OPISTHOBRANCHIATE MOLLUSCA FROM GHANA: GONIODORIDIDAE

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Abstract *Descriptions are given of eight species of Doridoidea belonging to the family Goniodorididae from Ghana, West Africa. There are six species of* Okenia *of which* Okenia impexa *Marcus 1957 is known from both sides of the Atlantic, while the other five species are only known from West Africa:* Okenia africana *n. sp. has many long lateral processes;* Okenia ghanensis *n. sp. has short lateral processes of variable form, while* Okenia *species A and species B have not been named as they are known only from single specimens. The sixth species,* Okenia digitata, *characterised by three circlets of gills, was originally placed in a new genus* Teshia *Edmunds 1966, but retention of this genus can no longer be justified.* Okenia africana *n. sp. exhibits a stage intermediate between typical* Okenia *and* Okenia digitata *with one circlet of gills and two short rows of small gills in the position where* O. digitata *has secondary circlets. Two species of* Trapania *are also described,* Trapania africana *n. sp. with yellow spots and maroon papillae, and* Trapania luquei *Ortea 1989 which is also known from the Cape Verde and the Canary Islands.*

Key words *Atlantic nudibranchs,* Okenia, Teshia, Trapania

Introduction

A review of the literature of the opisthobranchiate molluscan fauna of West Africa has been given by Edmunds (2007). The purpose of this paper is to describe the species of doridoid opisthobranchs collected by the author and colleagues in Ghana between 1963 and 1973 belonging to the genera *Okenia* and *Trapania* in the family Goniodorididae. Our current understanding and reviews of these genera have been given by Rudman (2004a) and Gosliner (2004) (for *Okenia*) and by Gosliner & Fahey (2008) (for *Trapania*).

Material and Methods

Unless otherwise stated, all of the material described here was collected near to Accra and Tema in Ghana, close to longitude 0 latitude 5.7. Collections were made by the author searching under stones etc. at low tide and by Mr Walter Pople either by SCUBA diving on the 9–12 metre deep reef at Kpone Bay off Tema or dredging in Tema Bay at 20–40 m depth. Rocks and detritus obtained by diving or dredging were kept in aquaria for a few days to encourage the smaller animals to crawl out. Most of the animals were first described alive, then narcotised with magnesium chloride and fixed, usually in Bouin's fluid, before storage in 70% ethanol. Body measurements and drawings of entire animals are from life unless otherwise stated. The buccal mass of some specimens was removed for examination of the radula. Muscle was softened in potassium hydroxide and the radula teased out before mounting in Gurr's 'Aquamount' for microscopical examination. Drawings of radular teeth were made with the aid of a camera obscura. Further details are given in Edmunds (2007).

The material collected and described in this paper (including microscope slides of radulae but excluding severely damaged specimens) is deposited in the Natural History Museum, London.

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Systematic Descriptions

Family Goniodorididae H.Adams & A. Adams 1854

Genus *Okenia* Menke 1830
Type species *Idalia elegans* Leuckart 1828 by monotypy

Okenia impexa Marcus 1957

Figs 1E,G, 3C–F

Okenia impexa Marcus 1957: 434–438, Figs 120–127

Material examined A total of 29 animals were found in the Accra-Tema area including: 10 m reef Kpone Bay 1 spm. 2 mm long 14 December 1969, 1 spm. 3 mm long 2 March 1970, 2 spm.

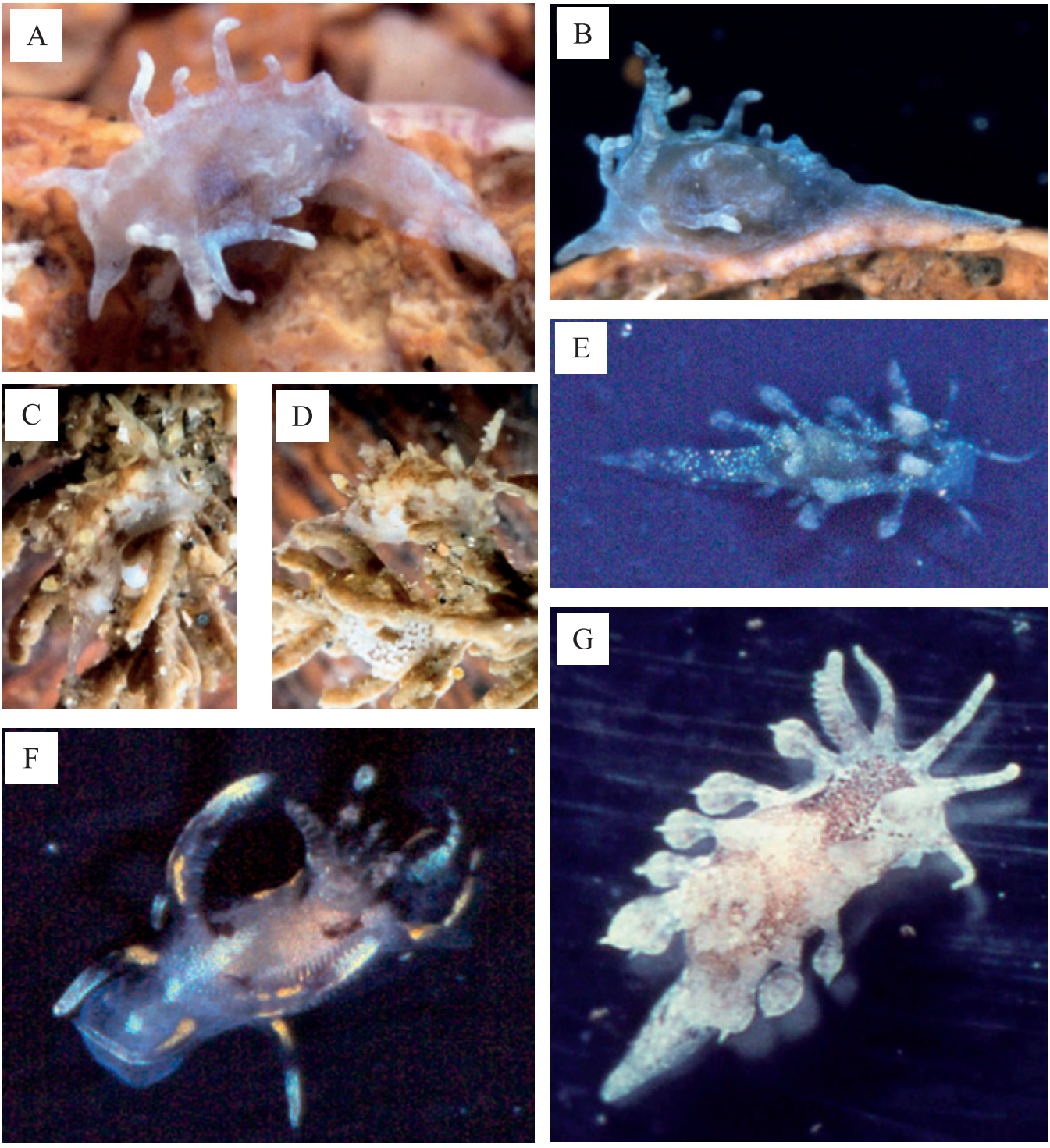

Figure 1 A, B *Okenia* species A, 5 mm long, September 1969. C, D *Okenia ghanensis* n. sp., 3 mm long with eggs, April 1973. E *Okenia impexa*, 3 mm long, Ghana, March 1970. F *Okenia* species B, 4.5 mm long, November 1968. G *Okenia impexa*, 4.5 mm long, Jamaica, October 1961.

3 & 2 mm long 4 April 1970, 4 spm. 3.5, 2.5, 2.5 & 2 mm long 10 April 1971; low tide under stone at Nungua 1 spm. 2 mm long 3 December 1963; rock pool at Teshie 3 spm. 2.5, 2.2 & 2.0 mm long 1 January 1971, 6 spm. 5, 4, 3.5, 3, 2.5 & 2 mm long 4 April 1973; under stones in lagoon at Parkinson Howard beach (Tema) 3 spm. 4, 3 & 2 mm long 6 April 1973.

