

HETEROBRANCHIA MOLLUSCA FROM GHANA: THE TRADITIONALLY CALLED DENDRONOTACEA AND ARMINACEA

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Abstract Seven species of Dendronotacea and three of Arminacea collected in Ghana between 1963 and 1973 are described. Three are new species: *Marionia ghanensis*, *Kabeiro atlantica* and *Janolus kinoi*, while two more require further material before they can be definitively identified: *Doto* species A and *Armina* species A. *Hancockia uncinata*, *Scyllaea pelagica*, *Tethys fimbria*, *Tritonia manicata* and *Janolus hyalinus* occur widely in the north-east Atlantic. Specimens of five species were found on Sargassum so these could easily drift considerable distances across the ocean, which could account for their wide geographical occurrence.

Key words Dendronotacea, Arminacea, taxonomy

INTRODUCTION

This is the final paper about the nudibranchiate molluscs from Ghana. Previous papers have dealt with the Doridacea and the Aeolidida (Edmunds, 2016 and papers cited therein). The aim of this paper is to describe the species belonging to the Dendronotacea and the Arminacea.

MATERIAL AND METHODS

All of the material described here was collected near to Accra and Tema in Ghana, close to longitude 0 latitude 5.7 by the first author and by Mr Walter Pople. The method of collection, processing and preservation of specimens is described by Edmunds (2007, 2011, 2015). Body measurements and drawings of entire animals are from life unless otherwise stated.

The material collected and described in this paper, but excluding severely damaged specimens is deposited in the Natural History Museum, London. All the species of this study are arranged based on the classification found in Bouchet & Rocroi (2005).

SYSTEMATIC DESCRIPTIONS

Subclass Heterobranchia Gray 1840
Order Nudibranchia Cuvier, 1817
Suborder Cladobranchia
Superfamily Tritonioidea Lamarck, 1809

Family Hancockiidae MacFarland, 1923

Diagnosis (based on Thompson & Brown, 1984 and Valdés, Hamann, Behrens & DuPont, 2006) Elongate body with bilobed oral veil bearing 3–8 digitiform projections; rhinophores with vertical lamellae on club, retractile into elevated, papillate sheaths; anus, renal and genital openings all on right side anteriorly; several large basally branched cerata dorso-laterally; buccal bulb with cuticular lining of rodlets; strong jaws and triseriate radula, median tooth denticulate; three-lobed digestive gland branched supplying numerous cnidosacs containing nematocysts on cerata, sides of body and rhinophore sheaths; larval shell not inflated.

Genus *Hancockia* Gosse, 1877

Type species *Hancockia eudactylota* Gosse, 1877, by monotypy.

Diagnosis With the characteristics of the Family (above).

Hancockia uncinata (Hesse, 1872)
Figs 1A–B

Doto uncinata Hesse, 1872: 347.

Hancockia eudactylota Gosse, 1877: 316–319, Pl. 11 Figs a-h.

Govia rubra Trinchese, 1885: 179.

Govia viridis Trinchese, 1885: 179.

Hancockia uncinata – Pruvot-Fol, 1954: 360.

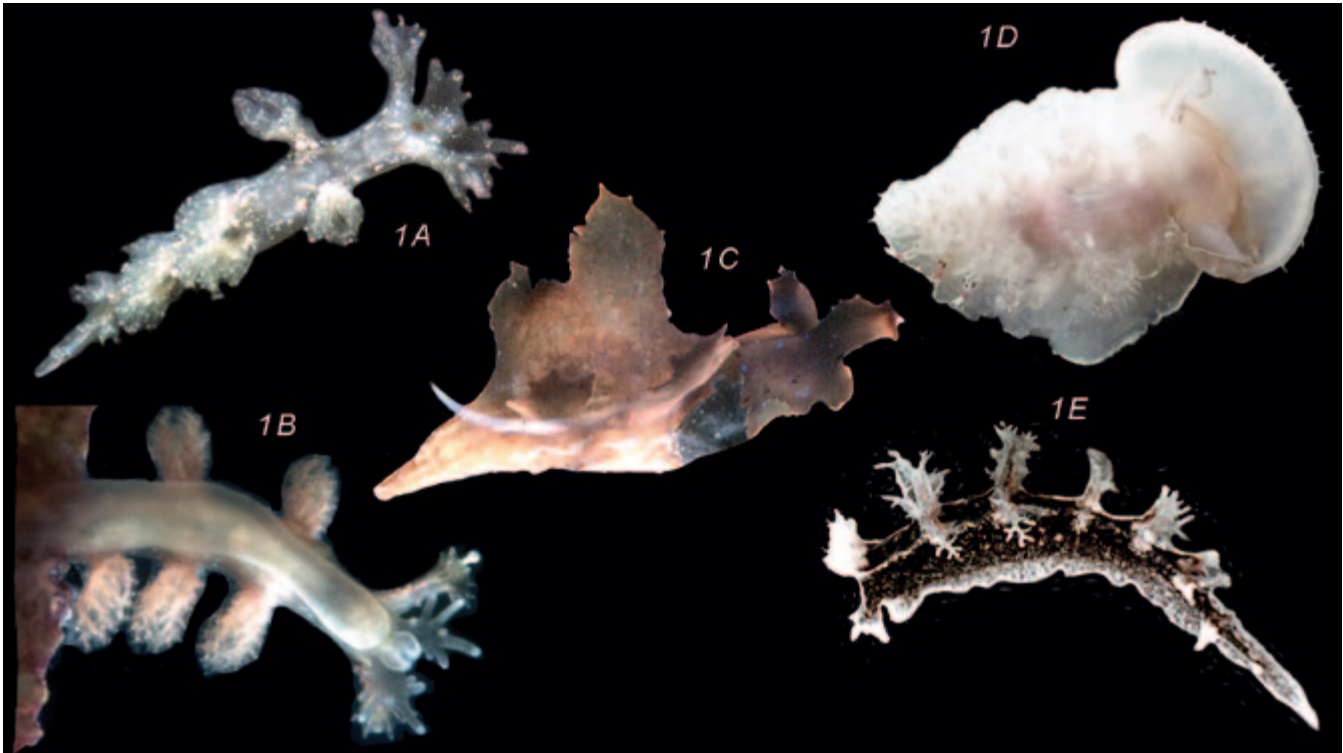


Figure 1A–B *Hancockia uncinata* (Hesse, 1872), 10m reef off Tema: **A** 5mm long, October 1969, **B** 8mm long October 1969. **C** *Scyllaea pelagica* Linnaeus, 1758, 10m reef off Tema, 35mm long, October 1969. **D** *Tethys fimbria* Linnaeus, 1767, from 30m depth off Tema, 80mm long, January 1970. **E** *Tritonia manicata* Deshayes, 1853, 10m reef off Tema, 15mm long, December 1967.

Material examined 10m reef on *Sargassum* 6 spec. 12, 8, 7, 5.5, 4.5, 4mm long 2 October 1969 Reg. no. NHMUK 20160422, 1 spec. 5mm long 8 October 1969, 1 spec. 2mm long 10 February 1971 (specimen not kept).

External features Body elongate; cerata paired branched, each with a gill on inner side (Figs 1A–B); oral veil bilobed with digitiform projections (seven pairs in the 12mm specimen, 4 pairs in 4.5 and 5mm specimens); rhinophores with longitudinal grooves on club and digitiform tip; rhinophorial sheath with short projections that are digitiform in larger specimens. Body translucent greyish in some small specimens with pinkish digestive gland in cerata, while one specimen with dark red body, and in another body greenish grey (Figs 1A–B). Largest specimen with brown body and pink digestive gland in the cerata, whereas smallest pale mauve. White spots over body, but densest on dorsum, cerata (including gill), and rhinophores.

Geographical range Scotland south to Portugal, Mediterranean and Canary Islands (Schmekel

& Portmann, 1982; Thompson & Brown, 1984; Cervera, Calado, Gavaia, Malaquias, Templado, Ballesteros, García-Gómez & Megina, 2006).

Remarks When Marcus examined specimens of *Hancockia* from Brazil he commented that existing descriptions of *Hancockia uncinata* from Europe were not sufficiently detailed for him to be able to compare them satisfactorily with his Brazilian material (Marcus, 1957). However, he noted several differences between the two populations, notably in the median radular tooth where the innermost lateral denticles are of similar size to the adjacent ones in *H. uncinata* but project at an angle in his new species, *H. ryrca*. This difference has been confirmed by Thompson & Brown's drawing of radular teeth in *H. uncinata* (Thompson & Brown, 1984, Fig. 5a). However, all of the Ghanaian specimens were living on hydroids attached to *Sargassum*, which frequently drifts across the Atlantic so there may be genetic interchange between west and east Atlantic populations. Further studies including morphological examination and DNA barcoding are needed to confirm the existence of one or two species of

Hancockia in the Atlantic. In the present contribution, we retain *Hancockia ryrca* Marcus, 1957 as the West Atlantic species and *Hancockia uncinata* (Hesse, 1872) as the East Atlantic species.

