

# OPISTHOBRANCHIATE MOLLUSCA FROM GHANA: FLABELLINIDAE, PISEINOTECIDAE, EUBRANCHIDAE & EMBLETONIIDAE

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*Abstract* This paper describes eight species of aeolid from Ghana, belonging to the families Flabellinidae, Piseinotecidae, Eubbranchidae and Embletoniidae. Three of the species are new: *Flabellina rubromaxilla* n. sp., *Eubbranchus rubrocerata* n. sp. and *Piseinotecus minipapilla* n. sp., while a fourth, *Embletonia* species A may be a currently undescribed species. *Embletonia pulchra* is cosmopolitan in its occurrence, *Flabellina albomaculata* is also known from Cape Verde, and *Piseinotecus sphaeriferus* and *Eubbranchus prietoi* are known from some of the East Atlantic Islands and the Mediterranean.

*Key words* Flabellinidae, Piseinotecidae, Eubbranchidae, Embletoniidae

## INTRODUCTION

Aeolid nudibranchiate molluscs are poorly known from West Africa (Pruvot-Fol, 1953; Edmunds, 1968a, b, 1989) but five species of the Aeolidiidae have recently been described from Ghana (Edmunds, 2015). The purpose of this paper is to describe the aeolid nudibranchs belonging to the families Flabellinidae, Eubbranchidae, Piseinotecidae and Embletoniidae collected in Ghana between 1963 and 1973.

Many of the nudibranch species described here and in earlier papers (Edmunds, 2013 and papers cited therein) are known from single specimens. Some of these belong to previously described species, but others appear to be new species and these present a dilemma: should I name them designating the single specimen as the holotype, or should I identify them to genus without a specific epithet? Because the specimens are very small I have not damaged them by attempting to examine the radula or other internal structures, so the descriptions are necessarily incomplete. Most species known from single specimens should not be given a specific name because it may be impossible to determine to which of several subsequently described species they belong. However, occasionally a new species is found whose external features are so distinctive that it may be justifiable to name it, and I have done this for two species in this paper.

## 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 author and by Mr Walter Pople. The method of collection, processing and preservation of specimens is described by Edmunds (2015) and in earlier papers (Edmunds, 2007, 2011). Body measurements and drawings of entire animals are from life unless otherwise stated. Numbers of cerata in a specimen are given using shorthand e.g. 4, 3, 4, 4, 3, 2, 1. Numbers before the semi-colon are in rows or arches anterior to the heart, numbers after the semi-colon are ceratal groups posterior to the heart. The anterior digestive gland supplies the cerata on the right side anterior to the heart, all the other cerata are supplied by the posterior digestive gland.

The material collected and described in this paper (including serial sections on microscope slides stained with Masson's trichrome but excluding severely damaged specimens) is deposited in the Natural History Museum, London.

## SYSTEMATIC DESCRIPTIONS

### Family Flabellinidae Bergh, 1889

*Diagnosis* (based on Thompson & Brown, 1984) Aeolidacea with pleuroproct anus (i.e. lateral to the rows of cerata); cerata often arising from raised peduncles; often with a dorso-lateral ridge demarcating the dorsum; tentacular anterior foot corners (propodial tentacles); unarmed penis;

long, coiled ampulla; bursa copulatrix (if present) usually opening into female genital atrium; denticulate edge to jaw; triseriate radula, lateral teeth usually denticulate; larval shell not inflated.

The family name Flabellinidae has sometimes been attributed to Voigt, but he only described the genus *Flabellina*, not the family (Voigt, 1834, page 124). Other recent authors (e.g. Cervera, Calado, Gavaia, Malaquias, Templado, Ballesteros, García-Gómez & Megina, 2006) attribute the family name to Bergh (1889). Bergh created the subfamily name Flabellininae (1889, page 215) which has subsequently been raised to family level (e.g. Thompson & Brown, 1984).

Genus *Flabellina* Voigt, 1834

*Type species* *Flabellina affinis* (Gmelin, 1791) by monotypy.

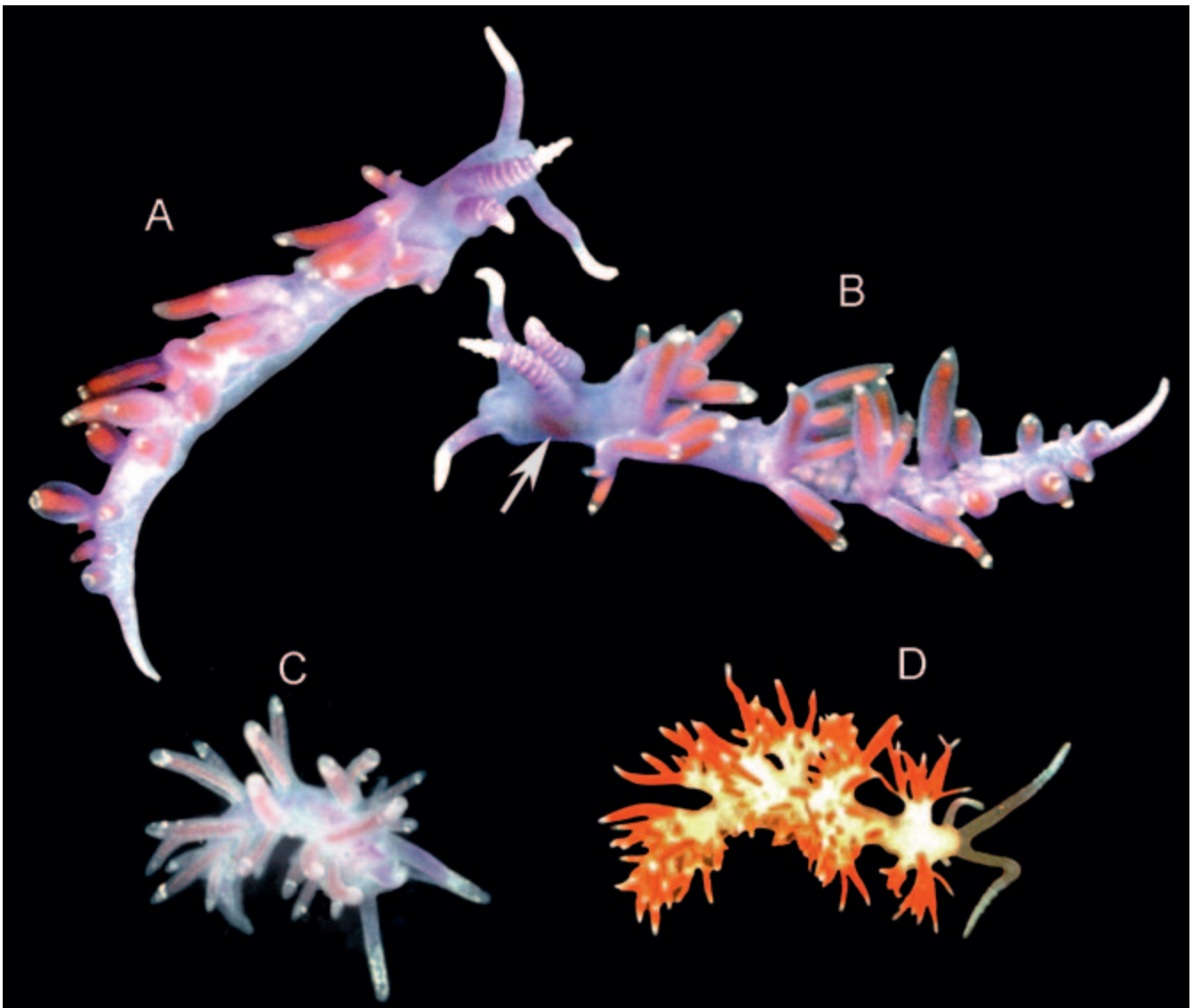
*Diagnosis* (based on Thompson & Brown, 1984) Flabellinids characterised by the cerata arising from short peduncles.

*Flabellina rubromaxilla* n. sp.

Figs 1A, B; 2

*Flabellina affinis* – Edmunds, 1977: 302.

*Flabellina* aff. *funeka* Ortea & Espinosa, 1998: 144.



**Figure 1A–B** *Flabellina rubromaxilla* n. sp.: Kpone Bay, two images of same specimen 7mm long, February 1970. Arrow in **B** indicates red jaw. **C** *Flabellina albomaculata* Pola, Carmona, Calado & Cervera, 2015: Tema, 3mm long, November 1968. **D** *Flabellina evelinae* Edmunds 1989: Port Harcourt, Nigeria, 7mm preserved, 1983, photo by Jim Wright.