Additional material available for study was collected from the mangroves at Port Royal,

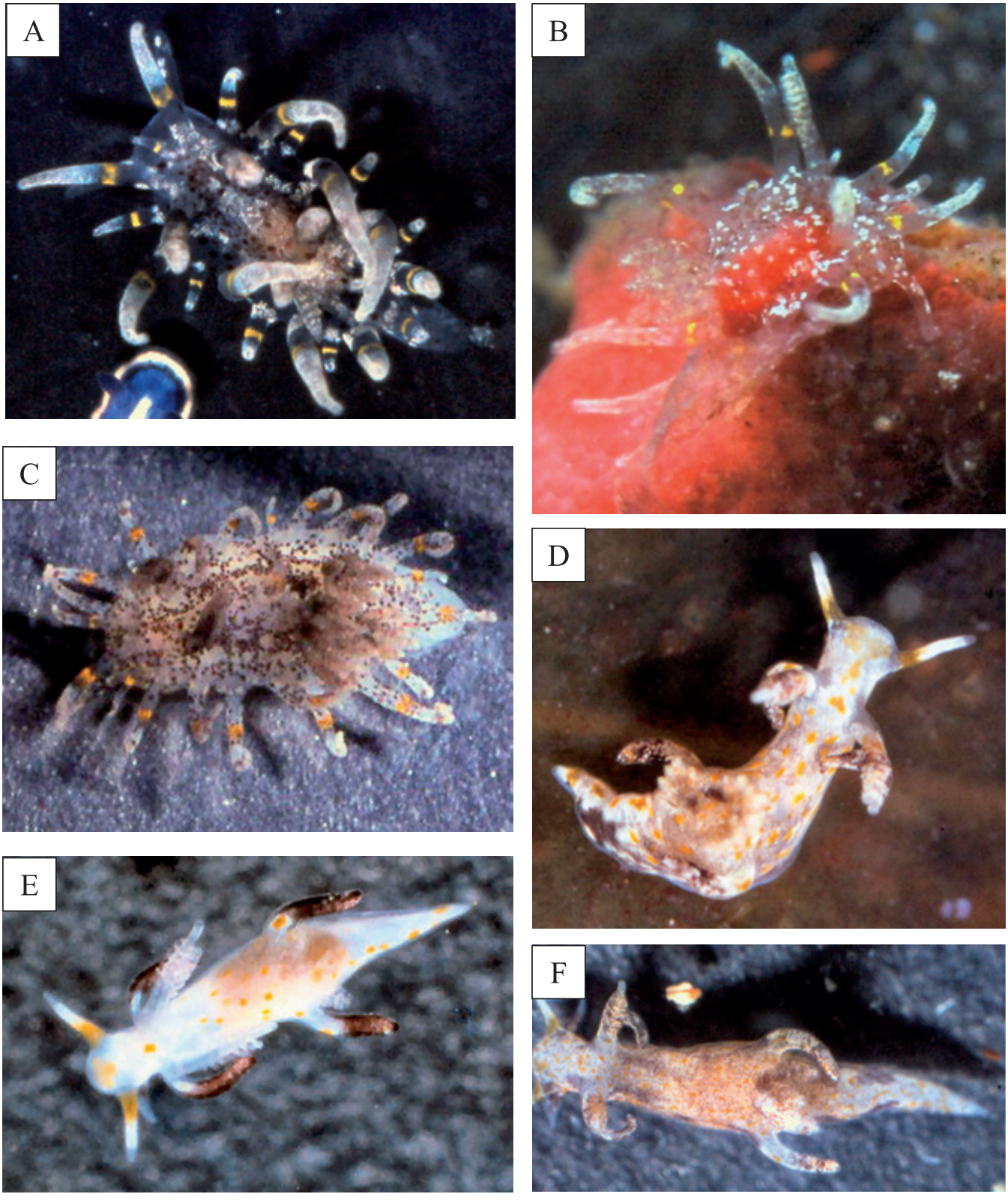

Figure 2 A *Okenia africana* n. sp., 4 mm long, April 1969. B *Okenia africana* n. sp., 4 mm long, April 1970. C *Okenia digitata*, 5 mm long, October 1969. D *Trapania luquei*, 6 mm long, October 1969. E *Trapania africana* n. sp., 4 mm long, November 1967. F *Trapania luquei*, 8 mm long, April 1968.

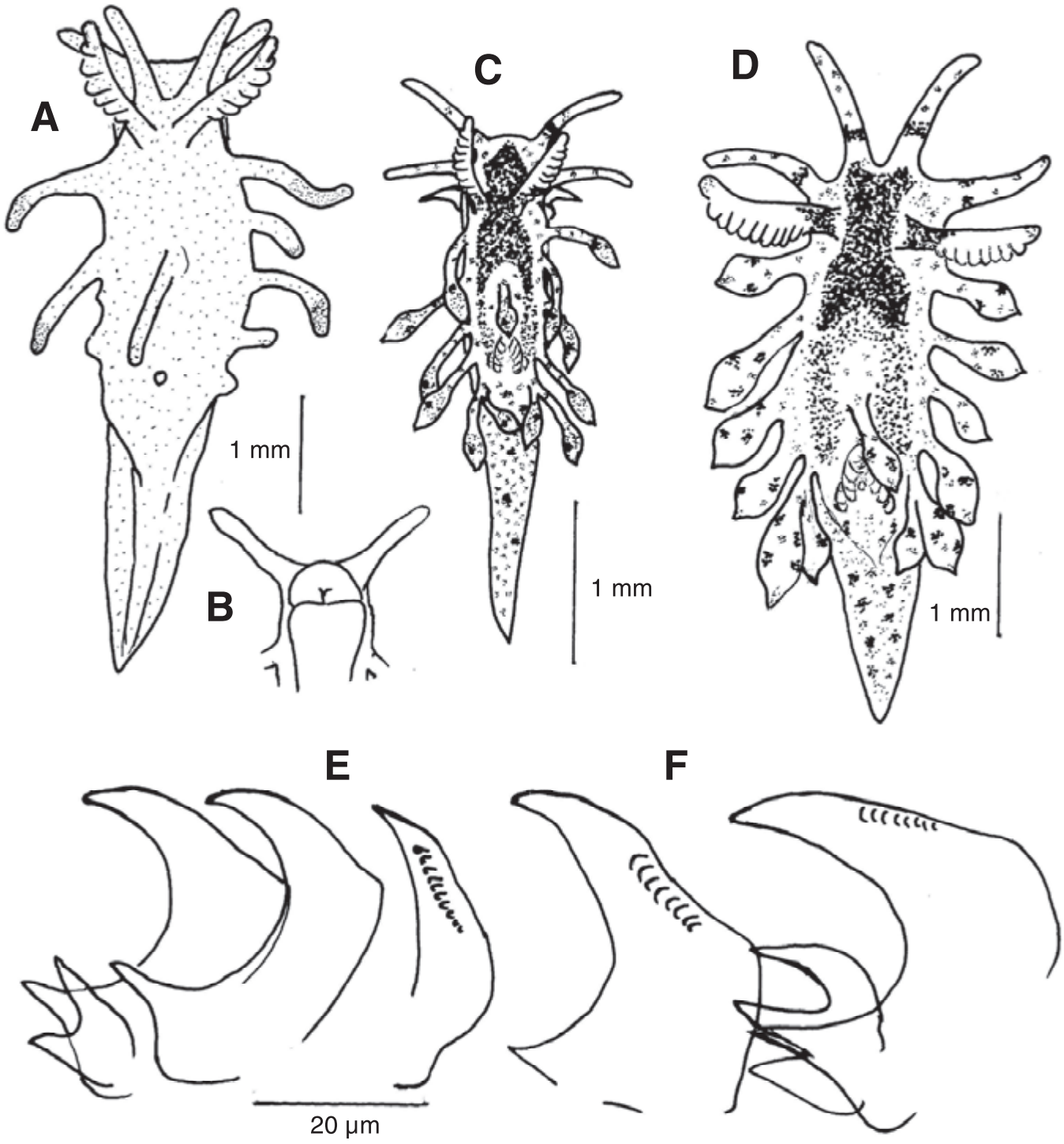

Figure 3 *Okenia* species A: A dorsal view; B ventral view of head. *Okenia impexa*: C dorsal view of live animal from Ghana; D dorsal view of live animal from Jamaica; E three lateral and one marginal radular tooth from 3 mm long Ghanaian specimen; F two lateral and one marginal radular tooth from 4.5 mm long Jamaican specimen. Fine stipple is white pigment; coarse stipple is brick-red pigment.