Family Scyllaeidae Alder & Hancock, 1855

Diagnosis (based on Pola, Camacho-García & Gosliner, 2012) Elongate, laterally compressed dendronotaceans with dorso-lateral mantle ridge elongated to form one or two large lobes with slender branchial tufts; velum indistinct; rhinophores swollen with oblique lamellae and tipped with digitiform processes, retractile into large flattened sheaths; tail dorso-laterally flattened; genital anal and renal openings on right side anteriorly; digestive gland compact with no projections to rhinophore sheaths or lateral mantle flaps; stomach plates present; stout jaws and broad radula; penis unarmed.

Genus *Scyllaea* Linnaeus, 1758

Type species *Scyllaea pelagica* Linnaeus, 1758, by monotypy.

Diagnosis Scyllaeids with two pairs of dorso-lateral appendages bearing small gills basally, rudimentary oral veil; rhinophore sheath with thin, posterior flap; radula formula $n. 1. n.$ where n may exceed 20.

Scyllaea pelagica Linnaeus, 1758
Fig. 1C

Scyllaea pelagica Linnaeus, 1758: 656.

Lepus pelagicus Linnaeus, 1754: 56.

Scyllaea ghomfodensis Forskål, 1775: 103.

Scyllaea quoyi Gray, 1850: 106, Pl. 203, Fig. 5.

Scyllaea hookeri Gray, 1850: 106, Pl. 203, Fig. 5.

Scyllaea grayae Amas & Reeve, 1850: 67, Pl. 19, Fig. 2.

Scyllaea edwardsi Verrill, 1878: 211.

Scyllaea lamyi Vayssièrè, 1917:

Material examined 10m reef on *Sargassum* 3 spec. 35, 20 and 8mm long 2 October 1969 Reg. no. NHMUK 20160423.

External features Body brown, with scattered minute spots of purple, blue, orange and white (Fig. 1C); rhinophores and oral lobes white tipped.

Behaviour The smallest animal was observed eating a hydroid attached to the *Sargassum*. The largest animal swam weakly by flapping its body and parapodia from side to side so that it should be possible for it to move amongst the *Sargassum* fronds to find fresh hydroids to eat.

Geographical range Warm waters of the Atlantic including the Azores and the Mediterranean, both in the oceanic surface waters and on coasts, occasionally reaching cooler waters (e.g. in Britain) (Thompson & Brown, 1984; Cervera *et al.*, 2006; Pola *et al.*, 2012).

Remarks The paired dorso-lateral lobes (parapodia), brown colouration and habit of living on *Sargassum* weed on which it is beautifully camouflaged make this species easily recognisable. *Scyllaea pelagica* has long been considered to be a circumtropical species but recent molecular studies by Pola *et al.* (2012) have shown that Indo-Pacific specimens differ substantially from those in the Atlantic and so they have resurrected the name *Scyllaea fulva* Quoy & Gaimard, 1824 for these animals. However, looking at images of Indo-Pacific specimens on the Internet (Nudi Pixel, 2010) there may be more than one species present differing in the size of the gill tufts on the parapodial lobes. It is therefore possible that, just as with species of *Notobryon* (Pola *et al.*, 2012), several species of *Scyllaea* may be present in the Indo-Pacific.

Family Tethydidae Rafinesque, 1815

Diagnosis (based on Valdés *et al.*, 2006) Body elongate with large oral hood edged with tentacles; rhinophores with transverse lamellae arising from cylindrical or flattened sheaths; fluid-filled cerata in a single row one each side of the body with gills on inner sides; anal, genital and renal openings on right side below cerata; radula absent.

Genus *Tethys* Linnaeus, 1767

Type species *Tethys fimbria* Linnaeus, 1767: 1809. On Official List, Opinion 200 *Int. Comm. Zool. Nomencl.* 3: 242, 1954.

Diagnosis (based on Rudman, 2002) Cerata smooth with small basal gills; stomach plates absent; digestive gland forming a solid mass surrounded by the gonad.

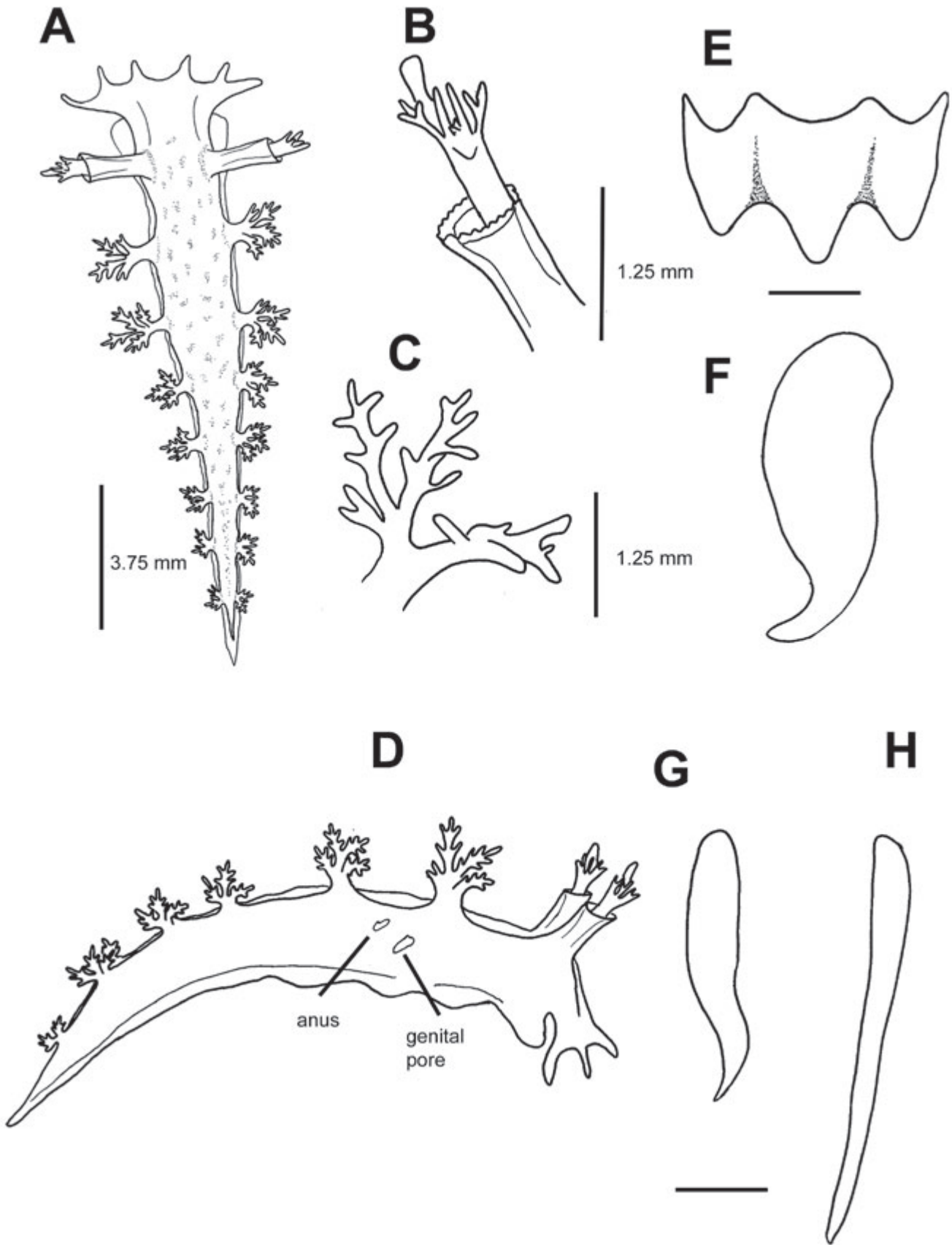


Figure 2A–H *Tritonia manicata* Deshayes, 1853: **A** dorsal view; **B** lateral view of rhinophore; **C** gill; **D** lateral view of animal; **E–H** radular teeth: **E** median tooth; **F** lateral tooth; **G** Inner marginal tooth; **H** Outer marginal tooth.