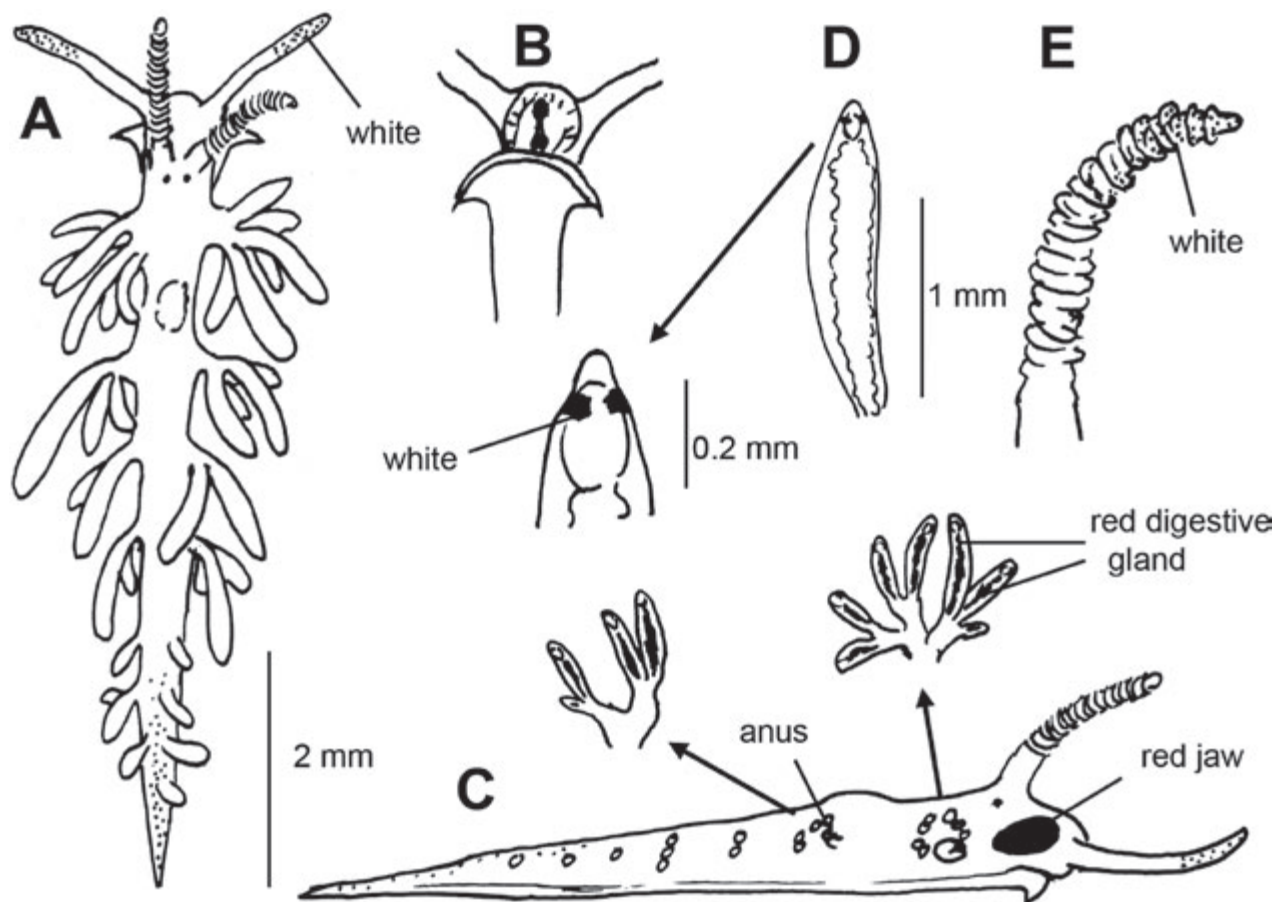
*Material examined* (Holotype) 10m reef Kpone Bay 1 spec. 7mm long, 6 February 1970, NHMUK reg. no. 20150405.

*External features* Body slender, foot rounded anteriorly, bilabiate with short, pointed corners, pointed tail extending beyond last cerata (Figs 1A, B; 2A, B); oral tentacles 1.5mm long, rhinophores almost 2mm long, with about 18 annulae, several of them incomplete (Fig. 2E); cerata arranged in short rows arising from raised peduncles (Fig. 2C), with two peduncles on each of the first two groups of cerata (3/4 indicates three cerata arising from the first peduncle and four from the second): 3/4; 2/3, 2/2, 2, 1, 2, 1 on the left side and 3/4; 2/2, 2, 3, 1, 1, 1, 1 on the right. Cerata normally up to 1.5mm long, each ceras slender, linear, with slight taper to rounded tip; anus just anterior to first ceratal group of posterior digestive gland; genital openings below first group of cerata (Fig. 2C).

*Colouration* Entire body bluish violet, colour in dense minute dots so that it appears to be a suffusion, foot paler, scattered white pigment dorsally between last rows of cerata and on tail (Figs 1A, B; 2A); oval-shaped jaws red, conspicuous in side view (Figs 1B, 2C) but appearing violet when viewed obliquely as in Fig. 1B (this pigment may be in the epithelium covering the jaw); basal half of oral tentacles violet, distal half white; rhinophores bluish violet becoming more reddish violet distally, top three lamellae and tip white with a few white spots on upper violet lamellae; cerata pale violet basally merging to pale grey distally, hepatic gland scarlet, cnidosac transparent with (usually) two white spots in cnidosac region (Fig. 2D), sometimes one or three spots or forming a complete ring.

*Internal morphology* Not examined

*Geographical range* Known from Ghana and Angola (Ortea & Espinosa, 1998; see below).



**Figure 2A–E** *Flabellina rubromaxilla* n. sp.: **A** dorsal view of living animal; **B** ventral view of head; **C** side view, semi-diagrammatic to show arrangement of cerata, with insets of first two groups of cerata on peduncles; **D** ceras with inset of tip to show white spots; **E** side view of rhinophore.

*Etymology* The species is named from its characteristic red jaws.

*Remarks* This species was first recorded from Ghana by Edmunds (1977) under the name *Flabellina affinis*, this being the only purple species of the genus with lamellate rhinophores known from Europe at that time. Many more species of *Flabellina* have been described since 1977, from both sides of the Atlantic, some of which have violet colouration. All of the West Atlantic species described by Valdés, Hamann, Behrens & DuPont (2006) differ from this species in colouration. Table 1 lists the East Atlantic and Mediterranean species of *Flabellina* with intense violet or purple suffusion to the body together with details of the jaws, rhinophores and ceratal colouration by which they can be distinguished. The present species differs from all of the species listed above it in Table 1 in having red jaws and white spots rather than a complete white band round the cnidosac. The specimen from Angola described by Ortea & Espinosa (1998) as *Flabellina* aff. *funeka* also has red jaws so is probably conspecific with my specimen from Ghana rather than with true *F. funeka* which occurs on the Indian Ocean side of Cape Town. Specimens from Principe identified as *F. arveloi* (Wirtz, 2004) have a white band round the cnidosac and smooth rhinophores so are not conspecific with my specimen from Ghana (photo kindly provided by Peter Wirtz). There is one other species of *Flabellina* from the Eastern Atlantic with red jaws: *Flabellina confusa* González-Duarte, Cervera & Poddubetskaia, 2008, but this species is not violet.

Although I have just a single specimen of this species and its internal organs are unknown I consider it is sufficiently distinctive for workers to recognise it in the future; it is therefore justifiable to name it.

*Flabellina albomaculata* Pola, Carmona, Calado & Cervera, 2014  
Figs 1C, 3

*Flabellina albomaculata* Pola, Carmona, Calado & Cervera, 2014: 218–222, Figs 1, 2.

*Material examined* In plankton tow off Tema about 40m depth where net caught in bottom mud 1 spec. 3mm long, 6 November 1968;

dredged from 30m off Tema 1 spec. 3mm long, 8 May 1970.

*External features* Body slender, foot rounded anteriorly with short, blunt projecting corners, pointed tail extending beyond last cerata (Figs 3A, B); oral tentacles 0.75 to 1mm long, rhinophores 1mm long, smooth; cerata arranged in short rows with 2, 3, 4; 3, 3, 2, 1 on each side in both animals (Fig. 3C), the first row arising from a slight ridge, cerata normally up to 1mm long, but more when the animal is disturbed and they are fully extended, each ceras linear with slight taper to rounded tip. Anus just in front of first row of cerata of posterior digestive gland in both specimens; there was no trace of the genital openings so the animals were evidently not sexually mature.

*Colouration* Body greyish white, but dorsal surface from in front of rhinophores to just behind last cerata tinged bright magenta or purple (Fig. 1C), the colour residing in dense, minute dots; sides paler purple fading to greyish ventrally, buccal mass tinged pale red; foot greyish white. Basal half of oral tentacles tinged pale purple, distal half with white reticulation, tip clear. Rhinophores magenta or purple, distal sixth grey with a few white spots, tip clear. Digestive gland in cerata red with colour concentrated in numerous small tubercles (Fig. 3F), cnidosac transparent in one specimen, white in the other, with white spots in cnidosac region sometimes forming a crescent or ring.

*Internal morphology* The fragile jaws were partly crushed but there was no trace of denticles on the cutting edge. There are 18 teeth to the radula each with four denticles on each side of the cusp (Fig. 3D). Because the specimen was so small the radular teeth were minute and I was unable to confirm the presence of lateral teeth.

*Behaviour* When crawling the cerata in each row are held at an angle to one another as shown in Fig. 3E.

*Geographical range* Known from the Cape Verde archipelago and now from Ghana (Pola *et al.*, 2014; this paper).