Jamaica: 1 spm. 4.5 mm long 7 October 1961, 1 spm. (damaged) 17 October 1961, 2 spm. 4 & 2.5 mm long 16 January 1962, 1 spm. 4.5 mm long 1 February 1962, 1 spm. 3.5 mm long 22 February 1962.

External features of Ghanaian specimens Body elongate with tapering tail, head with blunt oral tentacles but with two pairs of tentaculiform processes above them directed anteriorly and laterally (Figs 1E, 3C); mantle with six papillae

on each side, posterior two fused at base, and median dorsal papilla in front of gills, all papillae swollen distally with pointed tip; four to five unipinnate gills; rhinophores with eight lamellae at rear, smooth anteriorly; smaller specimens with fewer papillae, gills and annulae. Body translucent grey with white dots all over mantle, yellowish viscera showing through body, dark brick-red pigment forming a fine meshwork from just in front of rhinophores back to dorsal papilla and with scattered brick-red dots further back, papillae with white spicules visible in stalk and dense white dots in distal swelling with transparent tip, gills and rhinophores grey.

Internal morphology Radula formula of 3 mm long animal from Ghana 16×1.1.0.1.1. Lateral teeth (Fig. 3E) hooked with up to 10 minute serrulations on side of cusp and with a secondary much lower cusp; marginal tooth with two pointed cusps. The serrulations on the cusp of the lateral tooth are close to the limits of resolution of the light microscope and many teeth appear to lack them.

Geographical range São Paulo, Brazil, through the West Indies to North Carolina (Marcus, 1957, 1961; Marcus & Marcus, 1970; Valdés & Ortea, 1995); Cape Verde Islands (Valdés & Ortea, 1995) and Ghana (this paper).

Remarks The Ghanaian material has been compared with 6 specimens collected by the author in 1961–62 from Port Royal, Jamaica. Jamaican material reached 4.5 mm in length alive with a broader body and more bulbous papillae than the Ghanaian animals (compare Figs1E and 1G, also 3C and 3D), but the occurrence of 6 pairs of papillae, the last pair having a common stalk, the shape of the papillae swollen distally with pointed tip, and the distribution of dark pigment was very similar in all specimens. Jamaican specimens had four or five unipinnate gills with a few secondary pinnae on the largest gills, and seven to nine lamellae on the rhinophores. The animal from St Lucia illustrated by J. Hamann in Valdés *et al*. (2006) is also slender like my Ghanaian specimens, but those depicted in the Sea Slug Forum (2007) are similar to my Jamaican material, so there is some variation in body shape of this species in the Caribbean as well as in the east Atlantic.

Specimens from Brazil and Cuba have three cusps to the marginal teeth (Marcus, 1957; Valdés & Ortea, 1995) compared with two in the animal from Ghana. The radula of a 4.5 mm long Jamaican specimen was examined for comparison with Ghanaian material. In both preparations the radula was not fully flattened so that the marginal teeth were not well separated from the laterals. In the Ghanaian radula the lower cusp of each lateral tooth often lies between the two cusps of the marginal tooth so that the marginal tooth appears to have three cusps (Fig. 3E). Although a similar overlap of cusps occurs in the radula of the Jamaican specimen, these marginal teeth clearly have three rather than two cusps (Fig. 3F). This confirms the observations of Marcus (1957) and Valdés & Ortea (1995) that West Atlantic specimens have three cusps to the marginal teeth, and so they differ from the present Ghanaian animals, however Gosliner (2004) states that this species has bifid outer lateral (= marginal) teeth. Clearly further material needs to be examined to explore intraspecific variation more fully, if possible using molecular data.

Burn (1971) thought that *Okenia cupella* (Vogel & Schultz 1970) was synonymous with *Okenia impexa*, but Marcus (1972) followed by Valdés & Ortea (1995) considered these two species to be distinct. In the West Atlantic *O. impexa* occurs in tropical waters and has pointed papillae, a dark patch antero-dorsally and three cusps on the marginal teeth, while *O. cupella* lives in temperate waters and has rounded papillae, scattered brown spots and two cusps on the marginal teeth. A further possibly significant character, shown in their drawings but not commented on by Valdés & Ortea, is that in *O. impexa* the anterior corners of the foot are slender and digitiform while in *O. cupella* they are rounded (compare Figs 5A and 6A of their paper). The problem arises in the East Atlantic where specimens have been identified as *O. impexa* from Ghana (Edmunds & Edmunds, 1973; Edmunds, 1977), Cape Verde Islands (Valdés & Ortea, 1995) and the Mediterranean coasts of Italy (Sordi, 1974; Schmekel, 1979), France (Schmekel, 1979) and Spain (Templado, 1982). Valdés & Ortea (1995) concluded that *Okenia impexa* occurs in the Cape Verde Islands while all specimens from the Mediterranean belong to *Okenia cupella*; Cervera, Calado, Gavaia, Malaquias, Templado,

Ballesteros, García-Gómez & Megina (2006) agree with this view. However, this conclusion needs re-examining in the light of the material described here from Ghana.

Schmekel's (1979) description and photographs of Mediterranean specimens show that they have brownish markings especially on the notum behind the rhinophores as in *O. impexa*, but two cusps to the marginal teeth as in *O. cupella*. The papillae are described as 'apically pointed' on page 355 but 'rounded at the tip' on page 356 and again on page 357: the photographs clearly show that they are rounded and quite different from my own Ghanaian material where the papillae in preserved specimens have the same appearance as in life (see Fig. 3C) with pointed tips. Schmekel describes the foot as having 'short, 0.1 mm long, protruding and pointed front angles', but it is not clear if these are slender projections as in *O. impexa* or broader lobes as in *O. cupella*. Finally Schmekel (1979) reports a very small dorsal median papilla from Mediterranean specimens, but this may not be important: although almost all of my Ghanaian specimens have a large dorsal papilla, one has a rudimentary projection which had probably either broken off or been browsed. Another specimen has almost all papillae missing, probably eaten by a predator. It appears therefore that Mediterranean specimens are closer to *Okenia cupella* than to *O. impexa*.

The present material from Ghana clearly agrees with *Okenia impexa* in shape of papillae and in colouration but it differs in having only two denticles on the marginal teeth. I do not consider this difference sufficient justification for erecting a new species but clearly examination of more material is required. There are at least three possible explanations for the occurrence of *O. impexa* and *O. cupella* on both sides of the Atlantic:

1. They regularly cross the Atlantic either as planktotrophic larvae or as settled adults on bryozoan encrusted *Sargassum*. There is frequent gene exchange across the ocean so that both species occur on both sides of the Atlantic.
2. They have only recently crossed the Atlantic on boat hulls so that populations on the two sides are occasionally reinforced by migrant specimens from boats. There is occasional or frequent gene flow across the ocean but there has been insufficient time for speciation to occur with both species present on both sides of the Atlantic.
3. They only occasionally cross the Atlantic and survive the experience so that there may have been time for populations in the east and west to diverge. This would eventually lead to speciation with different species or subspecies on East and West Atlantic coasts.

For the present, although they have only two denticles on the marginal teeth, I consider that my Ghanaian specimens belong to *Okenia impexa* Marcus.

***Okenia ghanensis* n. sp.**

Figs 1C,D, 4A–E

Material examined Kokrobite rocks collected by Walter Pople just below low water 84 spm. up to 3.5 mm long 30 January 1972; Teshie under rocks at low tide 5 spm. 2–3 mm long 4 April 1973.

Holotype BM(NH) Reg. no. 20090218 from Teshie, Ghana, under rocks at low tide, 4 April 1973, collected by M. Edmunds.

External features Specimens from Teshie (Figs 1C, 4C): body elongate with blunt or shortly tapering tail, pair of digitiform tentacles arise anteriorly from oral veil; mantle with an inconspicuous dorso-lateral pallial ridge from which arise three to five pairs of papillae of variable size, first two pairs usually short linear, third pair usually swollen distally but linear in one specimen, last two pairs swollen distally like postero-dorsal papillae; one or two postero-dorsal papillae arising from a common stalk on each side behind gills, swollen distally in four specimens, linear in fifth; small median tubercle on pericardium, forming short linear projection in three specimens; three (in one animal) or four gills with irregular pinnae and an occasional secondary pinna (bipinnate) arising in an arc; rhinophores tapering, smooth or rugose, with 0–3 ridge-like projections posteriorly; foot longitudinally grooved (best seen preserved) rounded in front. Overall appearance of animal brownish; body translucent grey with maroon or blackish blotches concentrated in two lines down back, sparser behind gills and on sides (no cream dots in specimens fixed in Bouin's fluid).

