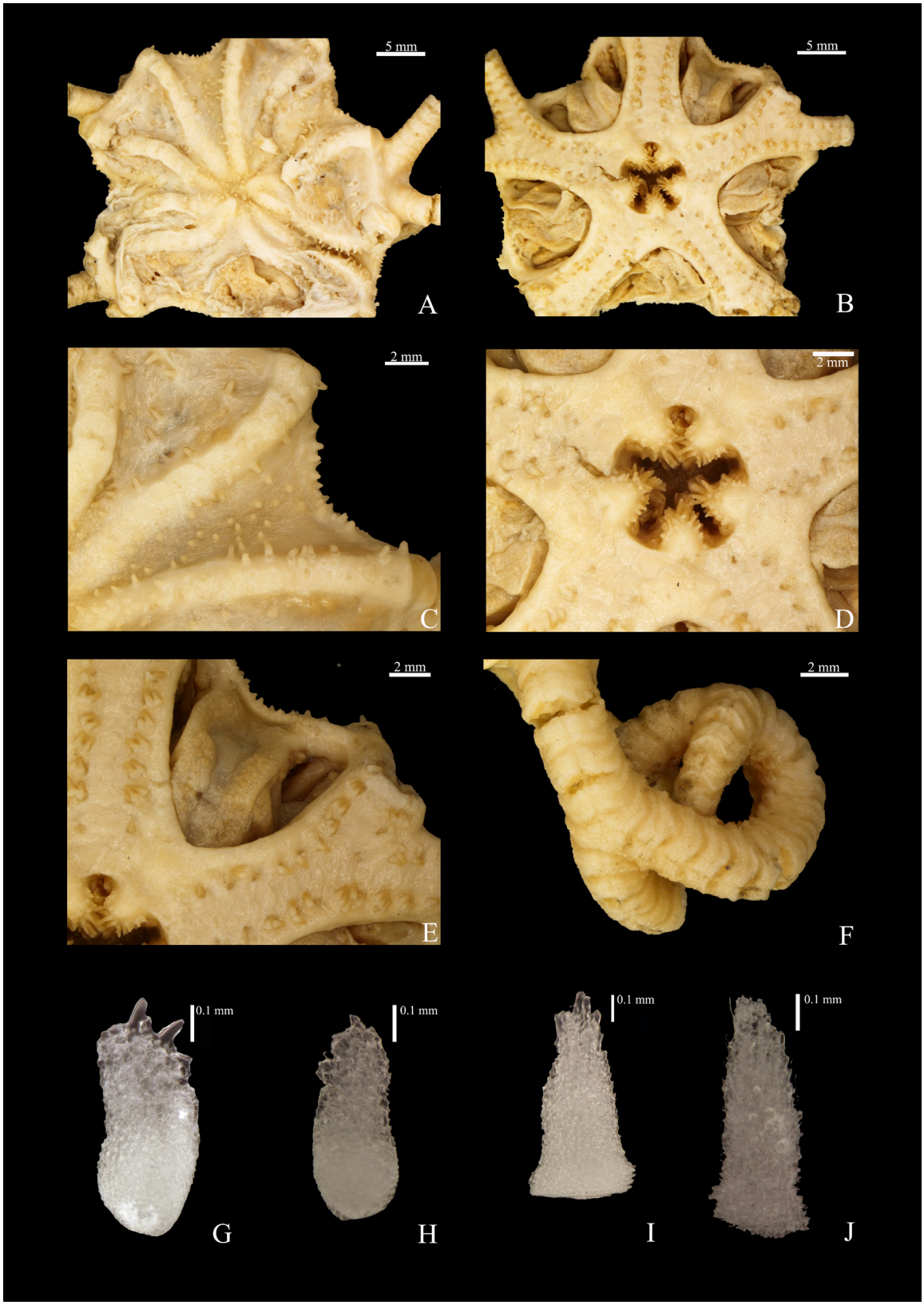

Fig. 11. *Gorgonocephalus pustulatum* (H.L. Clark, 1916) (LZM-UV Bissau-0810-18012). **A**. Dorsal view. **B**. Ventral view. **C**. Detail of dorsal view. **D**. Detail of ventral view. **E**. Detail of ventral disc and arm base. **F**. Arm tip. **G–H**. Arm spine. **I–J**. Spine of disc.