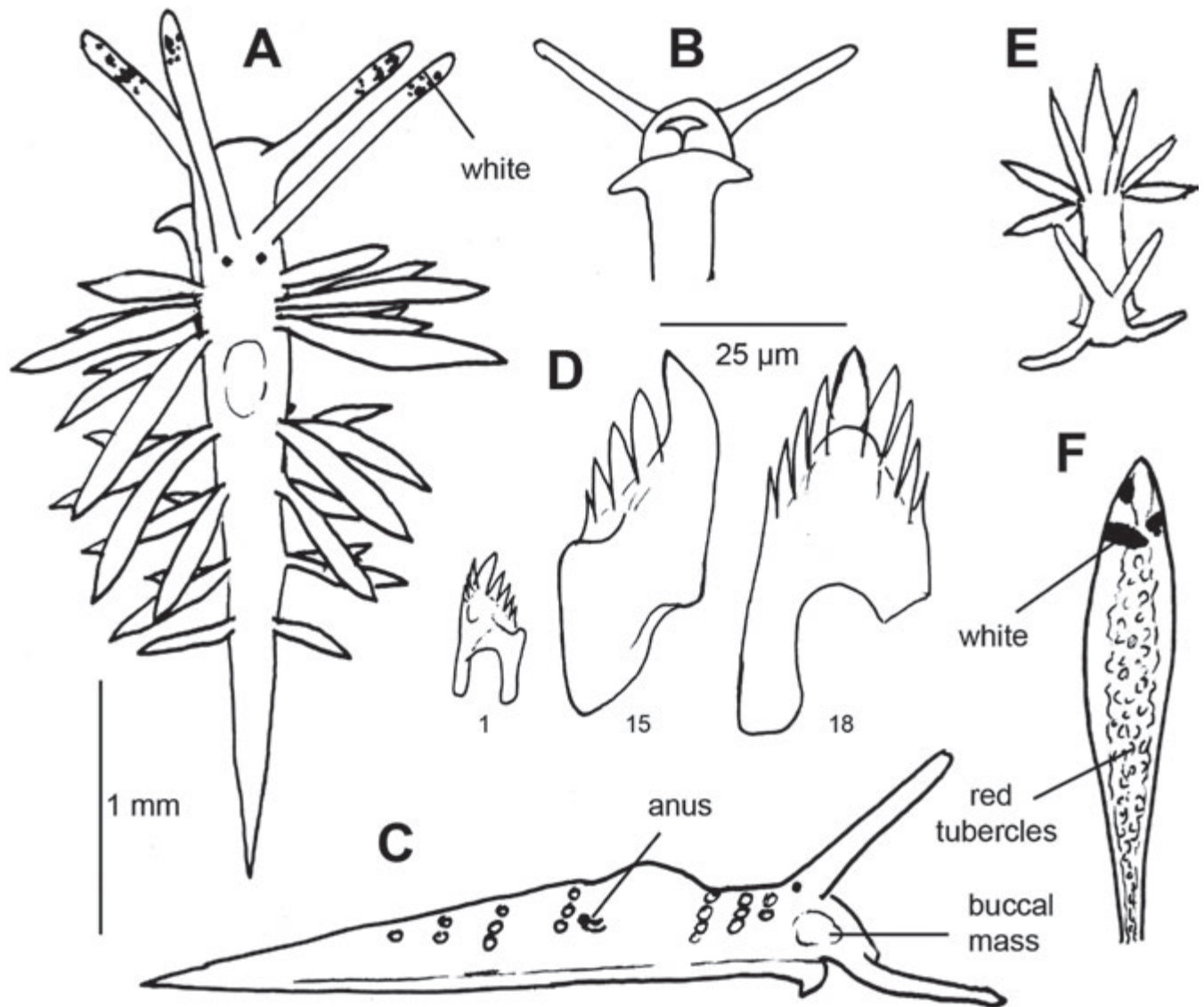
*Remarks* *Flabellina albomaculata* differs from other violet species of *Flabellina* from the East Atlantic in having smooth rhinophores, oral tentacles



**Table 1** Distinguishing characteristics of East Atlantic species of *Flabellina* with violet body.

| Species  | Geographical range                                | Jaws        | Rhinophores                                      | Colour marks on cerata   | Colour of digestive gland |
|--|---|-------------|--|--|---------------------------|
| <i>Flabellina affinis</i> (Gmelin, 1791) <sup>1,2</sup>                  | Mediterranean                                     | Translucent | Lamellate, tipped white                          | Epithelium violet, subapical white band, below this dark violet band | Cream to red              |
| <i>Flabellina ischitana</i> Hirano & Thompson, 1990 <sup>3,4</sup>       | Portugal  | Translucent | Lamellate, tipped white                          | Epithelium violet basally, subapical white band                      | Orange to red-orange      |
| <i>Flabellina pedata</i> (Montagu, 1815) <sup>1,5,6</sup>                | East Atlantic from Norway to Spain, Mediterranean | Translucent | Wrinkled, tipped white                           | Epithelium violet, subapical white band                              | Red                       |
| <i>Flabellina alternata</i> Ortea & Espinosa, 1998 <sup>7</sup>          | Angola, Canaries                                  | Translucent | Alternating large & small lamellae, tipped white | Epithelium translucent, white tipped                                 | Red                       |
| <i>Flabellina arceloi</i> Ortea & Espinosa, 1998 <sup>7</sup>            | Cape Verde Islands                                | Translucent | Papillate, tipped white                          | Epithelium violet, subapical white band                              | Red                       |
| <i>Flabellina funeka</i> Gosliner & Griffiths, 1981 <sup>8</sup>         | South Africa Cape Province                        | Translucent | Lamellate, tipped white                          | Epithelium colourless, peduncles purple, subapical white band        | Red                       |
| <i>Flabellina albomaculata</i> Pola <i>et al.</i> 2015 <sup>9</sup>      | Cape Verde Islands                                | Translucent | Smooth   | Epithelium pinkish, scattered white spots subapically                | Red                       |
| <i>Flabellina llerae</i> Ortea 1989 <sup>7</sup>                         | Cape Verde Islands                                | Translucent | Lamellate, yellowish, lilac & white distally     | Lilac, tip yellow with white lines                                   | Lilac, red distally       |
| <i>Flabellina rubrolineata</i> (O'Donoghue, 1929) <sup>10</sup>          | Indo-Pacific, Eastern Mediterranean               | Translucent | Papillate  | Variable, but with red or violet longitudinal lines on body          | Lilac or reddish          |
| <i>Flabellina rubromaxilla</i> n. sp. <sup>11</sup>                      | Ghana   | Red         | Irregularly lamellate, tipped white              | Epithelium violet basally, 1–3 white spots subapically               | Red                       |
| <i>Flabellina</i> aff. <i>funeka</i> Ortea & Espinosa, 1998 <sup>7</sup> | Angola  | Red         | Lamellate, tipped white                          | Purple peduncles, subapical band of white                            | Red                       |

References: <sup>1</sup>Schmekel & Portmann, 1982; <sup>2</sup>Mediterranean Opisthobranchs, 2014; <sup>3</sup>Hirano & Thompson, 1990; <sup>4</sup>Cervera, López-González & García-Gómez, 1998; <sup>5</sup>Picton & Morrow, 2010; <sup>6</sup>Thompson & Brown, 1984; <sup>7</sup>Ortea & Espinosa, 1998; <sup>8</sup>Gosliner & Griffiths, 1981; <sup>9</sup>Pola, Calado, Carmona & Cervera, 2015; <sup>10</sup>Rudman, 1998; <sup>11</sup>this paper.



**Figure 3A–F** *Flabellina albomaculata* Pola, Carmona, Calado & Cervera, 2015: **A** dorsal view; **B** ventral view of head; **C** side view, semi-diagrammatic to show arrangement of cerata; **D** 1<sup>st</sup>, 15<sup>th</sup> and 18<sup>th</sup> radular teeth, the latter with a broken basal arm; **E** normal position of cerata when crawling; **F** ceras.

and rhinophores with purple base and white tip, garnet-red digestive gland in cerata, and white spots on the cerata concentrated near the tip (Pola *et al.*, 2014). The two specimens from Ghana agree with *F. albomaculata* in all of these characters. The only character in which they differ is that *F. albomaculata* has 6–10 denticles on each side of the radular cusp whereas my specimen has just 4. However, my specimens were just 3mm long alive compared with up to 12mm for the Cape Verde specimens, and in many aeolids the number of lateral denticles in the radular teeth increases with the size of the animal. I therefore conclude that my Ghanaian specimens are *Flabellina albomaculata*.

One other species of *Flabellina* is known from the West African coast: *Flabellina evelinae* Edmunds, 1989 from Nigeria. This species has not been found since its original description, probably because it is one of the few species that occurs in low salinity water. It differs from the present species in the body being white rather than purple and is illustrated here for the first time (Fig. 1D).

#### Family Piseinotecidae Edmunds, 1970

*Diagnosis* (Edmunds, 1970) Aeolidacea with the anus in the interhepatic space (acleioproct), uniseriate radula, cerata on raised stalks or in rows

but with only one row or tuft arising from the anterior digestive gland, with hermaphrodite follicles in the gonad and with receptaculum proximal to the capsule and mucous glands, penis unarmed.

*Remarks* Recent phylogenetic studies of aeolids using both morphological and molecular characters has shown that the species of *Piseinotecus* are not monophyletic but are closely related to species of *Flabellina* (Gosliner, González-Duarte & Cervera, 2007; Carmona, Gosliner, Pola & Cervera, 2011; Carmona, Pola, Gosliner & Cervera, 2013), indeed Carmona *et al.* (2013) found that three species of *Piseinotecus* are sister species to three different species of *Flabellina*. This suggests that these two genera should belong to the same family, the Flabellinidae, with the Piseinotecidae as a junior synonym. It also suggests that *Piseinotecus* needs to be redefined based on the type species *P. divae* Marcus 1955 with several other species currently placed in *Piseinotecus* being moved to other genera. The phylogenetic analysis also implies that the reduction of the triseriate radula of *Flabellina* to a uniseriate condition in *Piseinotecus* has occurred several times independently, indeed most of the characters normally used in defining the Flabellinidae (see above) do not apply to the species currently assigned to *Piseinotecus*. Further phylogenetic work is required on species currently placed in *Flabellina* and *Piseinotecus* to resolve this issue, but for this paper I am following Tamsouri, Carmona, Moukrim & Cervera (2014) by retaining the family Piseinotecidae and the genus *Piseinotecus*.

#### Genus *Piseinotecus* Marcus, 1955

*Type species* *Piseinotecus divae* Marcus, 1955 by monotypy.

*Diagnosis* *Piseinotecus* is currently the only genus in the family so it has the characters of the family.

#### *Piseinotecus sphaeriferus* (Schmekel, 1965) Figs 4, 6A

*Calmella sphaerifera* Schmekel, 1965: 452–461, Figs 1–5.

*Piseinotecus sphaerifera* – Edmunds, 1970: 39.

*Piseinotecus sphaeriferus* – Schmekel & Portmann, 1982: 195–7, Pl. 9.1, Fig. 7.56.

*Material examined* 10m reef Kpone Bay 6 spec. 4.5, 4.5, 4.0, 3.5, 3.5, & 2.5mm long, 12 October 1969, Reg. nos. NHMUK 20150402 & Slides 1–7 NHMUK 20150409.