Specimens from Kokrobite (Fig. 4A) similar to above except for the following: three to five

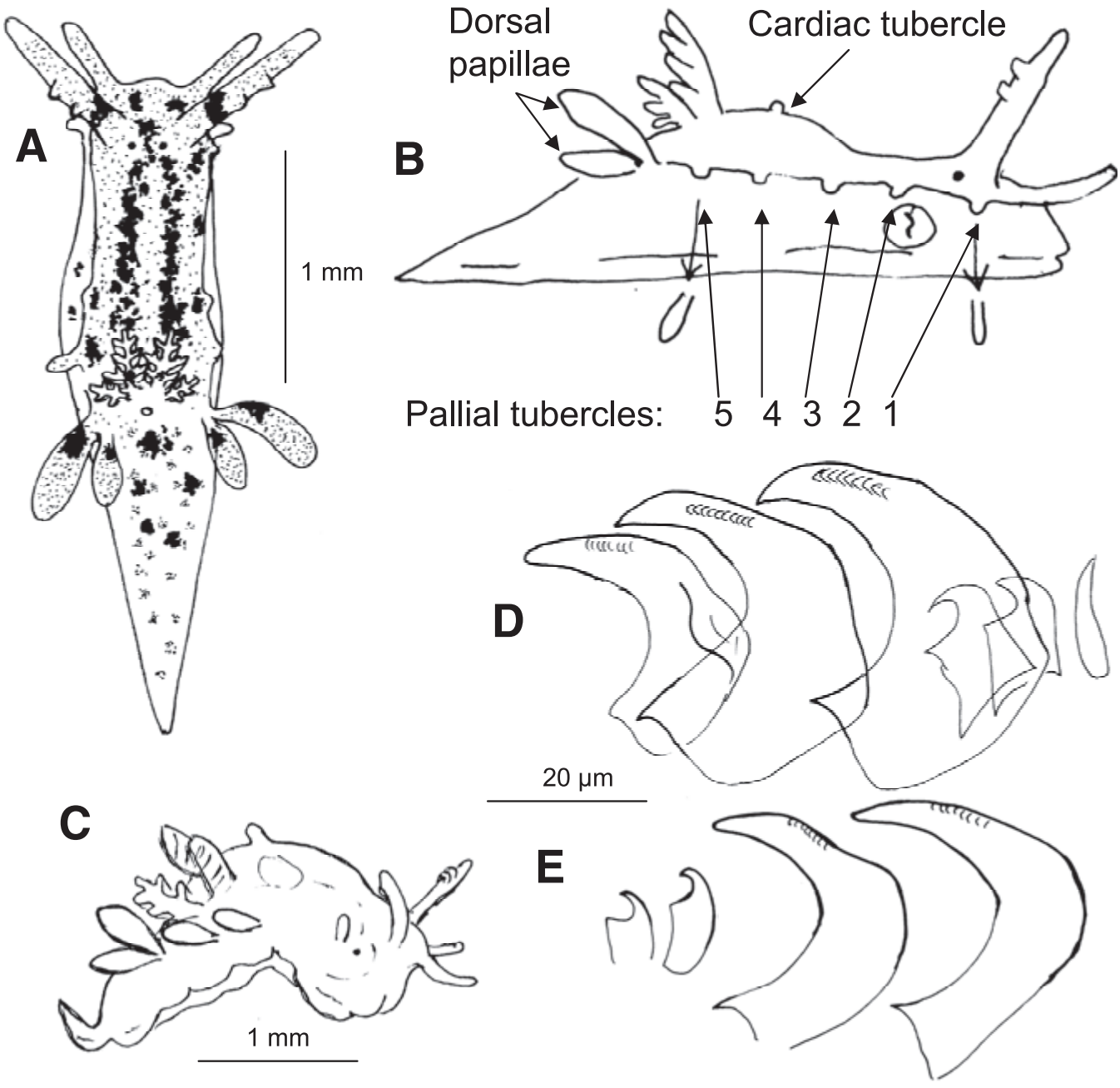

Figure 4 *Okenia ghanensis* n. sp.: A dorsal view of live animal from Kokrobite with pallial tubercles 4 & 5 on left and 1, 4 & 5 on right (fine stipple is cream pigment; coarse stipple is maroon pigment); B lateral view of animal to show pallial tubercles and their numbering; C lateral view of preserved spm. from Teshie with pallial projections 1, 4 & 5 on right side; D three lateral and three marginal radular teeth from 3 mm long specimen from Kokrobite; E two lateral and two marginal radular teeth from 2.5 mm long specimen from Teshie.

projections from dorso-lateral pallial ridge reduced to minute tubercles; minute papilla only occasionally present on pericardial hump; genital region in many specimens swollen with penis partly extruded. Overall appearance of animal brownish; body translucent grey with minute cream dots over entire dorsal surface back to gills including papillae, sides and tail with scattered cream blotches, maroon or blackish blotches concentrated in two lines down back, sparser behind gills and on sides (cream dots persist in Bouin's fixative); rhinophores and oral tentacles with white dots but tips clear, rhinophores sometimes tinged yellow with maroon band near base; gills with some maroon on anterior base, cream dots all over.

Table 1 Variation in external projections in 76 specimens of *Okenia ghanensis* n. sp. from Kokrobite, Ghana.

Pallial tubercles present on one side	0	1	2	3	4	5
n	15	113	1	2	70	105
Cardiac tubercle	0	1				
n	69	7				
Dorso-lateral papillae on each side	0:0	0:1	0:2	1:1	1:2	2:2
n		3		15	28	30
Number of gills	3	4	3/4			
n	26	47	1			
Number of ridges on rhinophores	0	1	2	3		
n	47	18	9	2		

Note that n = 76 for most of the characters in this table but n = 152 for the pallial tubercles present because this counts left and right sides of each animal separately.

Variation in morphology of appendages This species is variable in external morphology such that extreme specimens could easily be thought to belong to different species. This variation was therefore studied in 76 specimens collected at the same time at Kokrobite, only those which were obviously deformed or damaged being excluded (Table 1). Even so some of the variation probably reflects attacks by predators (e.g. small crabs, other crustaceans or possibly small fish): for example it is possible that all specimens originally had two pairs of papillae dorso-laterally behind the gills but some have been bitten or pinched off and some are obviously regenerating.

Preserved animals varied in length from 0.9 to 2.2 mm (mean 1.53 mm) and many including the smallest had the penis partially extruded indicating that they were probably sexually mature. There were up to 5 tubercles on the pallial ridge between the rhinophores and the gills (Fig. 4B), but in 15 specimens there were no tubercles on one side (Table 1). The tubercles most frequently present were numbers 1, 5 and 4 with the other two only rarely present. Thirteen specimens had the arrangement 1, 4, 5 on both sides of the body and just 3 specimens had no tubercles on either side. Usually the tubercles were small pustules, but in five the first was digitiform, while in several more the fifth was papillate, almost like a small dorso-lateral papilla in some specimens. A cardiac tubercle was occasionally present (Table 1). There were always three or four gills except where these had obviously been browsed; occasionally it was not possible to determine if there were a pair of medial gills or if there was one medial gill with a large pinna arising close to its base on one side and so appearing to be a second gill. Each gill had several pinnae, very occasionally with a few additional ridges indicating that it was intermittently bipinnate. Rhinophores were usually smooth but slightly rugose or kinked and a third of specimens had one to three posterior ridges on at least one of the two rhinophores (Table 1).

The five specimens from Teshie were less variable and had better developed projections from the pallial ridge (Table 2).

Internal morphology The radulae of two animals from Kokrobite and one from Teshie were examined. In one from Kokrobite the very small ribbon was not flattened so it is almost impossible to distinguish individual teeth. The other radula from Kokrobite was gently squashed to separate the teeth and the formula appears to be c14×1.1.0.1.1. This preparation has 27 lateral teeth but only two fragments that appear to be complete bicuspid marginals (Fig. 4D). Other fragments are presumably damaged marginal teeth. The lateral teeth are hooked with up to nine small denticles on the side of the cusp. The radula from Teshie has about 7 rows of teeth each of which is similar in morphology to teeth from Kokrobite (compare Figs 4D & E): the minor differences between these two drawings may be due to different angles of viewing.