Tethys fimbria Linnaeus, 1767
Fig. 1D

Tethys fimbria Linnaeus, 1767: 1809. (See above.)
Tethys leporina Linnaeus, 1767: 653, Rejected, Opinion 200, *loc.cit.*
Thethys leporina – Delle Chiaje, 1822: Plate XXXIX, Fig. 1.
Tethys fimbria – Delle Chiaje, 1822: Plate XXXIX, Fig. 2.
Tethys leporina – Mazzarelli, 1903: 14.
Fimbria fimbria – O'Donoghue, 1926: 226.
Tethys fimbriata Vicente, 1967: 155.
Thetis cornigera Macri, 1816: 164–167
Thetis parthenopeia Macri, 1816: 168–169
Thetis polyphylla Macri, 1816: 169, 171

Material examined All dredged: 55m off Cape Coast, 2 spec. both 65mm long 22 August 1969; 30m off Labadi 4 spec. 125, 85, 65, 50mm long 1 September 1969; 30m off Tema 11 spec. up to 100mm long, 9 January 1970 Reg. no. NHMUK 20160424.

External features Almost all of the specimens had autotomised their cerata, probably due to the rough treatment in the dredge (Fig. 1D). Smaller specimens white or pale grey. Largest specimens greenish grey. Most with dense cream spots, especially dorsally. Largest specimen with diagonal cream lines towards edge of mantle. Some had white edges on the rhinophore sheaths, reddish brown on the gill sockets and brown spots on the oral hood. Remaining cerata with dark grey blotches and a basal orange-red band.

Behaviour Several animals were observed swimming upside down with a sideways flexion every four seconds. When swimming the posterior half of the foot is folded longitudinally, the anterior half is concave, and the large oral hood and rhinophore sheaths are also important in giving extra thrust.

Geographical range Widespread on sandy substrates in the East Atlantic from the Bay of Biscay and the Canaries to the Gulf of Guinea (Ivory Coast, Ghana & Nigeria) and the Mediterranean (Marcus & Marcus, 1966, 1968; Schmekel & Portmann, 1982; Cervera *et al.*, 2006; *this paper*).

Remarks This species is so unusual and distinctive because of its flattened body with broad oral hood that it requires no further comment.

Family Tritoniidae Lamarck, 1809

Diagnosis (based on Thompson & Brown, 1984 and Valdés *et al.*, 2006) Body elongate, oral veil usually bilobed with digitiform and often divided papillae; rhinophores with terminal digitiform processes forming a club, arising from tall sheaths with lobed or scalloped edge; mantle with delicately branched dorso-lateral gills; anal, renal and genital openings all on right side; two lobes to digestive gland; strong jaws and broad radula with a (usually) tricuspidate median tooth; unarmed penis, larval shell inflated.

Genus *Tritonia* Cuvier, 1798

Type species *Tritonia hombergii* Cuvier, 1803, by subsequent designation (ICZN, 1963).

Diagnosis Digestive gland with two lobes fused into a single mass in adult, body broad, numerous gills of uniform or alternating size, anus midway down body, genital opening behind first gill tuft.

Tritonia manicata Deshayes, 1853
Figs 1E, 2

Tritonia manicata Deshayes, 1853: 59, Pl. 93 Fig. 3.
Nemocephala marmorata Costa, 1867: 137.
Tritonia moesta Bergh, 1884: 734–736, Pl. 74 Figs 21–24, Pl. 76 Figs 1–9.
Candiella moesta – Vayssière, 1901: 100–1, Plate I Fig. 19.
Candiella villafranca Vayssière, 1901: 101–2, Plate I Figs 20–21, Pl. 5 Fig. 19.
Tritonia gracilis Pruvot-Fol, 1953: 62–63, Fig. 20, Pl. 2 Fig. 36.
Tritonia villafranca – Pruvot-Fol, 1954: 350–51.

Material examined 10m reef 1 spec. 15mm long 21 December 1967 Reg. no. NHMUK 20160425.

External features Body elongate; oral veil broad with 6 digitiform papillae (Fig. 2A); rhinophore socket just over 1mm long with minute serrulations on rim (Fig. 2B); rhinophore projecting 1.5mm further beyond socket, with about

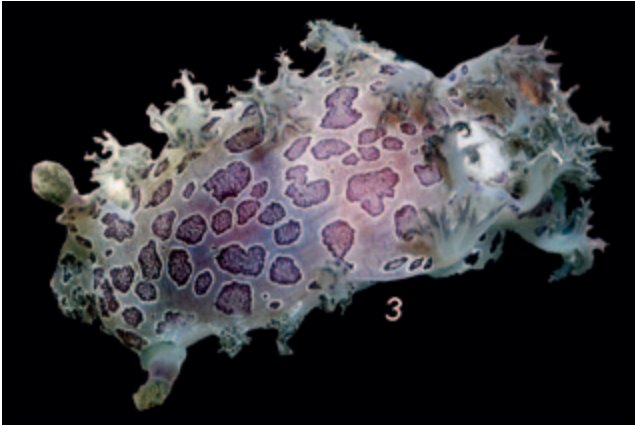


Figure 3 *Marionia ghanensis* n. sp., 30m depth off Labadi, 78mm long, September 1969.

8 processes, some branched, arising from it; rhinophore projecting beyond these processes posteriorly but also with a few minute projections arising from it distal to the larger processes; specimen with 7 pairs of gills, arranged dorso-laterally; largest pair 2.5mm long; each pair irregularly branched, with a small additional gill on right side between fifth and sixth gills (Fig. 2C); genital opening below first gill; anus high up between first and second gill on right side (Fig. 2D).

Body pale grey; dorsal and lateral surfaces with dense indigo-black pigment (Fig. 1E), small raised pustules and minute white or pinkish cream dots leaving tail, edge of foot, front of oral veil and pallial ridge grey; rhinophore and sheath grey with scattered pinkish cream dots; sheath tinged pale orange; gills grey with pink suffusion on stalk; anus and gonopore pink.

Internal morphology The buccal mass was removed for examination of the radula (Figs 2E–H). Radular formula: 18×7–13.1.1.1.7–13. Median tooth tricuspid; adjacent lateral and marginal teeth progressively longer and more slender.

Geographical range Atlantic coast from British Isles to Morocco, Mediterranean, and now Ghana (Pruvot-Fol, 1953; Thompson & Brown, 1984; Cervera *et al.*, 2006; this paper).

Remarks The external colouration of *Tritonia manicata* is variable. Haefelfinger (1963) stated that part of this variability is due to ontogenetic

changes. Specimens progressively become more slender with more velar appendages and more extensive black pigmentation (Haefelfinger, 1963). Additionally, Luque (1983) suggested that Atlantic and Mediterranean forms could be different species. However, this hypothesis has not been tested with a molecular approach. The external morphology, colouration and radular teeth of the present specimen agree with the descriptions in Haefelfinger (1963), Schmekel & Portmann (1982) and Thompson & Brown (1984). Therefore, we conclude that our specimen belongs to *T. manicata*.

Genus *Marionia* Vayssière, 1877

Type species *Marionia berghi* Vayssière, 1879 by monotypy.

Diagnosis (based on Odhner, 1963) Digestive gland in two parts, gills branched of uniform size, stomach plates present, anus midway down body, branched velar papillae.

Marionia ghanensis n. sp.

Figs 3, 4

Holotype Reg. no. NHMUK 20160426 Dredged from 30m off Labadi 75mm long preserved, 1 September 1969, collected by W. Pople.

Material examined Dredged from 30m off Labadi, 3 spec. of which 2 were kept, holotype (above) and one 70mm long preserved, 1 September 1969 Reg. no. NHMUK 20160427.

External features Body broad; oral veil (velum) almost imperceptibly bilobed with numerous short unbranched papillae (Figs 3, 4A); rhinophores broadly club-shaped; club comprising four bipinnate branches arising from stalk; rhinophore sheath barely raised above mantle, with undulating margin (Fig. 4B); mantle margin with irregularly branched gills (14 in larger specimen, 11 and 13 on the two sides of the smaller specimen; Figs 4 C, D, E); anus between the fifth and sixth gill; genital opening with 5 flaps under third gill (Fig. 4F); female opening posterior to male opening; in one specimen, male opening with projecting orange penis ejecting a white stream of semen.