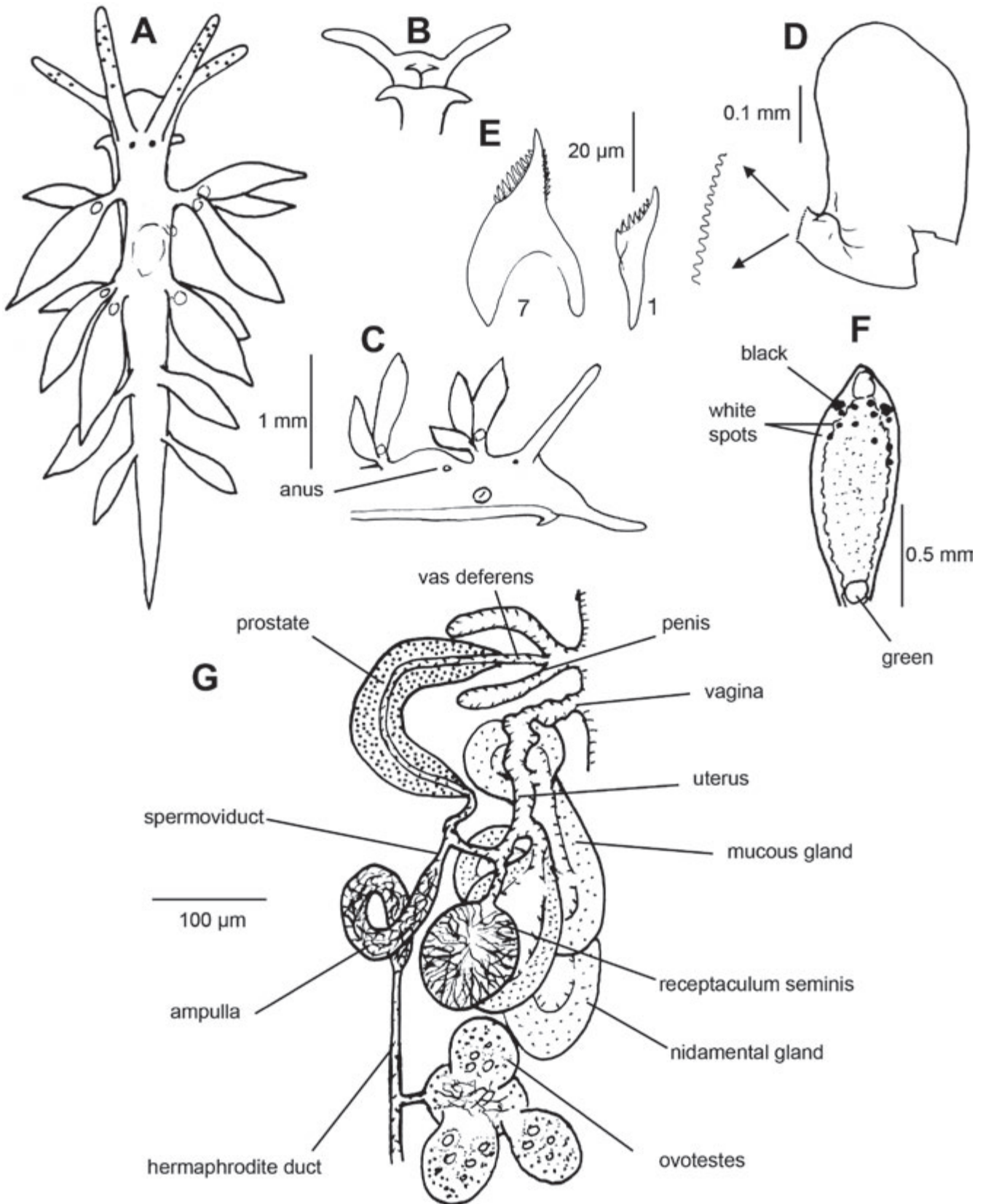
*External features* Body slender tapering to long tail with angular foot corners and a hint of a notch anteriorly (Figs 4A, B; 6A); oral tentacles of larger specimen 0.7mm, rhinophores 1mm and larger cerata 1mm long (or slightly more); rhinophores smooth; one row of cerata in front of heart, three rows behind it, each row arising from a common stalk with the maximum numbers of cerata in each row 5; 3, 2, 2 (Fig. 4C); cerata spindle-shaped, but more squat when contracted (Fig. 4F); anus high up on right side just behind first group of cerata and level with front of pericardial hump (Fig. 4C).

*Colouration* Body pale grey with zero or 1–3 circular white spots on each of head, back, sides and bases of cerata; oral tentacles and rhinophores with a few white spots distally (Fig. 4A: this specimen had no white spots on head or back); cerata pale grey with a few subepidermal white spots distally below white cnidosac, larger cerata with 2–3 black spots in this region and with a spherical green spot at the base (Figs 4F; 6A), digestive gland in cerata pale brown with some reddish brown mottling.

*Internal morphology* The buccal mass from a 3.5mm specimen was removed for examination before serial sectioning the rest of the animal. The oval jaw has 23 rounded denticles on the cutting edge (Fig. 4D, note break when flattened). There were 9 horse-shoe shaped teeth in the radula with 7–9 denticles arising from the sides of the cusp on each side (Fig. 4E).

In the reproductive system (Fig. 4G) the hermaphrodite duct runs into a slender looped ampulla. The spermoviduct is short, the male duct entering the U-shaped prostate which extends into the base of the broadly conical unarmed penis. The circular receptaculum seminis with spermatozoa attached to its wall by their heads arises from the oviduct before it enters the nidamental and mucous glands.

*Geographical range* Mediterranean (Schmekel, 1965; Schmekel & Portmann, 1982), Canaries



**Figure 4A–G** *Piseinotecus sphaeriferus* (Schmekel, 1965), 3.5mm long: **A** dorsal view; **B** ventral view of head; **C** side view, semi-diagrammatic to show arrangement of anterior cerata; **D** jaw, damaged bottom right when the curved structure was flattened; **E** 7<sup>th</sup> and 1<sup>st</sup> radular teeth; **F** ceras; **G** diagram of reproductive system reconstructed from serial sections.



(Cervera *et al.*, 2006), Ghana (Edmunds, 1977, this paper).

*Remarks* These specimens agree closely with the descriptions of this species from the Mediterranean (Schmekel, 1965; Schmekel & Portmann, 1982) in size, shape, colouration, pedunculate cerata with green spheres at the bases of the larger ones and radula. Although Schmekel & Portmann report up to 14 denticles on each side of the cusp they may have been looking at a larger specimen than the 3.5mm one reported here with just 9 denticles on each side of the cusp (their largest specimens were 5.5 and 6mm long). The reproductive system described here is similar to that depicted by Schmekel when allowance is made for the different appearances of a dissection and a reconstruction from serial sections. There is a report of *Piseinotecus sphaeriferus* from the Adriatic but the colour illustration (in both Mavrič & Lipej, 2012, and Tamsouri *et al.*, 2014) shows no trace of the green spheres at the ceratal bases which are characteristic of this species, so its identity is uncertain.

*Piseinotecus minipapilla* n. sp.

Figs 5; 6B

*Material examined* 10m reef Kpone Bay, 4 spec. 4, 3.5, 2.5 & 2mm long, on red algal turf with hydroids, 14 December 1969, Reg. nos. NHMUK 20150403, 20150404 & Slides 1–4 NHMUK 20150410.

*Holotype* Reg. no. NHMUK 20150403, 3.5mm long, on red algal turf with hydroids, 10m reef Kpone Bay, Ghana, 14 December 1969, collected by W. Pople.