Geographical range Currently only known from the intertidal zone in Ghana.

Ecology This species lives on the bryozoan *Anguinella palmata* van Beneden (det. P.L. Cook), but the live animals were seen browsing on

Table 2 Variation in external projections in 5 specimens of *Okenia ghanensis* n. sp. from Teshie, Ghana.

Pallial tubercles present on one side	0	1	2	3	4	5
n	0	10	5	8	5	10
Cardiac tubercle	0	1				
n	0	5				
Dorso-lateral papillae on each side	0:0	0:1	0:2	1:1	1:2	2:2
n				1	2	2
Number of gills	3	4				
n	1	4				
Number of ridges on rhinophores	0	1	2	3		
n	2	1	1	1		

Note that tubercles 3, 4 & 5 are usually swollen distally but blunt, like the dorsal papillae. Tubercles 1 & 2 normally linear. Cardiac tubercle linear in three specimens, very small in other two.

encrusting material on the surface of the *Anguinella* rather than on the polyps.

Remarks I considered the possibility that the specimens from Teshie and from Kokrobite are different species, but they have very similar radulae, external morphology and colouration, and they also live on the same species of bryozoan. The very considerable variation in the body appendages of animals from Kokrobite may be attributable to predatory attacks or to damage caused by turbulence and brushing against rocks or other substrates. It is further unlikely that there are two different species coexisting on the same bryozoan in this small region of Ghana.

Of the known small species of *Okenia* from the Atlantic Ocean the present material is most similar to *Okenia zoobotryon* (Smallwood 1910). Smallwood (1910, 1912) described his new species from Bermuda under the name *Polycerella zoobotryon* because it lived and fed on the bryozoan *Zoobotryon*. This species has been problematic for many years but its identity appeared to have been resolved by Clark (1984) who collected further material from the same species of bryozoan (*Zoobotryon verticillatum* (delle Chiaje 1828 = *Zoobotryon pellucidum* Ehrenberg 1831) in the type locality in Bermuda. His specimens agreed closely with type material in external features but there was a marked difference in the radula: Smallwood gave a formula of 3.1.0.1.3 with dagger-shaped lateral teeth and slender marginals, similar to the radulae of polycerids and justifying his placement of the species in the genus *Polycerella*. Clark, however, gave a formula of 1.1.0.1.1 with broad-based hooked laterals and compact marginals with two or three cusps. This is quite different from a polycerid radula but is similar to that of species of the goniodorid genus *Okenia*, so Clark transferred the species into this genus. Rudman (2004a, b) has summarised the status of this species and concluded that *Bermudella polycerelloides* Bouchet & Ortea 1983 is a synonym but that *Okenia evelinae* Marcus 1957 is a different species, contrary to the views of Clark (1984) and Valdés & Ortea (1995). Photographs of specimens which may perhaps be *Okenia zoobotryon* have been published by Rudman (2004–2008) in *Sea Slug Forum* from Senegal (Poddubetskaia, Mar 8, 2004; Ossokine, Jun 9 & Jun 19, 2006; Valdes, Jun 16, Jun 17 & Jun 21, 2006), Bahamas (Redfern, Dec 22, 2004), Venezuela (Grune, Apr 11, 2005), Florida (Ianiello, Oct 30, 2007) and Australia (Rudman, Dec 21, 2004; Atkinson & Atkinson, Jan 31 & Feb 12, 2008). The variation in external features of these specimens implies that several species are currently grouped under the name *Okenia zoobotryon*, most of which are reported as being found on *Zoobotryon verticillatum* and some of them were feeding and/or laying eggs on it.

Okenia ghanensis differs from *O. zoobotryon* as described by Smallwood (1910) and Clark (1984) as well as from *Bermudella polycerelloides* and all of the animals listed under the name *Okenia zoobotryon* in *Sea Slug Forum* (Rudman, 2004–2008) in the number, arrangement, size and shape of papillae on the mantle, body colouration and shape of the rhinophores. It also differs in its ecology since it occurs on the bryozoan *Anguinella palmata* instead of on *Zoobotryon verticillatum*. It is not known if these rather similar species of

Okenia are stenophagous in their food or if they occur on a variety of genera of ctenostomatous bryozoans, or how many of them are 'tramp' species (which travel widely across the oceans on boat hulls where their bryozoan food thrives).

Small species of *Polycerella* and small species of *Okenia* can be very similar in appearance, and the locality at Teshie where *O. ghanensis* was found also had a considerable number of *Polycerella emertoni*. Indeed I collected 26 specimens from Teshie on 4 April 1973 which I initially labelled "*Polycerella*" and only later realised that five of them were *Okenia*. It is thus quite possible that Smallwood actually found a species of *Polycerella* and a species of *Okenia* on his *Zoobotryon* and that he based his description of *P. zoobotryon* partly on one and partly on the other. Since his drawing of the intact animal resembles the drawings by Clark (1984) of an *Okenia*, it is reasonable to conclude (following Clark) that this was indeed an *Okenia*. But his radula could well have come from a different animal altogether, a species of *Polycerella*. If this is so then it might be prudent to consider Clark's material as the definitive species *Okenia zoobotryon* Smallwood 1910. Rudman (2004a,b) has described *O. zoobotryon* from Australia but accepts that it is possible that this material belongs to a different species from that found in Bermuda.

It is to be hoped that when further material attributable to *Okenia zoobotryon* is examined and described an attempt will be made to document the intra-population variation so that it is possible to clarify how many species are currently confused under this name. Ultimately, however, the problem of how many species are present will probably only be resolved when DNA profiles are available from different populations.

Okenia species A

Figs 1A,B, 3A,B

Material examined Dredged from 24 m Tema Bay 1 spm. 5 mm long 10 September 1969.

External features Body oval, tail slender, oral veil with tentaculiform corners; four lateral papillae on right side of mantle but only two on left (probably due to predation), single median papilla in front of gills, papillae linear of variable length, with trace of possible fifth papilla posteriorly on right; gills missing; rhinophores long with six annulae posteriorly. Entire body white.

Internal morphology The radula was not removed to avoid damaging the single specimen.

Geographical range *Okenia* sp. A is known only from this single specimen from Ghana.

Remarks This animal differs from *Okenia evelinae* Marcus in that the rhinophores were white not purple and the visceral organs did not show through the skin as being yellow. Since the present animal was 5 mm long compared with a maximum of 8 mm for type material, the difference in colour of the rhinophores is unlikely to be due to it being immature, but the visceral colour difference could be due to different diets. Marcus (1957: Figs 128, 129) illustrates the papillae as being short and linear, similar but shorter than in the present animal; by contrast Marcus & Marcus (1960: Fig. 49) show the papillae of Florida material as being swollen at the tip, like pins, yet they claim the appendages 'agree exactly with the Brazilian material'. Valdés *et al.* (2006) illustrate two further species of *Okenia* from the Caribbean which they call *Okenia* sp. 2 and sp. 3: these are similar to the present animal but have more brown pigment on the body and more numerous papillae. The present specimen also differs from the other East Atlantic species of *Okenia* described and reviewed by Valdés & Ortea (1995). With just a single damaged specimen I am reluctant to identify it as *O. evelinae*, but consider it is probably a hitherto undescribed species of *Okenia*. *Okenia japonica* Baba 1949 is also white with short papillae, but it typically has brown pigment as well and is currently known only from the Pacific (Japan to Australia) (Rudman, 2004a; Gosliner, 2004) so my Ghanaian animal is unlikely to belong to this species.

Okenia species B

Figs 1F, 5A,B

Material examined Dredged from 41 m Tema Bay 1 spm. 4 mm long 18 November 1968.

External features Body broadly oval, rounded at front, abruptly pointed at rear (Figs 1F, 5A,B); with three pairs of 1–1.5 mm long tentaculiform

processes, the first directed anteriorly, the second lateral to the rhinophores, the third arising beside the gills and directed postero-laterally; rhinophores 2 mm long with short stalk and 20 annulae meeting at frontal ridge; 7 unipinnate gills in a circlet, front pair largest with up to 10 pinnae, single minute posterior plume suggests animal may not be full grown. Colour semi-transparent grey, broad dorsal white patch from gills to frontal processes, smaller median white patch on oral veil and creamy white streak on tail, yellow streak in angle between foot and tail with two yellow spots in same angle lateral to gills and two yellow spots on each side just in front of posterior processes, brown patches lateral to gills and between gonopore and tail; tentacular processes grey proximally white distally with brown ring near base broken by yellow or orange-yellow patch on upper side (posterior processes with hardly any brown); rhinophores with brown patches basally and half way up on posterior side, cream stripe distally in front and pair of yellow patches antero-laterally near base; larger gills with brown patch below cream tip, smaller gills transparent.