Body of smaller specimen pale greenish grey; dorsum (especially centrally) suffused with dull

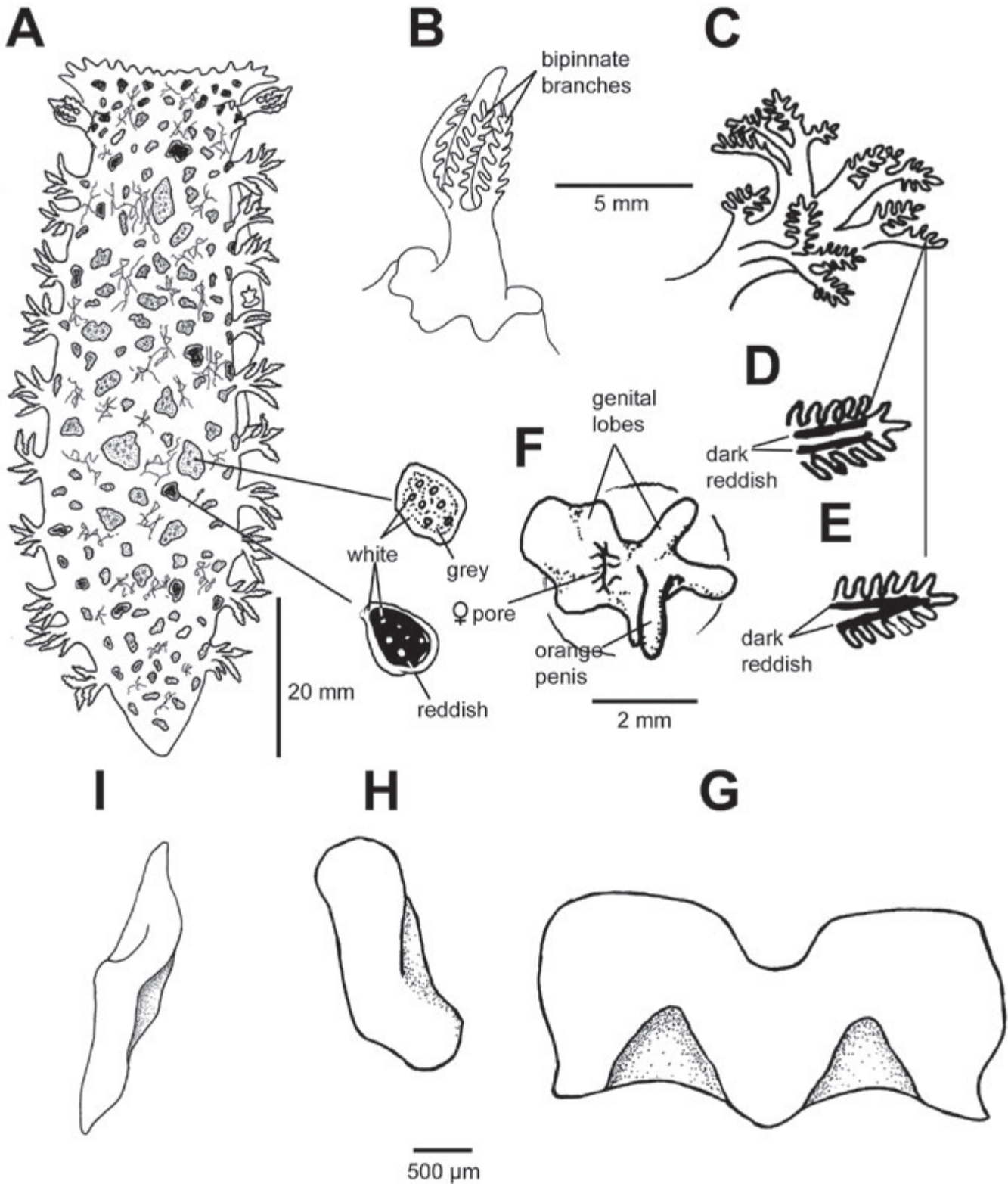


Figure 4A–I *Marionia ghanensis* n. sp.: **A** dorsal view of living animal with enlarged detail of coloured spots; **B** rhinophore from right side; **C** fully expanded gill; **D** outer side of gill pinna; **E** inner side of gill pinna; **F** genital opening with penis projecting; **G** Median radular tooth; **H** Lateral tooth; **I** Outer marginal tooth.

purple pigment (Fig. 3), and numerous irregularly shaped spots and blotches (largest centrally,

smaller on head and near gills); each spot with a white rim then a reddish purple ring; spot centre

slightly paler purple with dense minute white spots; between spots, some irregular purple lines are found; body sides grey, whiter near foot, with many irregular spots as on dorsum; larger animal similar but with red rather than purple pigmentation in mantle and spots, and some spots with minute greenish tubercles; rhinophore stalks grey-green with cream dots basally but with magenta or reddish suffusion distally; pinnate appendages brown with minute cream dots all over; socket edge suffused red with cream dots, greenish below; gills greenish grey; gill stalks with spots as on dorsum; gill branches with dark red or purple edges, inner surface with many cream dots; pinnae with two reddish lines, parallel on inner side (Fig. 4E), meeting distally on outer side (Fig. 4D); pinnules transparent.

Internal morphology The buccal mass of the 70mm specimen was removed for examination of the radula (Figs 4G–I). Radular formula: 85×2–124.1.1.1.2–124.

Geographical range Known only Ghana (this paper).

Etymology The species is named from its occurrence in Ghana.

Remarks This material is compared with other West African species of *Marionia*: *M. cabindae* White, 1955 from Angola, *M. vanira* Marcus & Marcus, 1966 from Ivory Coast and Ghana, and *M. pusa* Marcus & Marcus, 1968 from Ivory Coast. None of these was described from life so their colouration is not known, but Eveline Marcus's drawing of the notum of *Marionia pusa* (Marcus & Marcus, 1968: Fig. 3) shows irregular spots and blotches with white rims and stippled centre suggesting darker colour – very similar to the specimens described here. However, all three of these species have branched velar processes while *M. pusa* also has branched processes on the rim of the rhinophore. The specimens from Ghana have unbranched velar processes and no papillae on the rim of the rhinophore sheath. The European *M. blainvillea* (Risso, 1818), which occurs as far south as the Canary Islands, also has branched velar processes and a very different colouration from our specimens. Thus, we conclude that these specimens from Ghana belong to a currently undescribed species. The unbranched velar papillae

exclude this species from the genus *Marionia* following Odhner's (1963) definition of the genus. However, the genera of the Tritoniidae are in need of a thorough revision taking account of molecular as well as morphological characters, so for the present we place the new species in the genus *Marionia*, which contains other large tritoniids.

Superfamily Arminoidea Iredale &
O'Donoghue, 1923 (1841)

Diagnosis (based on Thompson & Brown, 1984) Nudibrachs with lamellate rhinophores retractile into pits; mantle ample, entire, lacking prominent papillae; anus lateral; usually with numerous gills in groove between edge of mantle and foot.

Family Arminidae Iredale & O'Donoghue, 1923
(1841)

Genus *Armina* Rafinesque, 1814

Type species *Armina tigrina* Rafinesque, 1814, by subsequent designation by Iredale & O'Donoghue, *Proc. Malac. Soc.* **15**: 217, 1923.

Diagnosis Arminids with wrinkled sensory caruncle in front of rhinophores and with mantle longitudinally ridged.

Armina species A
Figs 5A–E

Material examined Dredged from 45m off Tema by Mr Ameyaw Akumfi, 1 spec. 8mm long preserved 16 September 1968 Reg. no. NHMUK 20160439.

External features The specimen was fixed in formalin without prior narcotisation so had shrunk when examined, but the collector confirmed that the colour had not changed much since it was alive. Body 8mm long and wide due to preservation; slight notch at front; caruncle small; 13 longitudinal ridges dorsally; the outer three on each side only reaching half-way down the body; mantle edge broad, with no ridges; 17 gill lamellae, ventrally, between mantle edge and foot; gonopore below first gill; anus below fifth gill; first and largest gill with nine large lamellae and five smaller ones alternating with them (Fig. 5A).

When recently fixed in formalin the dorsal ridges were grey; grey pigment mostly on the