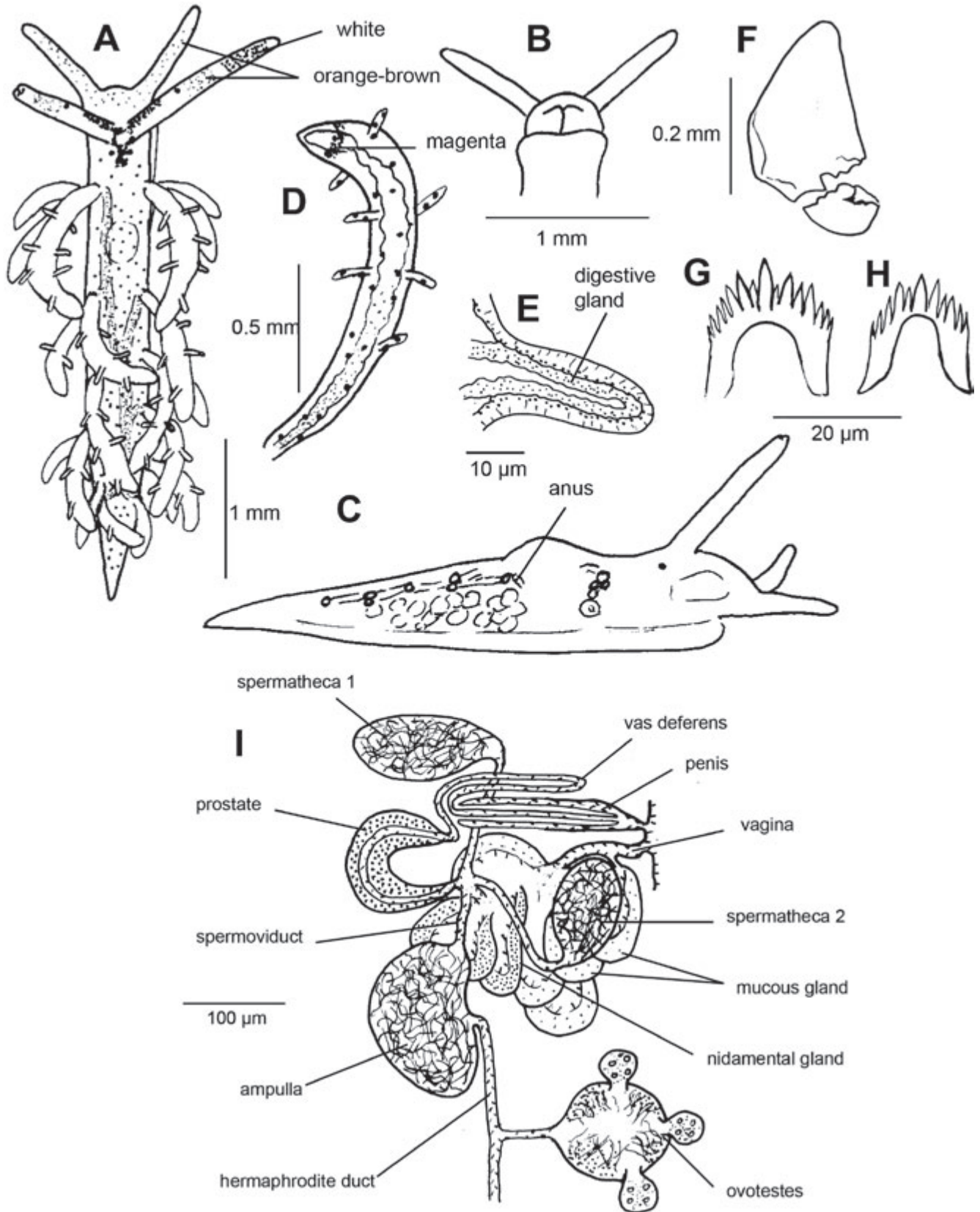
*External features* Body slender tapering to short blunt tail with rounded foot anteriorly (Figs 5A, B; 6B); oral tentacles up to 0.7mm, rhinophores up to 2mm and cerata up to 2mm long in largest specimen; rhinophores smooth; anterior cerata in clusters, posterior 5 or 6 groups in short rows: a 3.5mm specimen has 3; 2, 1, 2, 1, 1 cerata on left and 4; 1, 2, 1, 2, 1 on right (Fig. 5C), a 2mm specimen has 3; 2, 1, 1, 1 on left and 3; 1, 2, 1, 1 on right (there were 5 cerata in the anterior digestive gland of both the 4mm and the 2.5mm specimens), all four specimens have a single ceras in the first group of cerata of the posterior digestive gland on the right but 2 or 3 cerata in the equivalent group on the left; cerata slender, slightly rugose,

largest cerata of two large specimens with up to four pairs of digitiform papillae, smaller cerata smooth or with one or two slightly raised tubercles; anus visible in living animal high up very close in front of first row of cerata of posterior digestive gland (acleioproctic) (Fig. 5C).

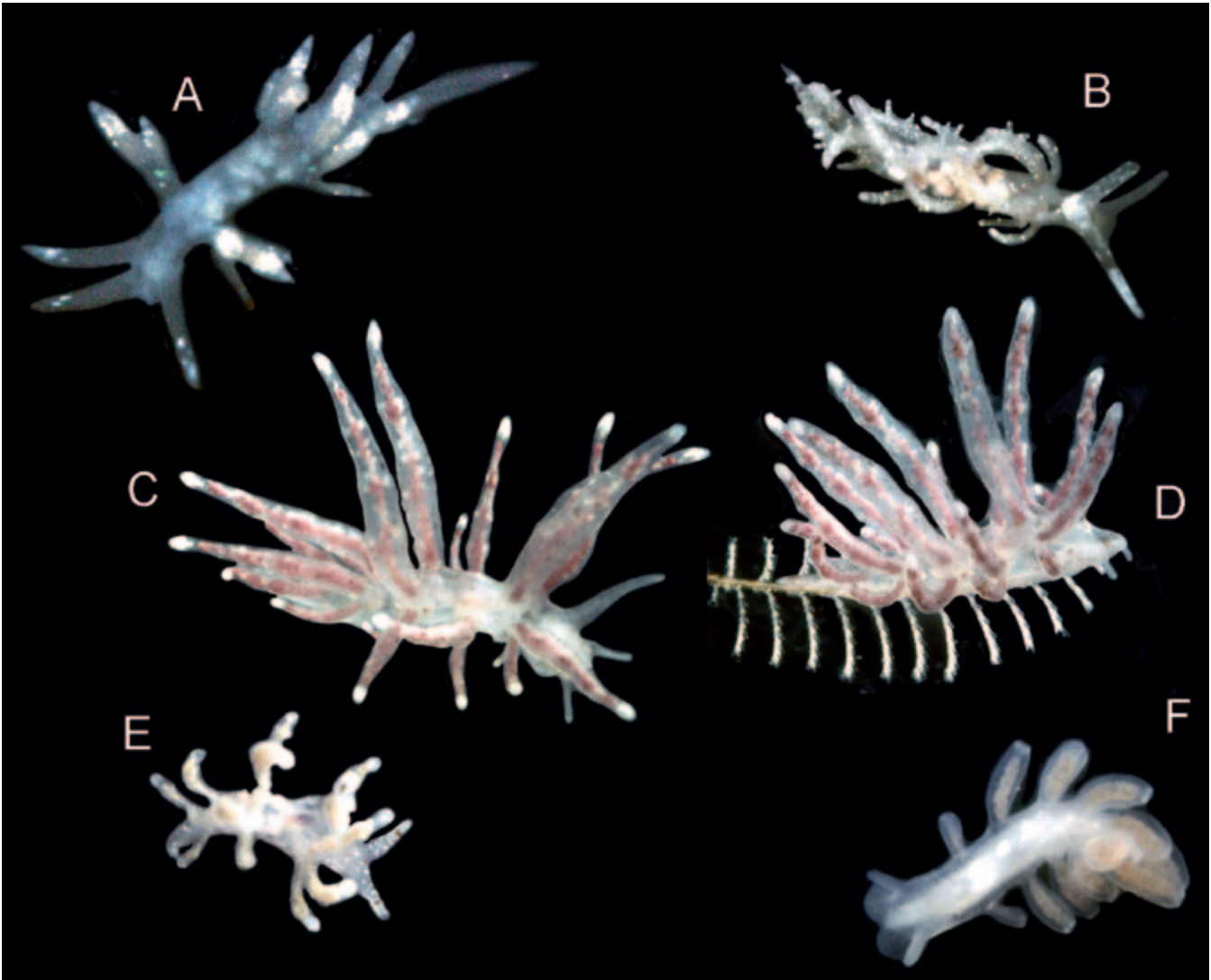
*Colouration* Body pale grey tinged orange-brown especially on head with sparse circular white spots scattered over body, white patch with yellow centre between rhinophores in two largest specimens (Figs 5A; 6B); orange-brown to pale brown digestive gland ducts visible dorsally; oral tentacles tinged orange-brown lacking white spots; rhinophores pale grey (tinged yellow in smallest specimen) with white patch on basal inner side, white spots in basal half, then a band tinged orange-brown, distal region white with minute clear tip; cerata pale grey with a few scattered white spots especially on digitiform tubercles, cnidosac white, ring of minute magenta dots or magenta suffusion near tip of largest cerata (Fig. 5D), digestive gland ducts in cerata orange-brown at base, pale brown or colourless distally, with a few white spots and (in largest cerata only) a few dark brown spots; sides of foot tinged orange-brown.

*Internal morphology* The radula and jaws of the 2.5mm animal were examined. The radula has 13 teeth each with the cusp projecting slightly beyond the lateral denticles; there are 5 denticles on each side of the cusp, the inner three irregular in size with the two outer ones smaller (Fig. 5H). The radula of the 4mm specimen was damaged but six of the remaining eleven teeth were just 20µm in width, scarcely larger than those of the smaller specimen, but with up to 7 irregular denticles on each side of the cusp (Fig. 5G). The jaws of both specimens were damaged while attempting to flatten the radula so I cannot confirm if the cutting edge was smooth or toothed (Fig. 5F).

The 4mm specimen was serial sectioned which enabled the precise position of the anus to be confirmed. Branches of the digestive gland in the cerata run up the small papillae and end blindly (Fig. 5E). There are a small number of mucous glands in the ceratal epidermis but there is no trace of the dense array of mucous and other glands in the cnidosac region which are characteristic of most species of Eubranchidae and Cuthonidae (Edmunds, 1966).



**Figure 5A-I** *Piseinotecus minipapilla* n. sp., 3.5mm long: **A** dorsal view of living animal with broken left rhinophore; **B** ventral view of head; **C** side view, semi-diagrammatic to show arrangement of cerata; **D** ceras. 4mm specimen: **E** histological section of ceratal papilla; **F** damaged jaw; **G**, 8<sup>th</sup> radular tooth. 2.5mm specimen: **H** 8<sup>th</sup> radular tooth; **I** diagram of reproductive system reconstructed from serial sections.



**Figure 6A** *Piseinotecus sphaeriferus* (Schmekel, 1965): Kpone Bay, 4.5mm long, October 1965. **B** *Piseinotecus minipapilla* n. sp.: Kpone Bay, 4mm long, December 1969. **C, D** *Eubranchus rubrocerata* n. sp.: Kpone Bay, two images of same specimen 6mm long, November 1968. **E** *Eubranchus prietoi* Llera & Ortea, 1981: Kpone Bay, 2mm long, October 1968. **F** *Embletonia pulchra* Alder & Hancock, 1844: Tema Bay, 4mm long, June 1970.

The reproductive system was reconstructed from the serial sections which confirmed that the 4mm animal was sexually mature (Fig. 5I). The kidney-shaped ampulla was full of sperm; there follows a short spermoviduct branching into four distinct ducts which arise so close together that it was not possible to determine which arose first. One leads into a U-shaped prostate followed by a long looped vas deferens to the slender penis which is unarmed. There is no penial gland. The second branch from the spermoviduct is short and opens into the nidamental part of the female gland mass. The third and fourth branches from the spermoviduct lead via long ducts to two oval spermathecae, one lying anteriorly to the penis,

the other lateral to the female gland mass and the penis and reached by a looped duct. Both sacs are full of sperm but these do not appear to be attached to the wall, so I cannot determine if one is a copulatory bursa and the other a receptaculum; I therefore call both sacs spermathecae. The vagina is short and appears to have more than one opening into the mucous part of the female gland mass.