Internal morphology The radula was not removed to avoid damaging the single specimen.

Geographical range *Okenia* sp. B is known only from this single specimen from Ghana.

Remarks The animal was crawling over the benthic foraminiferans *Jullienella foetida* (det. Dr. Ole Tendal) and *Schizammina* sp. on fine mud. It differs from all other species of *Okenia* in colouration and in the three pairs of long processes , but because there is just a single specimen I have not named it.

***Okenia africana* n. sp.**

Figs 2A,B, 5C–F

Material examined Dredged from 20–25 m Tema Bay 1 spm. 21 April 1968; 10–12 m reef Kpone Bay 1 spm. 1.5 mm long 12 December1968, 1 spm. 4 mm long 16 April 1969, 4 spm. 2, 3, 3 & 4 mm long 4 April 1970.

Holotype BM(NH) Reg. no. 20070666 from 10–12 m reef Kpone Bay, Ghana, 4 April 1970, collected by W. Pople.

External features Body broadly oval with short tail, mantle edge with ten long tentaculiform processes alternating with ten short ones, the short ones including median processes at front and rear (Figs 2A,B, 5C), small animals with much shorter processes; head with slender oral tentacles, rhinophores 1 mm long in a 4 mm specimen with up to 15 lamellae posteriorly, flat anteriorly; holotype with one circlet of eight unipinnate gills in front of anus, pinnae alternating on either side of rachis, small posterior gill on each side lacking pinnae, and row of three gills on each side behind anal papilla (Fig. 5D). Gills of second large specimen similar but lacking minute fourth pair of gills to anterior circlet; smaller specimens with three pairs of gills in anterior circlet, two minute gills on each side posteriorly (Fig. 5C); smallest specimen with two pairs of gills in anterior circlet and no trace of posterior gills. Body colour creamy white with vermilion red or brownish orange of gut contents visible dorsally; with numerous minute maroon dots and white dots usually aggregated into discrete spots, maroon spots scattered over dorsal and lateral surfaces, white spots equally numerous dorsally but sparse on sides; tentaculiform processes grey with some white spots in proximal half, suffused white in distal half, sometimes with a few maroon spots, with two yellow spots or a yellow ring near base (the yellow varies from orange-yellow to golden yellow); shorter processes grey with suffused white tip and with yellow spot only in largest animals; rhinophores grey with white spots and a few maroon or brown spots on stalk and lowest lamellae, rest of club with dense minute white dots; gills transparent with scattered white dots and a few maroon or brown spots on largest plumes.

Internal morphology Radula formula of 3 mm long animal 20×1.1.0.1.1. Lateral teeth with eight or nine denticulations below cusp; marginal teeth with single pointed cusp (Fig. 5F).

Behaviour Four of the animals were found on and were eating a dark red bryozoan *Alcyonidium* sp. (det. P. Cook). *Alcyonidium* is covered by a thin transparent cuticle which flakes off. *Okenia africana* tears off the cuticle and then sucks out the contents of the zooids. This colours its viscera and faeces vermilion or dark red. In the relaxed

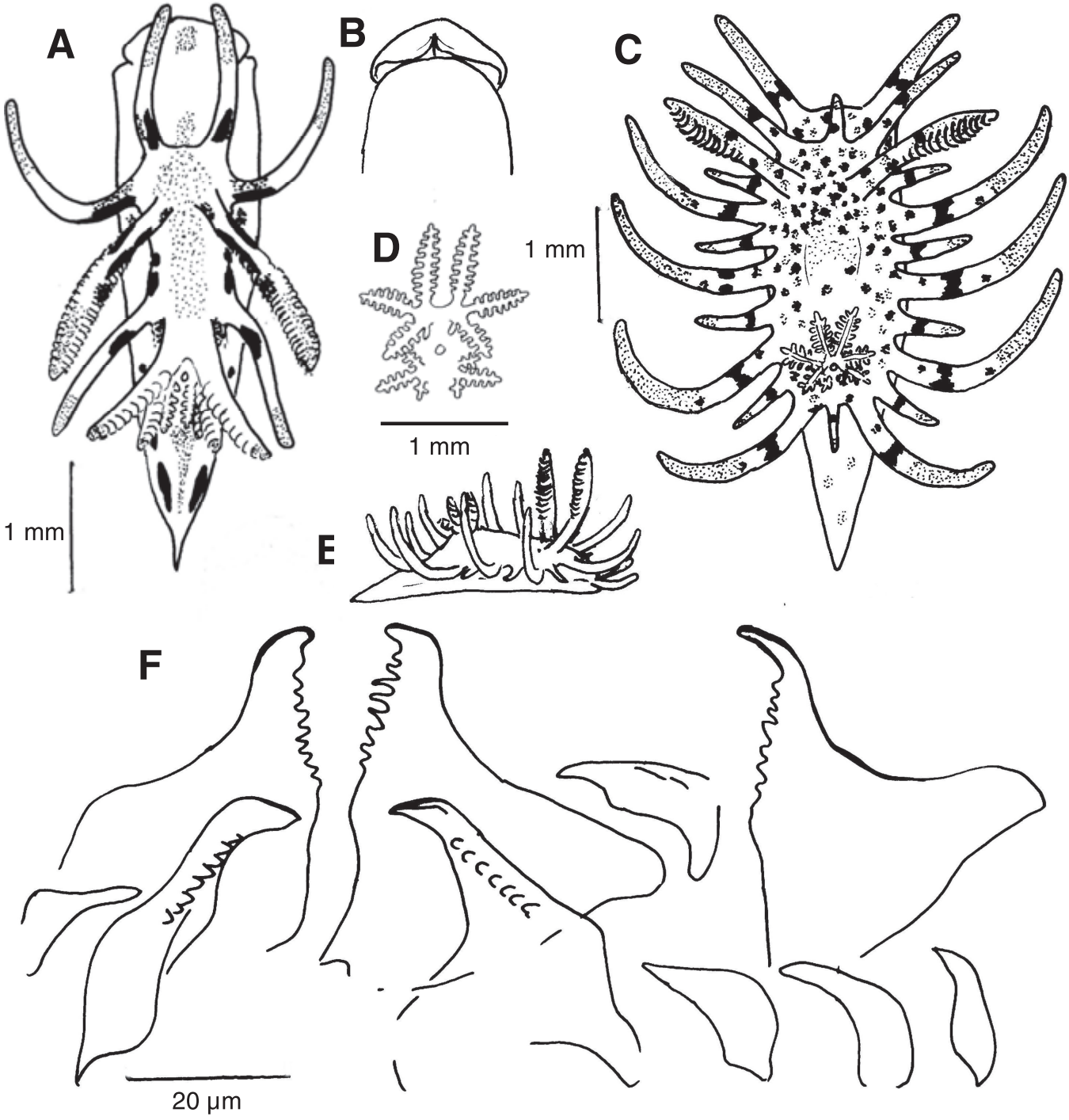

Figure 5 *Okenia* species B: A dorsal view; B ventral view of head. *Okenia africana* n. sp.: C dorsal view; D gills of holotype; E lateral view showing its deimatic display alternately waving the extended lateral processes up and down; F five lateral and five smaller marginal radular teeth from 4 mm long specimen. In A & C solid black is yellow pigment, coarse stipple is maroon or brown, fine stipple is white.

or crawling animal the tentacles are curled up and over the body. If an animal is sharply poked with forceps (simulating a predatory attack) the tentacles are elongated (from two to three mm in a large animal), extended laterally and then flapped dorsally over the back several times (Fig. 5D). This is similar to the behaviour of *Okenia digitata* (Edmunds 1966, Figs 4–5, as *Teshia digitata*), and it may be a deimatic display (i.e. which startles a possible predator). While many doridaceans possess protective chemicals there is no evidence for their occurrence in species of

Okenia so it is not known if the bright colours of this species are aposematic or frightening to a potential predator.

Geographical range Known only from offshore in the Tema region of Ghana.