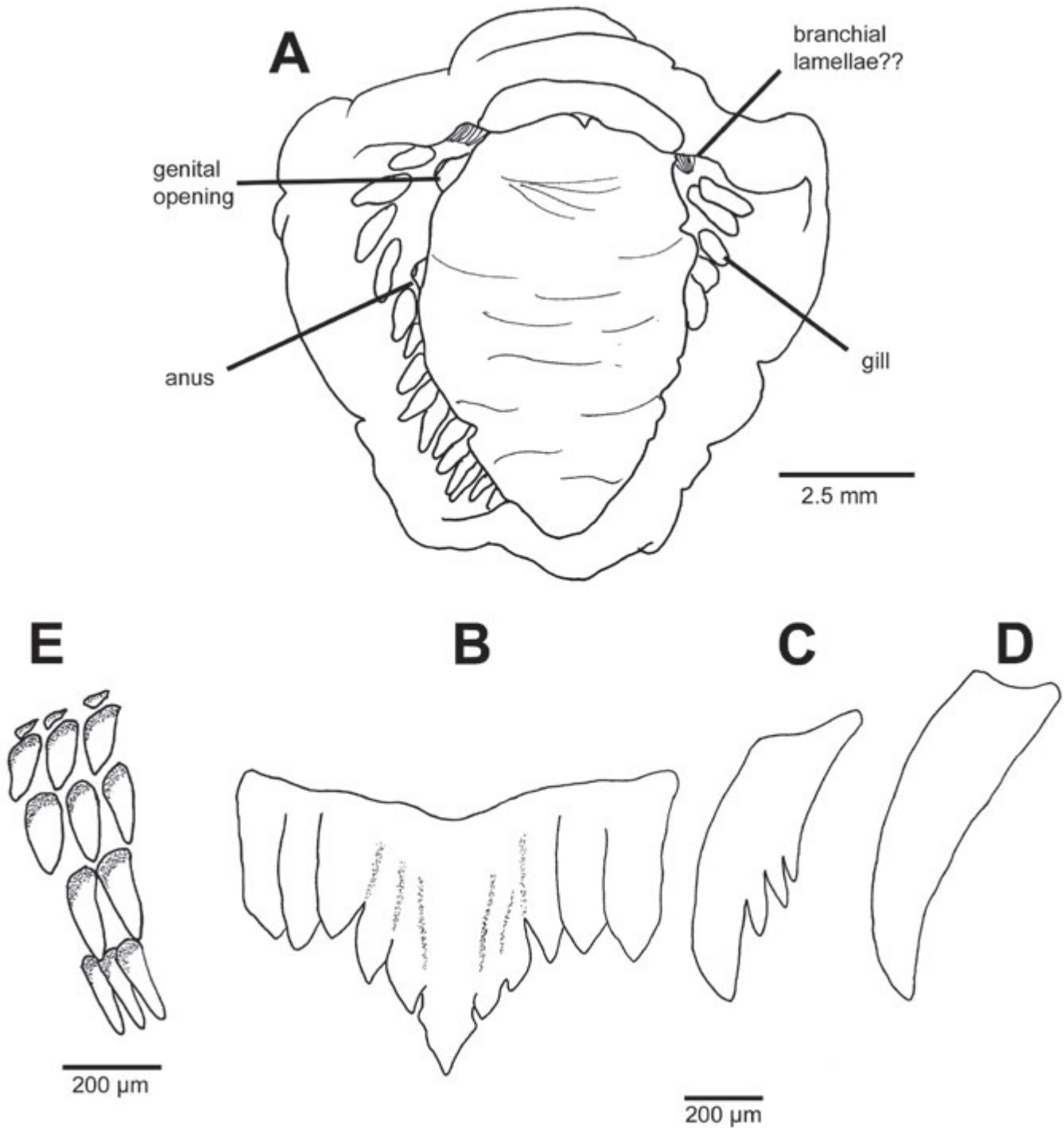


Figure 5A-E *Armina* species A, dredged off Tema, 8mm long, September 1968: **A** ventral view of preserved animal; **B** median radular tooth; **C** lateral tooth; **D** marginal tooth; **E** masticatory border of jaws.

sides of the ridges but with some also on the crests and in the troughs; caruncle black; transverse ridge in front of mouth dark grey; gills brick red.

Internal morphology The buccal mass was removed for examination of the radula (Figs

5B-D). Radular formula: 28×16-19.1.1.1.17-19. Masticatory border of jaws denticulated (Fig. 5E), bearing 5 rows of denticles.

Geographical range Because of uncertainty with its identification (see below) we cannot record its geographical range.

Remarks To date, there are ten species of *Armina* reported in the Atlantic and the Mediterranean: *Armina maculata* Rafinesque, 1814, *A. tigrina* Rafinesque, 1814, *A. neapolitana* (delle Chiaje, 1824), *A. loveni* (Bergh, 1869), *A. mulleri* (Ihering, 1886), *A. adami* White, 1955, *A. gilchristi* White, 1955, *A. wattla* Marcus & Marcus, 1967, *A. tricuspidata* Thompson, Cattaneo & Wong, 1990 and *A. juliana* Ardila & Diaz, 2002 (Kolb & Wägele, 1998; Ardila & Diaz, 2002). In terms of external colouration, *A. maculata* and *A. juliana* do not match with the traces of colouration in our specimen. In addition, in *A. juliana* the genital papilla is located anterior to the branchial lamellae, whereas in our specimen it is located posterior to the lamellae. Excluding *A. neapolitana*, whose colouration is unknown, the remaining species of *Armina* from the Atlantic and Mediterranean have a similar external colour pattern to our specimen from Ghana.

According to Kolb (1998), the shape of the radular teeth is the best character to separate species of this genus. The radular teeth of *A. maculata*, *A. loveni*, *A. tigrina*, *A. mulleri*, *A. wattla*, *A. gilchristi* and *A. adami* are similar in shape to those of *Armina* sp. A (Marcus & Marcus, 1960; Marcus & Marcus, 1967; Kolb, 1998). Hence, this character can also not be used for identification of our specimen.

Finally, in the west coast of Africa the species *A. maculata*, *A. tigrina*, *A. gilchristi* and *A. adami* occur. Our specimen is distinct from *A. maculata* (see above), but further studies with more material are needed to identify it.

Unassigned to Superfamilies
Family Dotidae Gray, 1853

Type species *Doto coronata* Gmelin, 1791, by subsequent designation (ICZN, 1964).

The correct name of the family is Dotidae (ICZN, 1964; summarised by Rudman, 2004).

Diagnosis (based on Thompson & Brown, 1984) Body elongate, oral veil convex with rounded (not tentacular) lateral projections; rhinophores digitiform, usually arising from cylindrical, often flared sheaths; single row of dorso-lateral cerata, cerata normally with rows of tubercles containing defensive glands, often with a basal gill on inner side of larger cerata, digestive gland which contain nematocysts ramifying cerata but

nematocysts are not in discrete cnidosacs; gonopore below first ceras and anus between first and second cerata on right side; stomach unarmed; weak jaws, radula formula 0.1.0; penis unarmed; larval shell inflated.

Genus *Doto* Oken, 1815

Diagnosis (based on Shipman & Gosliner, 2015) Elongate Dotidae less than 32mm long; with sheaths surrounding rhinophores and cerata with tubercles, usually in rows, regularly shaped and not widely spaced; pericardium not elevated; without penial gland (pocketed prostate).

Doto species A
Fig. 6A

Material examined On *Sargassum* on the 10m reef 10 spec. 7, 5, 3.5 (x5), 3, 2.5, 1.5mm long 19 November 1967 Reg. no. NHMUK 20160435, 2 spec. both 1.5mm long 2 October 1969 Reg. no. NHMUK 20160429, 2 spec. not measured 8 October 1969 Reg. no. NHMUK 20160428, 2 spec. 6, 5.5 mm long 12 October 1969 Reg. no. NHMUK 20160430; dredged off Tema 1 spec. not measured 15 March 1968 Reg. no. NHMUK 20160436.

Other material 2 spec. not measured 19 October 1969, 1 spec. 3mm long 11 March 1971; 10m reef (not on *Sargassum*) 1 spec. 3mm long 14 December 1969, 1 spec. 3mm long 1 March 1971; Buoy in Tema harbour 3 spec. not measured 28 January 1968.

External features Body usually with four pairs of cerata, but six in largest specimens; terminal tubercle of cerata large; cerata usually with three tiers of lateral tubercles but occasionally five tiers; gill small, with two or three lobes on mesial side of larger cerata; anus midway between first and second cerata.

Body grey with irregularly shaped black spots on oral veil, dorsum, flanks and (usually) rhinophore sheaths, sometimes coalescing into a patch over heart (Fig. 6A); minute white dots on rhinophores, oral veil, dorsum and some on rim of rhinophore sheaths; rim of anal papilla often white; cerata with numerous minute white glandular dots on tubercles; sometimes white glands also visible at ceras tips and larger tubercles; some white dots on gills; digestive gland in ceratal