*Geographical range* Known only from this single collection of specimens from Ghana.

*Etymology* The species is named from its characteristic minute papillae on the larger cerata.



*Remarks* I consider this species belongs to the genus *Piseinotecus* because of its acleiopect anus, a single row of cerata arising from the anterior digestive gland diverticulum, the receptaculum opening into the oviduct proximal to the female glands and uniseriate radula. It differs from all other species of the genus in having papillae on the larger cerata and having two receptacula (which I have called spermathecae pending information on their function). Most species of *Flabellina* have just one receptaculum but *Flabellina pedata* also has two (Schmekel & Portmann, 1982).

A few aeolids have tubercles or papillae on the cerata: *Piseinotecus gonja* Edmunds, 1970 has small tubercles, *Eubranchnus virginalis* (Baba, 1949) and *Eubranchnopsis indicus* Rao, 1968 have more elaborate tubercles, *Limenandra nodosa* Haefelfinger & Stamm, 1958 has small irregular sized papillae, while some species of *Phyllodesmium* and *Cuthona kuiteri* Rudman, 1981 have complex excrescences resembling their coelenterate food. However, only *Cuthona kuiteri* and *Piseinotecus minipapilla* have linear papillae containing blind branches of the digestive gland.

#### Family Eubranchnidae Odhner, 1934

*Diagnosis* (based on Thompson & Brown, 1984) Aeolids with short body, rounded foot and usually smooth rhinophores; inflated and often angled or tuberculate cerata arranged in simple or branched rows, usually with dense defensive epidermal glands in cnidosac region; anus in interhepatic space on right side, three rows of radular teeth, lateral ones usually lacking serrations; penial gland present, prostate and penial stylet usually present; larval shell inflated (type 1 of Thompson, 1961).

#### Genus *Eubranchnus* Forbes, 1838

*Type species* *Eubranchnus tricolor* Forbes, 1838 by monotypy.

*Diagnosis* The genus *Eubranchnus* is currently defined with the characteristics of the family but lacking additional complex stylets or glands in the reproductive system. Edmunds & Kress (1969) discussed splitting the genus into three or four genera but each genus would be distinguished by a single character which they felt was unsatisfactory. More recently Martynov (1998) has described several new eubranchnids

with unusual characters in the reproductive system and he has revised the family recognising seven genera, mainly based on details of the reproductive system. However, since the reproductive system is not known for the two species described in this paper I have placed them in the established genus *Eubranchnus sensu lato*, and I suggest that the genera of the family should await a comprehensive phylogenetic analysis of the known species.

#### *Eubranchnus rubrocerata* n. sp.

Figs 6C–D, 7

*Material examined* (Holotype) 10m reef Kpone Bay, 1 spec. 6mm long, 4 November 1968, Reg. no. NHMUK 20150379.

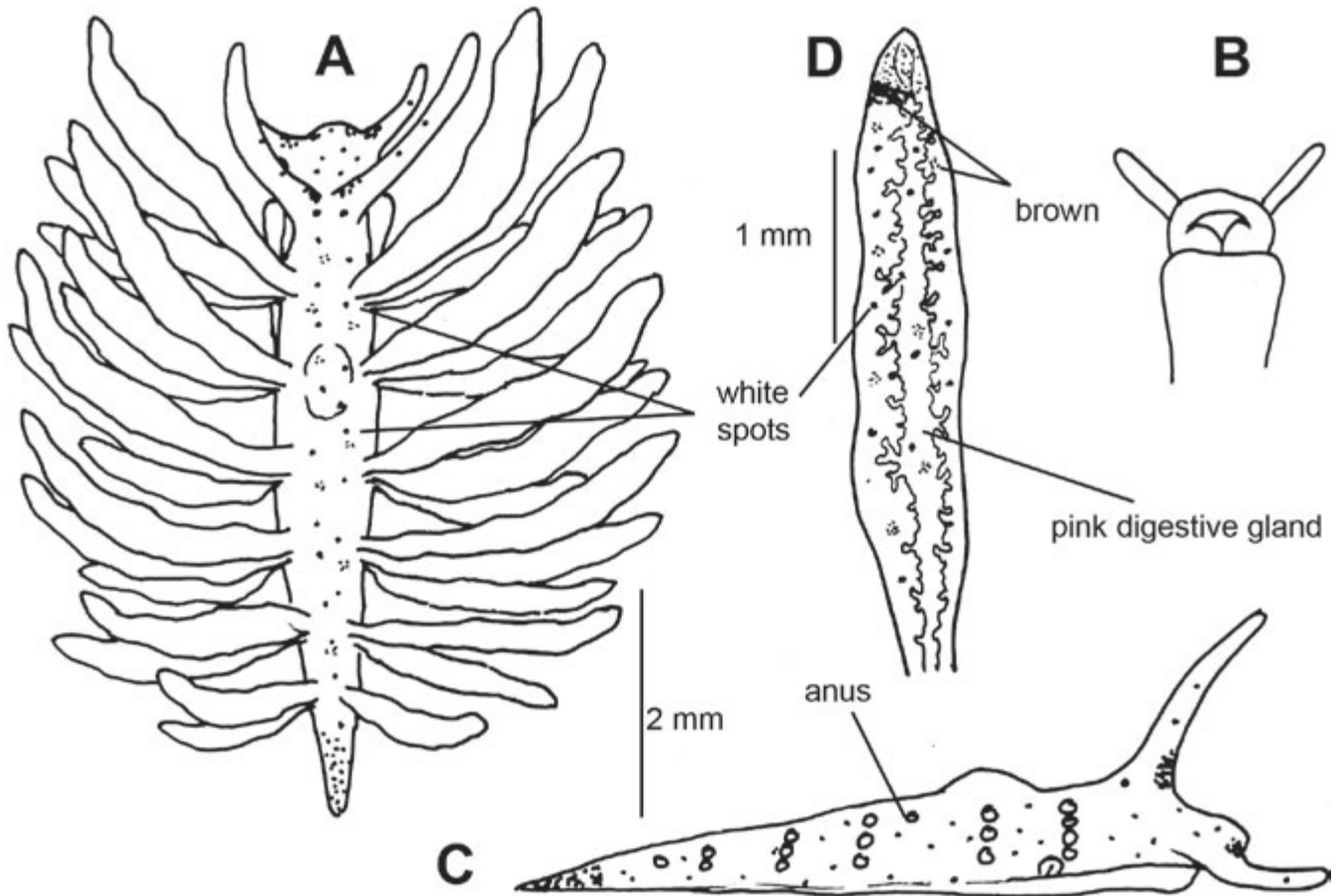
*External features* Body slender tapering to short blunt tail with rounded foot anteriorly (Figs 6C, D; 7A, B); oral tentacles slightly curved, 0.6mm long; rhinophores smooth, curved, 1.7mm long; cerata in vertical rows, 4, 3; 3, 3, 2, 2 on left side, 4, 3; 3, 3, 2, 1 on right, last two rows very close together (Fig. 7C); cerata up to 4mm long slender, very slightly rugose when contracted, with blunt tip, digestive gland ducts with branching lobules (Figs 6C, D; 7D).

*Colouration* Body whitish grey with about 8 white spots on dorsum and numerous small brown spots scattered over dorsal and lateral surfaces, more densely on short tail (Figs 6C, D; 7A); oral tentacles with brownish spot at base and one smaller spot near middle; rhinophores with large brown stripe anteriorly at base and two brown spots nearer middle; cerata pale grey, larger ones with 5–10 small white spots and 20–30 larger brown spots, both denser distally, sometimes with brown forming a partial band in cnidosac region, cnidosac white partly obscured by dense white glands as in other species of *Eubranchnus* (Edmunds, 1966), digestive gland ducts pale red or pink with lobules paler (Fig. 7D); foot whitish grey.

*Internal morphology* The internal anatomy was not examined so as not to damage the single specimen.

*Behaviour* The cerata are typically erect in the resting animal but extended at an angle laterally or held over the back when crawling. When





**Figure 7A–D** *Eubranchus rubrocerata* n. sp.: **A** dorsal view of living animal; **B** ventral view of head; **C** side view to show arrangement of cerata; **D** ceras. Coarse stipple is brown pigment, fine stipple is white. **A**, **B** and **C** all to same scale.

put into a relaxing medium before fixation (MS 222 in sea water) a copious white exudate was produced from the white defensive glands at the tips of the cerata.

*Geographical range* Known only from this record from Ghana.

*Etymology* The species is named from its large reddish cerata.

*Remarks* So as not to damage the single specimen I have not examined the radula or reproductive system, but it is so distinctive in colour and behaviour that it should be easy for future workers to recognise it. I have therefore decided that it is appropriate to name it as a new species in the genus *Eubranchus sensu lato*. It has all of the external features characteristic of the family and genus (see above). It differs from all other Atlantic species of *Eubranchus* in its large, almost smooth (very slightly rugose) cerata held at

characteristic angles dorso-laterally, pink digestive gland in cerata and brown and white markings (see Table 2).

*Eubranchus prietoi* Llera & Ortea, 1981  
Figs 6E, 8

*Eubranchus prietoi* Llera & Ortea, 1981: 266–270, Figs 1–3, Pl. A–E.

*Material examined* 10m reef Kpone Bay, 1 spec. 2mm long, on hydroids, 21 October 1968, Reg. no. NHMUK 20150406.