a circum-global distribution, *Ophiocreas oedipus* widely distributed in the West Pacific and Atlantic Oceans, and *Gorgonocephalus pustulatum* with an Indo-Pacific distribution but also reported along the Atlantic coast of South Africa.

Further five species are Amphi-Atlantic (*Astrodia tenuispina* (Verrill 1884), *Astrochele lymani* Verrill, 1878, *Gorgonocephalus arcticus* Leach, 1819, *Gorgonocephalus eucnemis* Müller & Troschel, 1842 and *Gorgonocephalus lamarckii* (Müller & Troschel, 1842)) and the remaining four are exclusively Eastern Atlantic species.

Among these Atlantic species, seven species (the five Amphi-Atlantic species, *Asteroschema inornatum* and *Gorgonocephalus caputmedusae* (Linnaeus 1758)) are distributed throughout the Boreal and/or Lusitanian Provinces.

Astrospartus mediterraneus (Risso, 1826) is a common species in the Mediterranean Sea, and has also been reported in the Atlantic from Portugal and Morocco (Tortonese 1985). However, despite the great sampling effort deployed during our surveys in Northwest Africa, we have not found this species in the region.

In the Southeast Atlantic, *Astrodendrum capense* (Mortensen, 1933) is distributed throughout the Benguela Province. In addition, *Astrocladus euryale* (Retzius, 1783) and *Astrocladus africanus* Mortensen, 1933 are reported from South Africa, and *Astrothorax waitei* Benham, 1909, an Indo-Pacific species, also reaches the Atlantic side of South Africa (Mortensen 1933).

Euryalida fauna from NW Africa seems to have a higher affinity to warm-temperate regions, while most of species know from the Eastern Atlantic have a cool-temperate affinity.

During this study, only five species of Euryalida have been collected. Among them, three species have a wide distribution, where *Asteronyx loveni* seems to be circum-global, and *Gorgonocephalus pustulatum* and *Ophiocreas oedipus* have been reported from scattered localities in warm-temperate waters from