Remarks This species is characterised by the ten tentaculiform and ten short processes which distinguish it from all of the *Okenia* species from the Mediterranean and the Caribbean described by Valdés & Ortea (1995) and Valdés *et al.* (2006). These lateral processes together with its colouration also distinguish it from the numerous species of Indo-Pacific *Okenia* described by Gosliner & Bertsch (2004), Gosliner (2004) and Rudman (2004a, 2007). *Okenia africana* also differs from all other species of *Okenia* except for *Okenia digitata* by possessing three groups of gills. *Okenia digitata* has three complete circlets of gills (see below) while *Okenia africana* has one anterior circlet and a pair of very short rows of three minute gills postero-laterally. The smallest specimen had no trace of these postero-lateral gills, so they evidently develop as the animal grows. Slightly larger specimens had minute postero-lateral gills, but these could be described as the most posterior gills of a U-shaped arch of gills which are separated by a small gap from the anterior part of the arch. The gill arrangement of this species is thus intermediate between that typical of *Okenia* and that of the more unusual species *Okenia digitata*.

***Okenia digitata* (Edmunds 1966)**
Fig. 2C

Teshia digitata Edmunds 1966: 69–72, Figs 1–10.
Okenia digitata – Vallès *et al.*, 2000: 18–20, Figs 2–3.

Material examined 10 m reef Kpone Bay 1 spm. 19 October 1969.

External features The animal was 5 mm long but moribund and not fully extended when found. As far as could be seen from its poor condition it was similar in morphology and colouration to the type specimen (compare Fig. 2C with Edmunds, 1966, Figs 1–2) with three circlets of gills and maroon and yellow markings, but it had more maroon pigment dorsally than the type specimen.

Internal morphology The buccal mass and radula were described by Edmunds (1966) and conform to the pattern typically found in the genus *Okenia*.

Geographical range Recorded from Teshie at low tide and Kpone Bay reef, Ghana (Edmunds, 1966; this paper), and from Angola (Vallès *et al.*, 2000).

Remarks This unusual animal was originally placed in a new genus, *Teshia*, on the basis of possessing three circlets of gills. Vallès *et al.* (2000) state that the three circlets of gills in their Angola material arise from a single point on the dorsum, not from three separate points, and they attribute the original description of three circlets arising from separate points on the dorsum as being due to study of preserved material. However, the type description and drawing given by Edmunds (1966) were of the living animal; I have also checked the photograph of the living animal (Fig. 2C) which shows three separate circlets of gills, so this criticism is unfounded. The gill circlets of preserved Angolan material apparently have a common triangular region, clearly shown in Fig. 2 of Vallès *et al.* (2000), but not present in my type specimen. This difference could be due to a different method of fixation: Ghanaian material was anaesthetized before fixation, but there is no indication if this was done for Angolan specimens.

The type specimen from Ghana had 24 tentacular papillae compared with 16 pairs (text) or 34 papillae (drawing) in Angolan material, but this may be variation due to age and size of the animals: the type specimen was 10 mm long alive compared with 6 mm preserved for Angolan animals which may equate to more than 10 mm alive. Ghanaian animals are described as grey with creamy viscera and maroon spots whereas those from Angola are described as white with black spots. On checking my notes and photographs again it is clear that the living animals are very pale grey, which could equally be described as almost white, and the spots are very dark maroon which could be described as blackish. The rhinophores of the type specimen have brown clubs with a few dark spots, those

from Angola are white with a few black spots; gills of the type are brown with dark spots, those from Angola white with black and yellow spots; gills from the Ghana specimen have alternating long and short pinnae but this is not mentioned for Angolan specimens (and not indicated in the drawing). No radular formula is given for Angolan specimens but the shape of the radular teeth appears to be similar to that of the Ghanaian specimen although it is difficult to be certain as the illustration is in lateral view.

There can be little doubt that my Ghanaian *Okenia digitata* and the specimens from Angola are closely related, and while I am not wholly convinced that they are conspecific because of the differences outlined above, I do not consider there is sufficient information available at present to create a new species for Angolan material.

The genus *Teshia* Edmunds 1966 was created for goniodoriids with three circlets of gills. However, the external features, buccal mass and radular teeth of *Teshia digitata* are all similar to those found in the genus *Okenia*, and so, following Gosliner's (2004) phylogenetic study of *Okenia* in which he synonymised three genera with *Okenia*, I agree with Vallès *et al.* (2000) that recognition of the genus *Teshia* can no longer be justified, and this species should therefore be named *Okenia digitata*. The two posterolateral tufts of gills in *Okenia africana* show how the unique condition of three gill circlets in *O. digitata* has evolved. The occurrence of these two remarkable species of goniodorid in West Africa suggests that the three circlets of gills evolved here, but what the advantage of these extra gills might be remains unknown.

Genus *Trapania* Pruvot-Fol 1931

Type species *Drapania fusca* Lafont 1874 by monotypy

The genus *Drepania* was renamed *Trapania* by Pruvot-Fol (1931) because *Drepania* was preoccupied.

***Trapania africana* n. sp.**
Figs 2E, 6A–C

Material examined 10 m reef Kpone Bay: 1 spm. 4 mm long 24 November 1967, 1 spm. 2.5 mm long 2 October 1969.

Holotype BM(NH) Reg. no. 20070667 from 10 m reef Kpone Bay, Ghana, 24 November 1967, collected by W. Pople.

External features Body elongate tapering posteriorly with pair of club-shaped papillae lateral to rhinophores and second pair just behind gills (Figs 2E, 6A); oral tentacles shorter than rhinophores; rhinophores 1 mm long, smooth in front, 7 annulae posteriorly on distal two thirds; 3 bipinnate gills; foot notched with pronounced pointed corners. Colour semitransparent grey, most of back and sides covered with white pigment and pale maroon freckles, with scattered yellow spots on back, sides and tail, cream or pinkish cream viscera visible through skin; papillae maroon with yellow spot at base and white spot or ring below tip; oral tentacles white with maroon freckles, yellow spot at base, tip clear; rhinophores white with some maroon on annulae; foot corners with purplish spot; gills white with yellow spot on rhachis of median gill.

Internal morphology Labial cuticle from the 4 mm animal semi-circular with pointed rodlets (Fig. 6B). Radula formula 10×1.0.1; tooth with prominent cusp and from 8–10 pointed denticles of variable size laterally (Fig. 6C).

Geographical range Known only from a single site in Ghana.

Remarks This species differs from all of the eight species of *Trapania* recorded from the Iberian peninsula and the three species from the Caribbean as well as those from the Indo-Pacific in its pale body with dark papillae (see Cervera *et al*. (2006) for checklist, and Cervera, García-Gómez & Megina (2000), Valdés *et al*. (2006), Gosliner & Fahey (2008) and Sea Slug Forum (2007) for colour illustrations of species of *Trapania*).

***Trapania luquei* Ortea 1989**
Figs 2D,F, 6D–J

Trapania luquei Ortea 1989: 21–22, Figs 5–6.

Material examined Dredged from 25–29 m Tema Bay 1 spm. 8 mm long 28 April 1968; 10 m reef, Kpone Bay: 1 spm. 6 mm long on *Sargassum* 2