*External features* Body broad with rounded foot anteriorly and short tail (Figs 6E, 8A); rhinophores twice as long as oral tentacles, smooth; cerata arranged in short rows 3; 3, 2, 1 on each side of body, longest cerata considerably longer than rhinophores, up to a third of body length when extended, each ceras with two tiers of up to four rounded tubercles less noticeable when cerata

**Table 2** European and east Atlantic species of *Eubbranchus* showing distinctive external characters by which they differ from *Eubbranchus rubrocerata* n.sp.

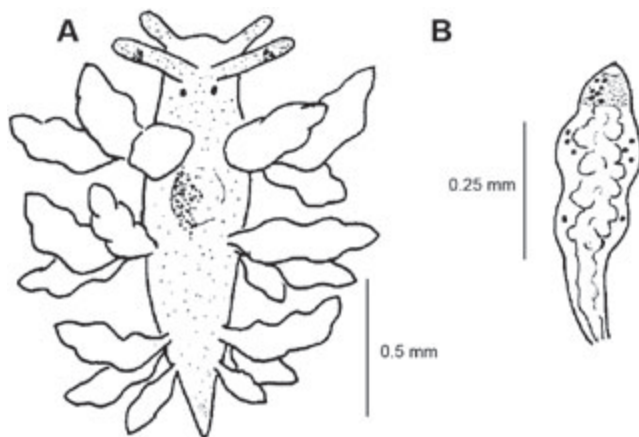
| Species   | Geographical range  | Distinguishing features  |
|---|---|--|
| <i>Eubbranchus amazighi</i> Tamsouri, Carmona, Moukrim & Cervera, 2015 <sup>1</sup> | Morocco   | Cerata smooth, orange-red & yellow spots on body & cerata, red-orange & white rings near tips of cerata, digestive gland ochre                                 |
| <i>E. arci</i> Ortea, 1981 <sup>2</sup>   | Canaries  | 2 tiers of tubercles, cream to red-brown digestive gland, greenish or brownish on body & cerata  |
| <i>E. capellinii</i> (Trinchese, 1879) <sup>3, 4, 5, 6</sup>                        | British Isles and Atlantic coast of Europe, Mediterranean               | 2–3 tiers of tubercles, cream to red-brown digestive gland, greenish or brownish on body & cerata  |
| <i>E. cingulatus</i> (Alder & Hancock, 1847) <sup>3, 4, 7, 8</sup>                  | Norway and Atlantic coast of Europe, Mediterranean                      | Cerata smooth, slender, occasionally with 2–3 tiers of very low tubercles, pale digestive gland, green or brown rings on cerata and as scattered spots on body |
| <i>E. coniclus</i> (Marcus, 1958) <sup>9, 10, 11</sup>                              | Brazil, Caribbean   | 2–3 tiers of tubercles, yellow to olive-greenish digestive gland, greenish or brownish spots on body & cerata  |
| <i>E. convenientis</i> Ortea & Caballer, 2002 <sup>10</sup>                         | Caribbean   | 2 tiers of tubercles, pale digestive gland, numerous white and greenish brown spots on body  |
| <i>E. doriae</i> (Trinchese, 1874) <sup>3</sup>                                     | Italy   | 2–3 tiers of tubercles, green digestive gland, orange spots on body & cerata   |
| <i>E. exiguus</i> (Alder & Hancock, 1848) <sup>4, 5, 6, 7, 17</sup>                 | Norway and Atlantic coast of Europe, Mediterranean                      | Smooth, urn-shaped cerata, pale digestive gland, greenish to brownish colouration  |
| <i>E. farrani</i> (Alder & Hancock, 1844) <sup>4, 5, 6, 7, 12, 17</sup>             | Norway and Atlantic coast of Europe, Mediterranean, Canaries, Azores    | Smooth, often inflated fusiform cerata, pale digestive gland, white, orange & white or orange, white & brown colouration                                       |
| <i>E. leopoldoi</i> Caballer, Ortea & Espinosa, 2001 <sup>10, 11, 13</sup>          | Costa Rica, Canaries  | Smooth, inflated fusiform cerata, red digestive gland, red spots on body and multi-coloured cerata   |
| <i>E. linensis</i> García-Gómez, Cervera & García, 1990 <sup>14</sup>               | Iberian Atlantic coast, Gibraltar                                       | Smooth, slightly fusiform cerata, pale digestive gland, red blotches & white tipped cerata   |
| <i>E. pallidus</i> (Alder & Hancock, 1842) <sup>4, 5, 6, 7, 12</sup>                | North America, Iceland, Norway, Atlantic coast of Europe, Mediterranean | Smooth, often inflated fusiform cerata, pale digestive gland, reddish or brownish and white spots  |
| <i>E. prietoi</i> Llera & Ortea, 1981 <sup>15, 16</sup>                             | Mediterranean, Atlantic coast from France to Senegal                    | Cerata knobbly, cream to olive digestive gland, body pale with brown markings, rhinophores with two dark bands   |
| <i>E. rupium</i> (Möller, 1842) <sup>17, 18</sup>                                   | Greenland, Iceland, Scandinavia   | Smooth, fusiform cerata, brown to greenish digestive gland, reddish brown dots on body & cerata  |
| <i>E. telesforoi</i> Ortea, Caballer & Bacallado, 2002 <sup>19</sup>                | Canaries  | Knobbly cerata, cream digestive gland, white and brown marks on body, rhinophores with two dark bands  |
| <i>E. toledanoi</i> Ortea & Caballer, 2002 <sup>10</sup>                            | Caribbean   | Smooth cerata, reddish spots and blotches all over body and cerata   |
| <i>E. tricolor</i> Forbes, 1838 <sup>4, 5, 6, 7, 17</sup>                           | North America, Greenland, Norway, Atlantic coast of Europe              | Large size, numerous smooth, fusiform cerata, brown digestive gland, yellow tipped cerata  |

| Species   | Geographical range  | Distinguishing features   |
|---|---|---|
| <i>E. vascoi</i> Ortea, Caballer & Moro, 2002 <sup>19</sup> | Azores  | 2–3 tiers of tubercles, dark brown digestive gland, brown on body   |
| <i>E. vittatus</i> (Alder & Hancock, 1842) <sup>6,7</sup>   | British Isles and Atlantic coast of Europe, Mediterranean | Smooth to slightly rugose cerata, cream digestive gland, greenish or brownish on body   |
| <i>E. rubrocerata</i> n. sp. <sup>20</sup>                  | Ghana   | Large slightly rugose cerata with red digestive gland, and numerous brown spots, rhinophores short with anterior brown stripe at base and 2 brown spots near middle |

Principal references: <sup>1</sup>Tamsouri, Carmona, Moukrim & Cervera, 2015; <sup>2</sup>Ortea, 1981; <sup>3</sup>Caballer *et al.*, 2010; <sup>4</sup>Edmunds & Kress, 1969; <sup>5</sup>Thompson & Brown, 1984; <sup>6</sup>Picton & Morrow, 2010; <sup>7</sup>Alder & Hancock, 1845–1855; <sup>8</sup>Ortea & Caballer, 2001; <sup>9</sup>Marcus, 1958; <sup>10</sup>Ortea & Caballer, 2002; <sup>11</sup>Valdés *et al.*, 2006; <sup>12</sup>Schmekel & Portmann, 1982; <sup>13</sup>Caballer, Ortea & Espinosa, 2001; <sup>14</sup>García-Gómez, Cervera & García, 1990; <sup>15</sup>Llera & Ortea, 1981; <sup>16</sup>García-Gómez, 1987; <sup>17</sup>Just & Edmunds, 1985; <sup>18</sup>Martynov, 1998; <sup>19</sup>Ortea, Caballer, Moro & Bacallado, 2003; <sup>20</sup>this paper.

extended, tip broadly rounded. Fig. 8A shows cerata all contracted while in Fig. 6E they are all extended with the tubercles barely noticeable.

**Colouration** Body pale grey with scattered circular white dots, denser on oral tentacles and rhinophores (Figs 6E, 8A); rhinophores with magenta band below tip; magenta digestive gland visible through heart, pale brown gonads visible dorsally between first two rows of cerata of posterior digestive gland; cerata with pale brown digestive gland and superficial white dots concentrated on tubercles and at tip (Fig. 8B) which also has dense white glands obscuring the cnidosac, as in other species of *Eubranchus* (Edmunds, 1966).



**Figure 8A–B** *Eubranchus prietoi* Llera & Ortea, 1981: **A** dorsal view of living animal with cerata contracted; **B** ceras. In **A** coarse stipple on rhinophores and beneath heart is magenta, fine stipple is scattered white dots. In **B** coarse stipple is white spots, fine stipple is white ceratal glands.

**Internal morphology** The radula was not examined so as not to damage this minute specimen.

**Geographical range** Mediterranean, Atlantic coast from France to Senegal (Llera & Ortea, 1981; Poddubetskaia Ossokine, 2005, 2006; Rudman, 2005) and now Ghana.

**Remarks** Identifying small and almost certainly immature eubranchids is not always possible, but the tubercular cerata, one row of cerata from anterior digestive gland, white dots on the body and cerata, pale digestive gland in cerata and coloured ring on rhinophores and in digestive gland beneath the heart indicate that this specimen most closely resembles *Eubranchus prietoi* and *E. telesforoi* (see Table 2). It is possible that *Eubranchus prietoi* and *E. telesforoi* are synonyms: their colouration is similar and although *E. prietoi* has more denticles on its radular teeth than *E. telesforoi* (Ortea, Caballer & Moro, 2002) the number of denticles increases with the size of the tooth in most aeolids, and while the radula of *E. prietoi* came from a 6mm animal that of *E. telesforoi* was from a 2mm specimen. *E. telesforoi* has more dark brown pigment than the original specimens of *E. prietoi*, but Poddubetskaia Ossokine (2005, 2006) illustrates both dark and pale specimens of *E. prietoi*. My specimen differs from previous descriptions of *E. prietoi* (and from *E. telesforoi*) in the colour of the digestive gland beneath the heart, the colour of the rhinophoral band, and in having just one rhinophoral band instead of two. However, some of the specimens of *E. prietoi* illustrated by Llera & Ortea (1981)



and by Poddubetskaia Ossokine (2006) appear to have just a single dark mark on each rhinophore with a faint dark suffusion at the base. I therefore consider that my specimen is most probably *E. prietoi*.