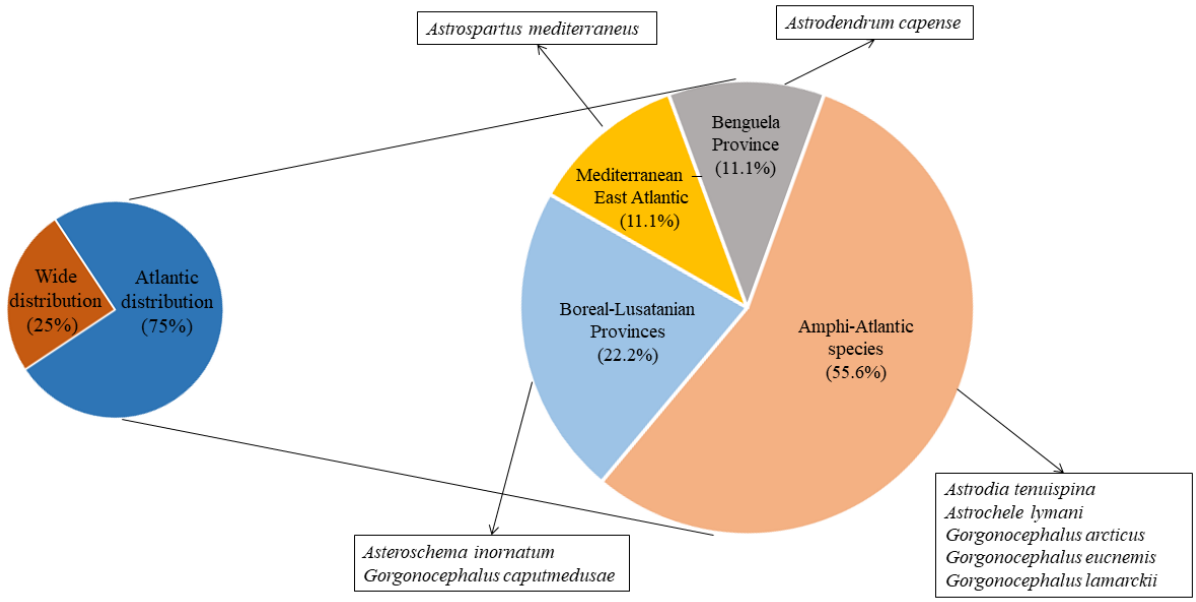

Fig. 12. Distribution of the main biogeographic components of species of Euryalida Lamarck, 1816 identified along the East Atlantic.

the Atlantic and Indo-Pacific oceans. Only *Asteroschema inornatum* shows a clear affinity to the boreal-temperate fauna of the East Atlantic, with records from the Reykjanes Ridge to the Western Sahara. Finally, the new species *Astrodendrum juancarlosi* sp. nov. has only been found from the Western Sahara to Guinea Bissau.

Our results leave the question about the boundary between the Tropical East Atlantic and the Lusitania Provinces unresolved. Traditionally, this boundary has been established at Cape Vert (Senegal) by Briggs (1974, 1995) but at Cape Juby (north of Western Sahara) by Briggs & Bowen (2012), in their proposal of realignment of marine biogeographic provinces mainly based on fish distributions. Our study area, which falls within the CCLME region, is characterised by a mix of tropical and warm temperate waters (Pelegrí *et al.* 2017), where the turnover between warm temperate and tropical biotas occurs somewhere along the Mauritanian-Senegalese margin (van Soest 1993). This question can be illustrated by *Asteroschema inornatum*, with a Boreal-Lusitanian distribution, whose southern limit of distribution is located in the Western Sahara (present paper), but also by *Ophiocreas oedipus*, whose Atlantic distribution stretches from Ascension Island (Lyman 1882) to Madeira (Koehler 1909).

Calero (2017) and Calero *et al.* (2017) showed that in NW Africa other groups of Ophiuroidea seem to have a higher affinity with Atlantic-Mediterranean fauna (Boreal-Lusitanian Provinces), and similar results were obtained by Gil 2017; Gil & Ramil 2017; Gil *et al.* 2020. Nevertheless, in the same region other invertebrates, like decapod crustaceans (Matos-Pita 2015) and molluscs (Castillo 2017), display a clear affinity with the Tropical East Atlantic fauna but not with those of the Lusitania and Boreal Provinces. These different biogeographical affinities along NW Africa seems related with different dispersal strategies displayed by the benthic fauna (Matos-Pita 2015; Calero *et al.* 2017; Castillo 2017; Gil & Ramil 2017). However, their tolerance to different environmental conditions should also play a key role in the geographic distribution of marine species (Boero & Bouillon 1993), particularly in transition areas, such as the CCLME region.

Acknowledgements

We are sincerely grateful to the librarians of the Oceanographic Centre of Vigo, Uxía Tenreiro and Alexia Luiña, whose effectiveness has allowed us to have the scientific literature necessary for our taxonomic research. We would also like to give special thanks to Dr Ana Ramos, for her support and all her constructive comments and suggestions throughout all stages of the work. This work was undertaken within the framework of the EcoAfrik and CCLME-FAO projects and has been partially funded by the MAVA Fondation pour la Nature (MAVA contract 12/87 AO C4/2012). It constitutes the EcoAfrik publication number 46.

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Manuscript received: 31 January 2022
Manuscript accepted:14 December 2022
Published on: 12 May 2023
Topic editor: Tony Robillard
Section editor: Didier VandenSpiegel
Desk editor: Eva-Maria Levermann