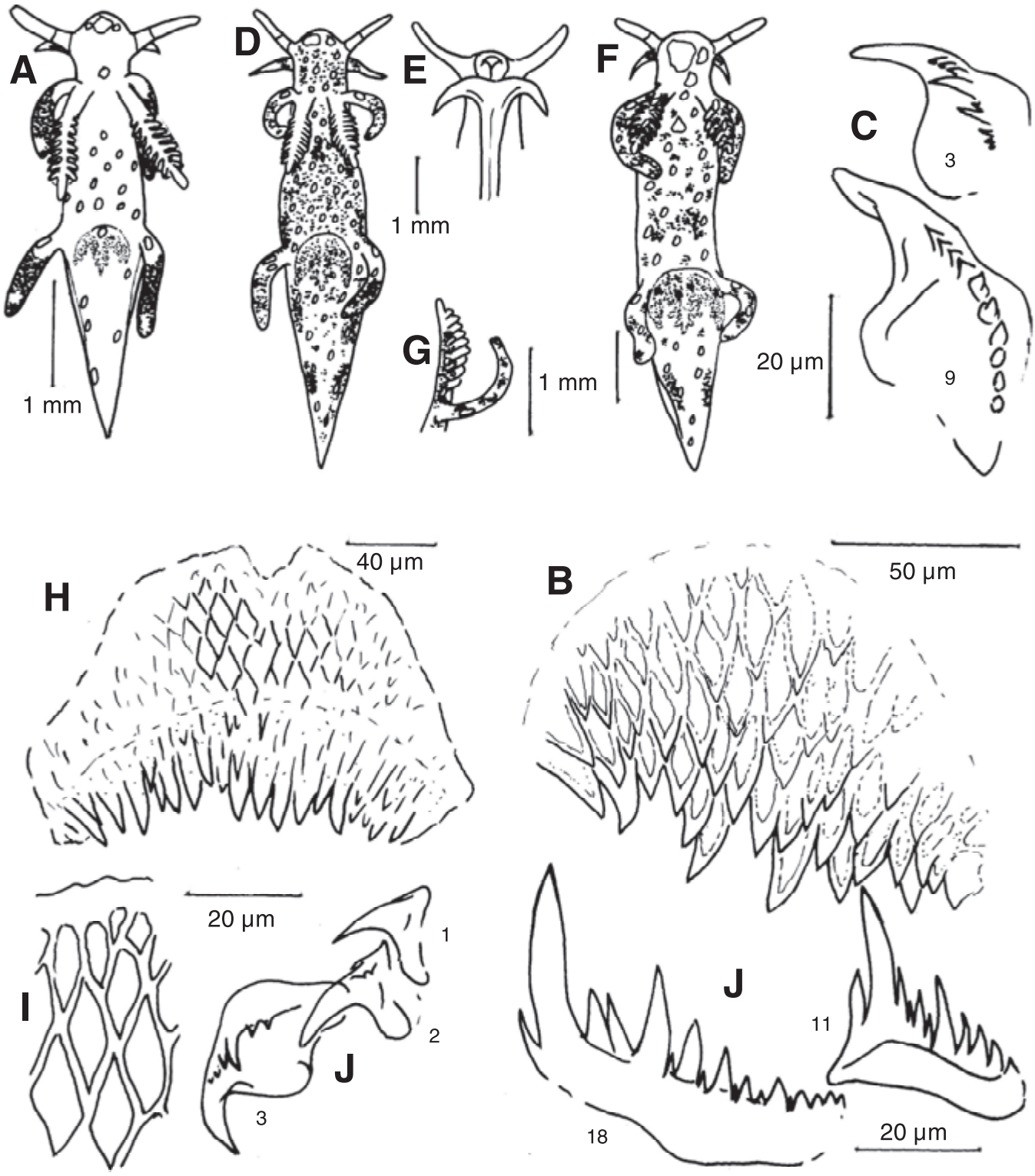

Figure 6 *Trapania africana* n. sp.: A dorsal view; B labial disc with rodlets; C two radular teeth from 4 mm long specimen. *Trapania luquei* Ortea: D dorsal view; E ventral view of head; F dorsal view of smaller animal; G detail of rhinophore and its papilla of same specimen; H labial disc; I detail of polygonal pattern of rodlets on labial disc; J radular teeth from 8 mm specimen. In A, D, F & G circles and bands at bases of oral tentacles are yellow; coarse stipple is maroon or purple in A, purplish brown in D, F & G; finer white pigment not shown. In C & J the small numbers on radular teeth indicate the position of each tooth on the radular ribbon.

October 1969, 1 spm. 5.5 mm long 14 December 1969.

External features Body elongate, tapering posteriorly, one pair of papillae arising from outer base of rhinophores and second pair lateral to gills (Figs 2D,F and 6D,F); oral tentacles shorter than rhinophores; rhinophores up to 2 mm long, with flat frontal ridge and up to 9 annulae posteriorly (Fig. 6G); 3 bipinnate gills; foot longitudinally grooved with shallow notch at front and slender pointed corners (Fig. 6E). Colour greyish, dense minute creamy white dots all over back and tail forming broad line on tail and patch on head but as discrete spots on sides; red-brown or purple-brown mottling on back and sides except at tail tip and foot edge, the brown composed of scattered sparse minute dots but forming denser stripes dorso-laterally behind rhinophores, in front of gills, behind gills on tail and (in one animal) forming a T shaped mark on head; golden yellow spots all over back, sides and tail; papillae creamy white with brown especially at base and middle region, with 2–3 yellow spots, largest at base; oral tentacles creamy white with yellow patch at base and clear tip; rhinophores creamy white except tip, brown mottling concentrated on club and with 2–4 yellow spots; gills mottled creamy white and brown with a few yellow spots; anterior margin of foot brown, corners with brown dots and clear tip.

Internal morphology Labial cuticle from 8 mm animal notched, with polygonal pattern and pointed rodlets distally (Fig. 6H,I). Radula formula 19×1.0.1; oldest tooth hamate with no lateral denticles, succeeding teeth with one pointed denticle distal to cusp and progressively more lateral denticles of variable size proximal to cusp, 16 in the newest teeth (Fig. 6J).

Geographical range West Africa from the Canary Islands (Moro, Ortea & Bacallado, 1997) to the Cape Verde Islands (Ortea, 1989) and Ghana (this paper).

Remarks Characteristics of the genus *Trapania* have recently been reviewed by Gosliner & Fahey (2008) who emphasize the importance of colouration, radula and jaw morphology and details of the reproductive system for distinguishing species. *T. luquei* was described from a single specimen from the Cape Verde Islands (Ortea, 1989) and further details including colour photos of two animals were added based on three specimens from Tenerife (Moro *et al.*, 1997). The Tenerife animals are greyish with white patches and yellow spots, but the most noticeable feature is brownish pigment over much of the dorsal and lateral surfaces including rhinophores, gills and papillae. Cervera *et al*. (2000) illustrate another specimen from the Canaries with black pigment over most of the back and sides of the animal, much darker than the other material from the same islands. The present material has very similar colouration to the Tenerife specimen in Moro *et al*. (1997) Plate 1 B, with white markings, golden yellow spots and brown reticulation, but with some variation in the hue and intensity of the brown and lacking the median white band on the head. The specimen in Plate 1 A of Moro *et al*. is a darker animal, while the specimen illustrated by Cervera *et al.* (2000) Fig. 1C is much blacker; neither of these animals appears to have a white band on the head. A further specimen from the Canary Islands illustrated in Debelius & Kuiter (2007) page 20 is pale in colour. Specimens from the Canary Islands are clearly variable in colouration and my Ghanaian specimens probably belong to the same species.

I am less certain, however, that all of these animals are conspecific with the type of *T. luquei* from Cape Verde which is white dorsally with a yellow patch on the head and yellow spots on the body, the flanks are blackish and the four papillae are white with small black spots (Ortea, 1989). The labial rodlets and radular teeth of the 9 mm long type specimen are illustrated, but the scales for these drawings are surely incorrect: the rodlets are shown to be up to 200 µm long and the radular teeth 180 µm broad compared with 30 µm and 52 µm for my 8 mm long Ghanaian specimen. Setting this error aside, the rodlets are similar in the two specimens but the radular teeth show some differences: the outermost denticle is smaller relative to the main cusp and the entire plate is narrower in the Ghanaian animal than in the type specimen. However, there is so much variation in shape of teeth along the length of the radular ribbon (Fig. 6 J) that I cannot be sure that these differences are significant. Moreover, Dr Ortea not only described the type specimen from Cape Verde but also co-authored the paper describing specimens from Tenerife;

he was evidently convinced that the specimens were conspecific. For the present I accept his view and regard my Ghanaian specimens as also belonging to *Trapania luquei*, but I hope it may be possible to describe further material from the Cape Verde Islands so that the situation can be clarified.

Discussion

The eight species of Goniodorididae described in this paper together with *Okenia* cf. *amoenula* (Vallès *et al.* 2000) are the only species of this family currently recorded from the entire Gulf of Guinea. One of these, *Okenia impexa*, occurs on both sides of the Atlantic, while *Trapania luquei* occurs from Cape Verde Islands to the Canaries; *Okenia digitata* is currently known from Ghana and Angola; *Okenia* cf. *amoenula* is only known from Angola; and *Okenia ghanensis*, *Okenia africana*, *Trapania africana*, and *Okenia* spp. A and B are known only from the coast of Ghana. Because of the limited exploration of the Gulf of Guinea searching specifically for nudibranchs it is likely that many further species occur in this area.

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