#### Family Embletoniidae Schmekel, 1970

*Diagnosis* (based on Pruvot-Fol, 1954) Dorso-ventrally flattened nudibranchs, anus mid-lateral, single row of cerata on each side, nematocyst pad at tip of each ceras lacking a cnidosac, rhinophores smooth, lacking a sheath, bilobed oral veil, foot rounded anteriorly, jaws with toothed cutting edge, uniseriate radula each tooth having prominent cusp and several lateral denticles, receptaculum opening into genital atrium, no prostate or penial gland.

*Remarks* The Embletoniidae have been considered to be primitive members of the Aeolidacea (Schmekel & Portmann, 1982; Thompson & Brown, 1984). More recently, however, it has been argued that their lack of a cnidosac to hold the nematocysts at the tips of the cerata together with an oral veil instead of oral tentacles and a tri-lobed oral gland suggests that they may be more closely related to *Doto* and *Hancockia* in the Dendronotacea (Miller & Willan, 1991). This view is supported by Martin, Tomaschko, Hess & Schrödl (2010) who also note that both *Embletonia* and *Doto* lack a muscular cnidosac while *Hancockia* has numerous small cnidosacs in each ceras. Rudman, however, has pointed out that *Embletonia* has simple rhinophores without sheaths (as in aeolids) while several aeolidaceans also have complex oral glands, so whether *Embletonia* is a dendronotacean or an aeolidacean remains uncertain.

#### Genus *Embletonia* Alder & Hancock, 1851

*Type species* *Pterochilus pulcher* Alder & Hancock, 1844 by monotypy.

*Diagnosis* With the characteristics of the family.

#### *Embletonia pulchra* Alder & Hancock, 1844 Figs 6F, 9A–D

*Pterochilus pulcher* Alder & Hancock, 1844: 329.

*Embletonia pulchra* Alder & Hancock, 1851: Part 5, Family 3, Pl. 38.

*Material examined* Dredged from 25m in Tema Bay 1 spec. 4mm long, 13 June 1970, Reg. no. NHMUK 20150408.

*External features* Body elongate with eyes set far apart and short tail, foot narrow, square at front with rounded corners (Figs 6F; 9A, B); two semi-circular oral lobes; rhinophores short, smooth; two pairs of cerata in front of heart, four pairs close together behind and one median one in front of short tail, cerata swollen, tip rounded or almost square (Fig. 9C).

*Colouration* Body pearly white/grey, without any superficial white pigment (Fig. 6F), digestive gland ducts in cerata pale brown, tips of cerata with 6–8 white structures which are probably clusters of cnidophages loaded with nematocysts (Martin *et al.*, 2010) (Fig. 9C).

*Internal morphology* Not examined.

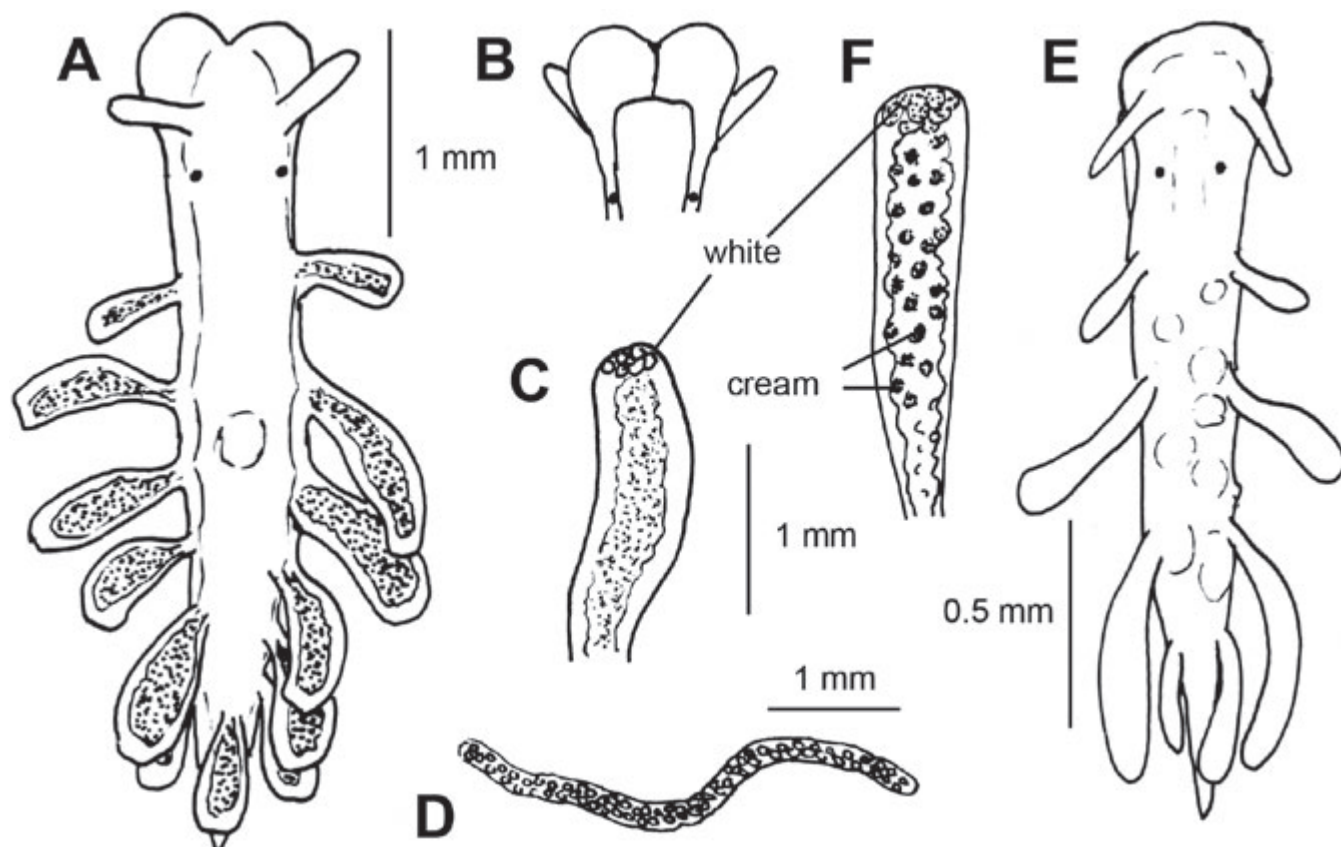
*Behaviour* The animal was observed burrowing through sand grains. When poked with forceps the cerata were erected and secreted a viscous white material from the tips. Martin *et al.* (2010) examined the tips of the cerata and found no evidence of defensive ceratal glands such as occur in *Eubranchus*, but they described a mass of nematocysts, so this white material was nematocysts ejected in the animal's defence.

The animal laid a slender egg ribbon almost 4mm long (Fig. 9D).

*Geographical range* Barents Sea & Scandinavia (Martynov, Korshunova & Savinkin, 2006; Martynov, 2007), Atlantic coast of Europe from British Isles (Thompson & Brown, 1984) to Portugal (Cervera *et al.*, 2006), Mediterranean (Schmekel & Portmann, 1982; Cervera *et al.*, 2006).

*Remarks* Some photos on the Internet show specimens of *E. pulchra* with scattered white spots on body and cerata (Martynov, 2007; Picton & Morrow, 2010), while others have dense white pigment over the dorsum (Ballesteros, Madrenas, Pontes *et al.*, 2012), so it is possible that further work may reveal that more than one species is currently included in *E. pulchra*.





**Figure 9A–D** *Embletonia pulchra* Alder & Hancock, 1844: **A** dorsal view of living animal; **B** ventral view of head; **C** ceras; **D** egg ribbon. **E, F** *Embletonia* species A: **E** dorsal view of living animal; **F** ceras.

***Embletonia* species A**  
Figs 9E, F

**Material examined** Dredged from 30–35m south of Tema 1 spec. 2mm long, 21 February 1970, Reg. no. NHMUK 20150407.

**External features** Body tapering from broad oral veil to tail (Fig. 9E), no trace of oral tentacles or oral lobes, rhinophores short, smooth and slender; four pairs of cerata with anus between second and third cerata on right side, each ceras with broad, blunt tip.

**Colouration** Entire body pale grey with no trace of white pigment spots, but internal organs showing through epidermis as white structures; digestive gland ducts in cerata brown with cream tubercles, tip with dense white structures which are probably masses of nematocysts (Fig. 9F).

**Internal morphology** Not examined.

**Geographical range** Known from this single specimen from Ghana.

**Remarks** This specimen differs from *Embletonia pulchra* in the semi-circular anterior end of the body rather than two oral lobes, slender rhinophores and slender much paler cerata, and appears to be a currently undescribed species of *Embletonia*.

## DISCUSSION

This paper describes two species of aeolid from each of the families Flabellinidae, Piseinotecidae, Eubranchidae and Embletoniidae from Ghana. Three of the species are new: *Flabellina rubromaxilla*, *Eubranchus rubrocerata* and *Piseinotecus minipapilla*, while a fourth, *Embletonia* sp. may be a currently undescribed species. None of the species described here were found in the fouling community of Tema harbour, but *Embletonia pulchra* is a member of the interstitial community in coarse sand and gravel where it feeds on hydroids (Picton & Morrow, 2010) and is cosmopolitan in its geographical occurrence. Three other species are currently only known from warm waters of the East Atlantic: *Flabellina albomaculata*

from Cape Verde Islands and *Piseinotectus sphaeriferus* and *Eubranchus prietoi* from the Mediterranean and some of the East Atlantic Islands.

#### ACKNOWLEDGEMENTS

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