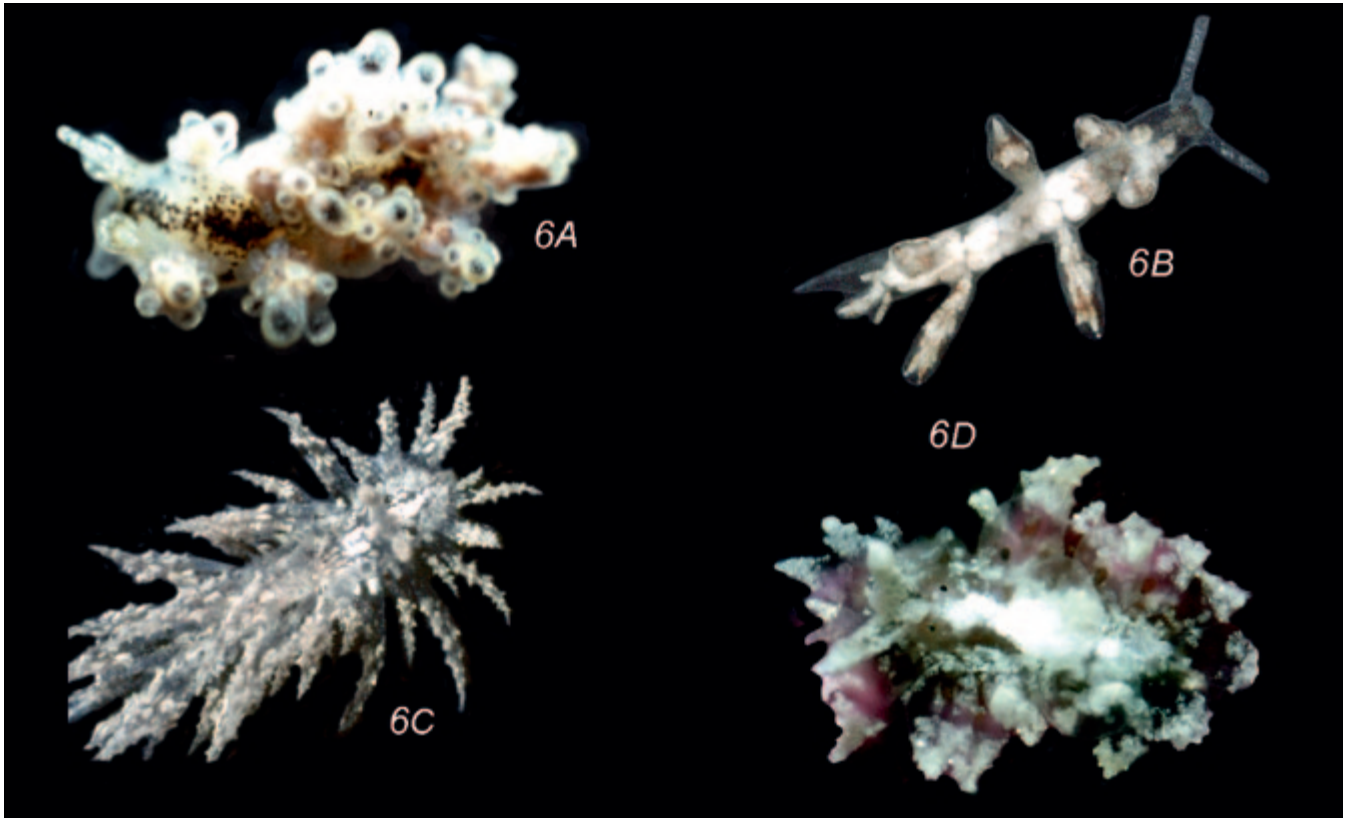


Figure 6A *Doto* species A, 10m reef off Tema, 7mm long, November 1967; **B** *Kabeiro atlantica* n. sp., 10m reef off Tema, 4mm long, October 1969; **C** *Janolus hyalinus* (Alder & Hancock, 1854), Teshie, 14mm long, December 1970; **D** *Janolus kinoi* n. sp. 10m reef off Tema, 5mm long, May 1971.

tubercles cream or pinkish brown with some black or dark purple pigment; smaller tubercles grey with no trace of digestive gland or of darker colouration.

Geographical range Known only from Ghana, but see below.

Remarks Distinguishing species of *Doto* is almost impossible without good quality photos of living animals. For many years it was assumed that there were just a handful of species in the north Atlantic but the meticulous work of Lemche (1976) with colour paintings in Just & Edmunds (1985), Ortea & Urgorri (1978, who give earlier references), and Shipman & Gosliner (2015) has shown that there are a large number of very similar species distinguished by the colouration of living animals or through a molecular approach.

While it is possible that the present collection comprises more than one species there appears to be continuous variation in the amount of white pigment, black markings and colour of the digestive gland, and therefore we consider they are all

conspecific, although further studies a molecular examination are needed. Because several specimens were found on floating *Sargassum* it is likely that they can travel widely in the Atlantic Ocean and so they need to be compared with species from both East and West Atlantic as well as the Mediterranean. They differ in morphology and colouration from the 14 species of *Doto* from the Caribbean illustrated by Valdés *et al.* (2006), from the 14 species described and illustrated by Picton & Morrow (2010), from most of the Spanish species (including Canary Island) described by Ortea & Urgorri (1978), Ortea, Moro, Ocaña & Bacalaldo (2010) and Ortea, Moro, Bacallado & Caballer (2014), those described from Cape Verde (Eliot, 1906b; Ortea, Moro & Espinosa, 1997; Ortea & Moro, 1999) as well as from the two South African species described by Shipman & Gosliner (2015) and Pola & Gosliner (2015). Within the last two contributions, the authors highlighted the necessity of a thorough revision of this group, including detailed descriptions and molecular data. However, we could not determine if our specimens belong to the species from

the Canary Island *D. eo* Ortea, Mora, Bacallado & Caballer (2014) and *D. fructifraga* Ortea & Perez (1982) or to the species from Cape Verde *D. moravesa* Ortea (1997) (in Ortea *et al.*, 1997). All these species together with our *Doto* species A share pale bodies (translucent, grey or whitish) with black spots over the dorsum, rhinophoral morphology, and similar ceratal arrangement, colouration, and ornamentation. Therefore, a deep revision of the group is needed, including complete descriptions and molecular analyses.

Genus *Kabeiro* Shipman & Gosliner, 2015

Diagnosis (according to Shipman & Gosliner, 2015) Elongate Dotidae, generally with widely spaced cerata with branched external digestive gland. Pericardium enlarged, elevated. Reproductive system with a pocketed prostate (penial gland).

Kabeiro atlantica n. sp. Figs 6B, 7

Holotype Reg. no. NHMUK 20160432 10m reef, 4mm long 8 October 1969, collected by W. Pople.

Material examined 10m reef 12 spec. 2–4mm long 8 October 1969 Reg. no. NHMUK 20160434.

External feature Body long, usually with 4 pairs of cerata; oral veil convex, with hardly any

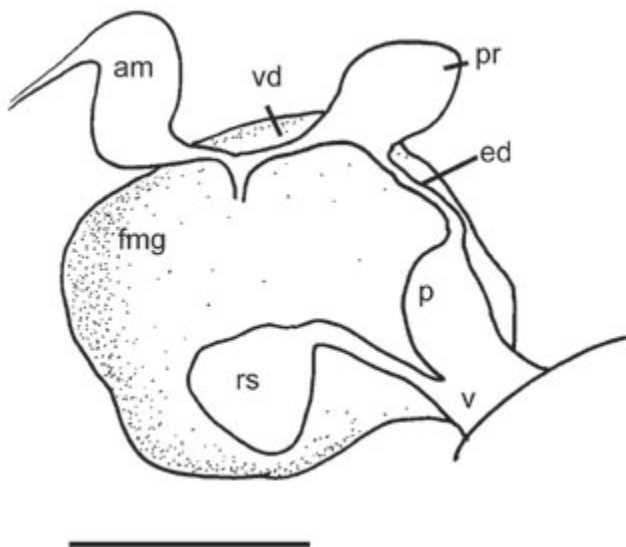


Figure 7 *Kabeiro atlantica* n. sp., dissection of reproductive system; a – ampulla, ed – ejaculatory duct, fmg – female mucous gland, p – penis, pr – prostate (penial gland), rs – receptaculum seminis, v – vagina, vd – vas deferens.

antero-lateral projections; rhinophore sheath merging abruptly into rhinophore with no hollow; cerata elongate with small number of low, angular tubercles, not clearly forming tiers; anus just behind first ceras.

Body grey with conspicuous cream gonads visible from above (Fig. 6B); back and body sides with meshwork of dense or sparse brownish orange pigment; minute white dots on rhinophores; cerata with cream digestive gland and sparse or dense brownish orange pigment between tubercles; tip of ceras with perhaps a dozen white spots packed beneath epidermis; most tubercles have one white spot at the tip, all of these spots are probably defensive glands; anus white.

Internal anatomy Ampulla short and rounded (Fig. 7); postampullary duct branching into oviduct and vas deferens; oviduct entering into female gland; vas deferens very short, entering into prostate; prostate forming a bumpy pocket; prostate inserting into a short ejaculatory duct that ends in the penis; receptaculum seminis rounded, with long duct that connects with the vagina.

Geographical range Known only from Ghana, but see below.

Etymology The species is named from its occurrence in the Atlantic Ocean.

Remarks Recently, Shipman & Gosliner (2015) conducted the first molecular phylogeny of the genus *Doto*: they obtained two separate clades depending on body size and the configuration of the reproductive system. Shipman & Gosliner (2015) erected the genus *Kabeiro* for those Dotidae that have elongated body and a pocketed prostate (penial gland). Until now, *Kabeiro* has been restricted to the Indo-Pacific and comprised three species. However, in the present contribution we describe *Kabeiro atlantica*, the first species from the Atlantic Ocean. *Kabeiro atlantica* differs from *Kabeiro phasmida* Shipman & Gosliner, 2015, *K. christiana* Shipman & Gosliner, 2015, and *K. rubroreticulata* Shipman & Gosliner, 2015 in external colouration. *Kabeiro christiana* is the most similar in appearance to *K. atlantica*. The new species lacks the dark grey pigmentation over the dorsum as well as having fewer tubercles on the cerata.

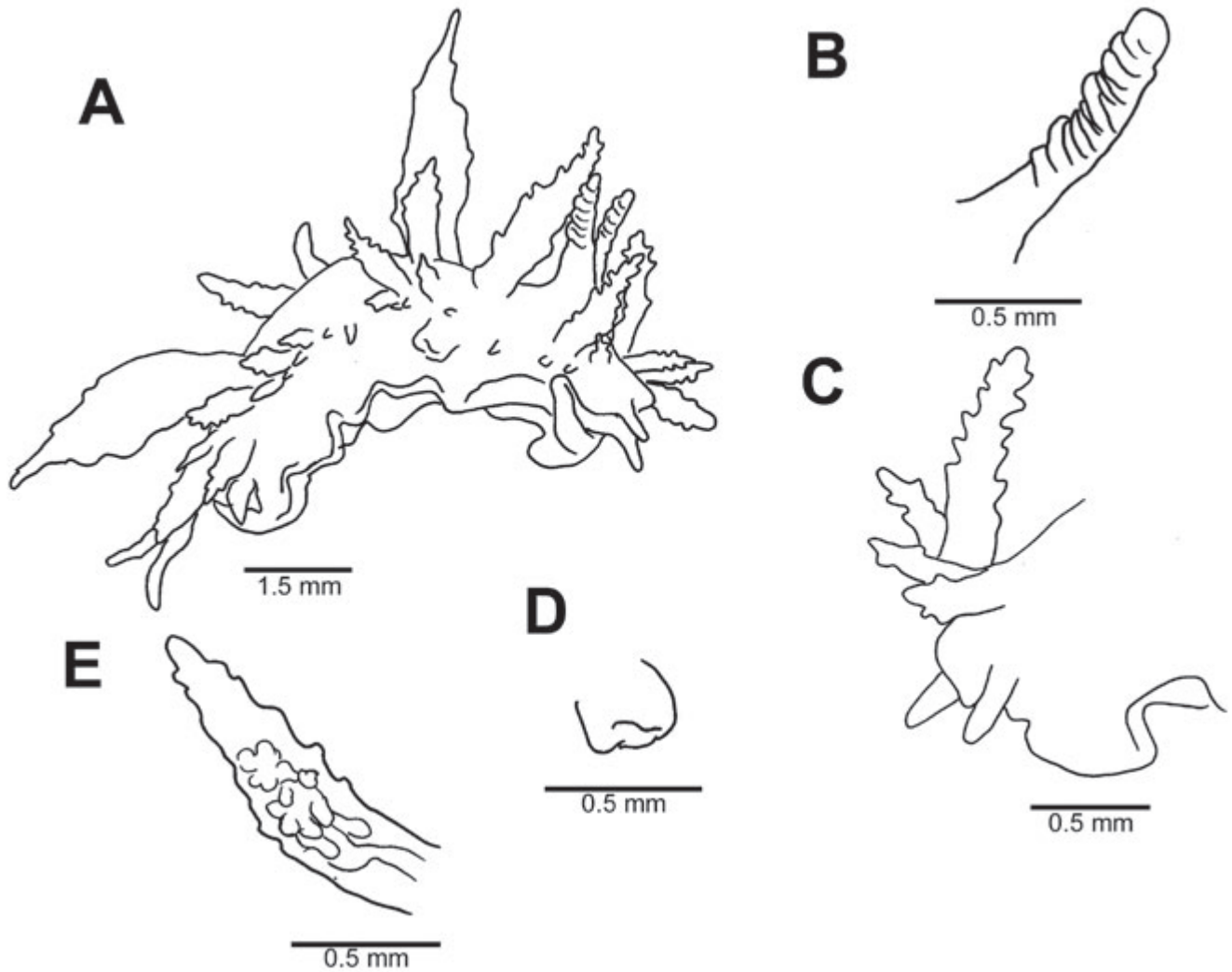


Figure 8A–E *Janolus hyalinus* (Alder & Hancock, 1854), preserved specimen: **A** lateral view; **B** rhinophore from right side; **C** lateral view of head to show short oral tentacles and anterior cerata; **D** penis; **E** ceras with digestive gland.

As with *Doto* species A, this species was found on *Sargassum* so could have a widespread geographical occurrence. *Kabeiro atlantica* also differs in external morphology and colouration from all of the West Atlantic species of *Doto* illustrated in Valdés *et al.* (2006) and from the East Atlantic species described by Ortea & Urgorri (1978), Shipman & Gosliner (2015) and Pola & Gosliner (2015).

Family Proctonotidae Gray, 1853

Diagnosis (based on Gosliner, 1981 and Thompson & Brown, 1984) Metarminoideans with median anus at posterior end of body, broad radula, and digestive gland extending into cerata.

Genus *Janolus* Bergh, 1884

Type species *Janolus australis* Bergh, 1884, by monotypy.

Diagnosis (based on Gosliner, 1981) Janolids lacking a helmet-like extension to front of head. Gosliner (1981) synonymised *Janolus* and *Antiopa*, a conclusion that we have accepted here.

Janolus hyalinus (Alder & Hancock, 1854)
Figs 6C, 8

Antiopa hyalina Alder & Hancock, 1854: 105.
Janolus hyalinus – Eliot, 1906a: 374, pl. xi fig. 23.

Janolus flagellatus Eliot, 1906a: 374–376.

Antiopella hyalina – Thompson Brown, 1976: 140.

Material examined 3 spec. 8, 7 & 3mm long on *Sargassum* 17 May 1969 Reg. no. NHMUK 20160438, 4 spec. 12, 8, 3 & 2mm long 4 April 1973 Reg. no. NHMUK 20160440, 1 spec. 14mm long 28 December 1970 Reg. no. NHMUK 20160437.

Other material 10m reef 1 spec. 5mm long 31 December 1967, 1 spec. 2mm long 2 October 1969, 1 spec. 6mm long 1 March 1971, 1 spec. 4mm long 11 March 1971, 1 spec. 5mm long 10 April 1971; rock pool at Teshie 2 spec. 6 & 5mm long 1 May 1965.

External features Body gradually tapering to tail, tail length depending on specimen size (Fig. 6C, 8A); oral tentacles short and digitiform (Fig. 8C); rhinophores lamellate, lamellae irregular, sloping from an anterior ridge to a posterior groove; 9 lamellae in the 14mm specimen (11, 8, 8 and 5 lamellae in specimens 8, 6, 5 and 7mm long respectively, Fig. 8B); caruncle between rhinophores with a zig-zag ridge; cerata arranged dorso-laterally from head to tail; some cerata on head dorsal to oral tentacles, maximum of 45 cerata per side; each ceras broadest near base, tapering to slender tip with numerous low wart-like tubercle (Fig. 8E); anus in midline behind heart forming a socket with a wide rim. In two not very healthy animals the penis was protruded and has no trace of a stylet (Fig. 8D).

Body pale grey; dorsum except for heart and sides with brown or dark brown dots and some larger creamy brown spots (Fig. 6C); white patches on head and just behind rhinophores; white dots over dorsum and sides; white line on tail; rhinophores light brown, with white dots and dark brown spots, especially on stalk, distal third orange in some specimens, tipped with white; caruncle orange; basal half of cerata with dense brown pigment spots which partly hide the olive-brown or yellow-brown digestive gland; a few white dots also elsewhere on cerata; distal third of cerata orange (but not in all cerata), tip creamy white with dense dots; anus with white rim; foot ventrally with white dots and brown spots.

Behaviour The cerata in this species are easily autotomised on the slightest disturbance.

Although species of *Janolus* are reported to feed on bryozoans (Thompson & Brown, 1976), the 14mm specimen was observed biting off the stalks of a calyptoblastic hydroid and then swallowing the entire hydranth and stalk.

Geographical range British Isles and the Netherlands south to Morocco, Mediterranean (Thompson & Brown, 1984; Schmekel & Portmann, 1982; Lipmann, 1999; Rudman, 1999; Cervera *et al.*, 2006).

Remarks There is a reference to this species in Part VI of Alder & Hancock's monograph (1845–1855) dated 1852 that may cause confusion because this is two years earlier than their description of this species in the Ann. Mag. nat. Hist. cited here. However, Drs Serge Gofas and Gary McDonald have drawn our attention to the last pages of Part VII of the monograph which states that Part VI was actually published in 1854 for 1852, so the correct date for this species is 1854.

This species in Ghana shows considerable variation in the amount of white and brown pigment, notably in whether or not there are large patches of white on the head and just behind the rhinophores. They are quite similar to the painting by Albany Hancock (Alder & Hancock, 1845–55, part VI, 1852, Family 3 plate 44) although Eliot (1906a) states that these drawings are 'not good'. European specimens of *Janolus hyalinus* show similar variation in colour: the specimen illustrated by Picton & Morrow (2010) has no white patches, the one painted by Greg Brown in Thompson & Brown (1984) has a white mark behind the rhinophores while the one photographed in the Netherlands by Lipmann (1999) has a larger white patch. However, a second specimen from the Netherlands photographed by Patrick van Moer (Mediterranean slug site, accessed 2015) has pink digestive gland in the cerata and the entire animal is very pale with numerous white dots, quite different from other photos of *Janolus hyalinus*.

There are also reports of *Janolus hyalinus* from Australia and New Zealand (Burn, 1958; Miller & Willan, 1986) but the appearance of these animals is very different from those from Europe or Ghana: they are more colourful with blue and yellow pigment instead of brown (Green, 2001) and the digestive gland runs almost to the tips of

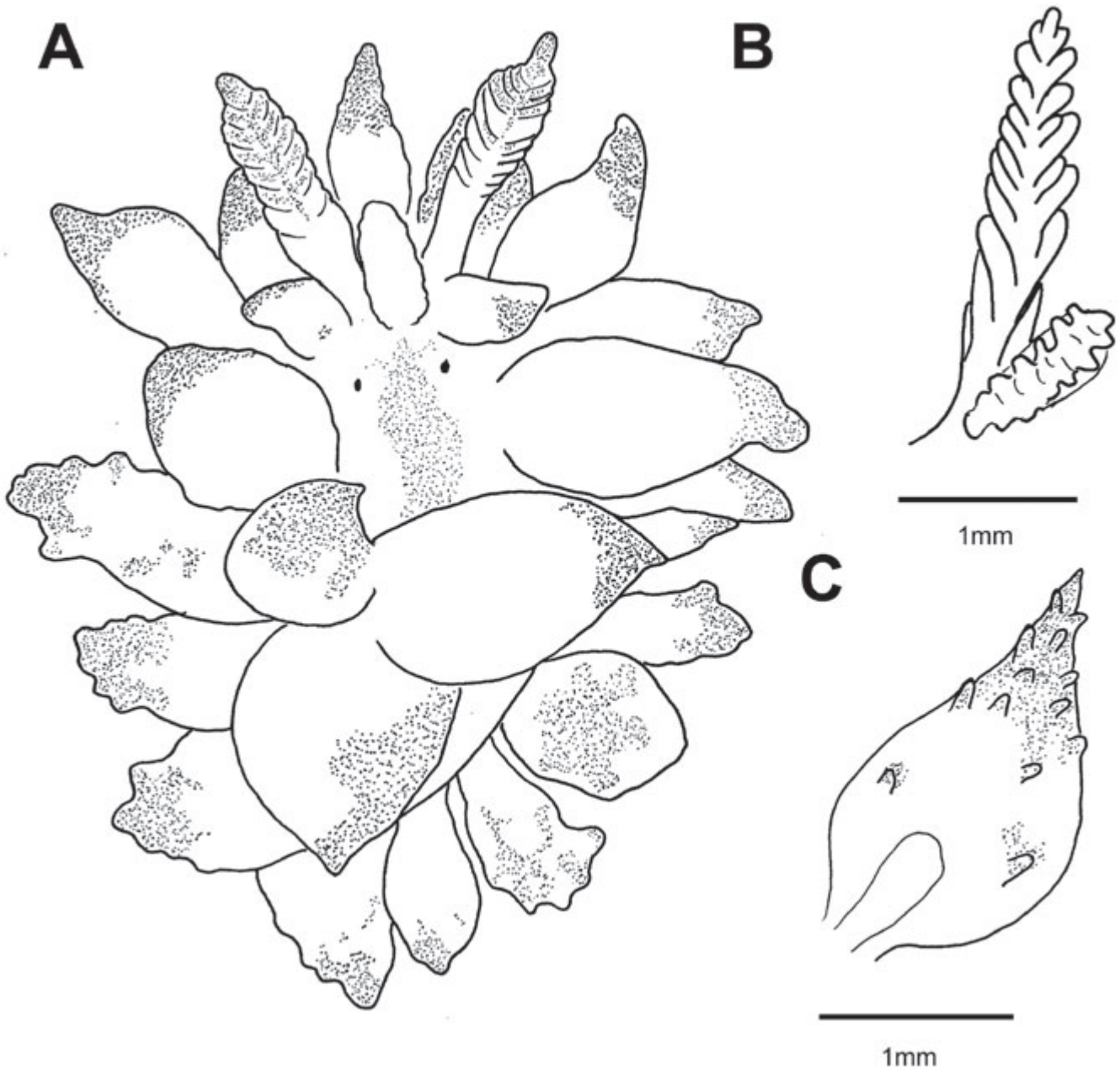


Figure 9A–C *Janolus kinei* n. sp.: **A** dorsal view; **B** rhinophore from right side and caruncle; **C** ceras. Stipple is white, cream or buff pigment.

the larger cerata, unlike in European *J. hyalinus*. Willan & Miller (1986) and Willan (2001) consider that their material is *J. hyalinus* but we agree with Rudman (2001) that the differences are sufficient to cast doubt on this conclusion and that they belong to a different species. It is of course possible that *Janolus hyalinus* is a tramp species travelling worldwide on boats, but if so we would have expected to see records of it from the Atlantic Isles, South Africa and elsewhere in the Indo-Pacific. Without more extensive material and further studies with a molecular approach,

we consider all of the present specimens belong to a single species.

Janolus kinei n. sp.
Figs 6D, 9

Holotype Reg. no. NHMUK 20160441 10m reef, 5mm long 7 May 1971, collected by W. Pople.

Material examined A single specimen, the holotype.

External features Body short, broad with no tail (presumably damaged and broken) (Figs 6D, 9A); oral tentacles short and digitiform; rhinophores with 11 irregular lamellae sloping from front to posterior groove; caruncle pronounced, with zig-zag ridge (Fig. 9B); cerata dorso-lateral; some small cerata in front of head; each ceras bulbous below, distal half tapering with small warts (Fig. 9C); anus in midline at rear of body.

Body olive-grey; broad irregular white patch dorsally from between eyes to anus (Figs 6D, 9A); pair of elongated brown spots just in front and behind rhinophores; buff spots on dorsum on either side of white patch; digestive gland brown and visible just in front of heart; rhinophores buffish cream distally, with brown spots near base and between some of lamellae; cerata with brown digestive gland in basal third; cerata with a few buff spots near base and solid patch of buff distally; anus white.

Geographical range Known only from this single specimen from Ghana.

Etymology This species is dedicated to Joaquín Callejo, also called Kino, husband of the second author of this paper.

Remarks There are just two species in Eastern Atlantic with papillate cerata: *Janolus hyalinus* (Alder & Hancock, 1854), from the north-east Atlantic, and *Janolus faustoi* Ortea & Llera 1988, from the Canary Island. However, there are differences in colouration between *Janolus kinoi* n. sp. and the latter two species. For instance, *J. hyalinus* has an orange caruncle whereas *J. kinoi* n. sp. has it olive-grey. *Janolus faustoi* presents brown marks all over the dorsum and cerata (Ortea & Llera, 1988), which are not found in *J. kinoi* n. sp. Besides its papillate cerata, *J. kinoi* n. sp. also differs in colour from the north Atlantic *Janolus cristatus* (delle Chiaje, 1841), *Janolus praeclarus* (Bouchet, 1975), and from the South African *Janolus longidentatus* Gosliner, 1981, *Janolus nakaza* (Gosliner, 1981) and *Janolus capensis* Bergh, 1907.

DISCUSSION

This study updates the knowledge on the nudibranch fauna from Ghana, reporting seven species of Dendronotacea and three of Arminacea.

Three of these species are new (*Marionia ghansensis*, *Kabeiro atlantica* and *Janolus kinoi*) and two more require further material before they can be definitively identified. This contribution increases the known species of nudibranchs from Ghana to ninety-five (Edmunds, 2013, 2016) and highlights the lack of records of nudibranchs from West Africa.

In addition, we extend the geographical range of five species in the East Atlantic (*Hancockia uncinata*, *Scyllaea pelagica*, *Tethys fimbria*, *Tritonia manicata* and *Janolus hyalinus*), however, the geographical distribution of most of these species needs to be tested with a molecular approach.

Specimens of five species were found on *Sargassum* (*Hancockia uncinata*, *Scyllaea pelagica*, *Doto* species A, *Kabeiro atlantica* and *Janolus hyalinus*) so these could easily be transported considerable distances across the ocean. However, none of the species described here are currently also known from the Indo-Pacific region as is the case with some aeolids from Ghana (Edmunds, 2016).

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