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Coral reef inhabiting tubeworms (Polychaeta: Serpulidae) from Enewetak, Kwajalein, Rongelap and Utirik Atolls, Marshall Islands

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The coral reef inhabiting tubeworms from the Marshall Islands have been studied by few authors mainly by samplings in Enewetak Atoll. We report several new records of serpuline and spirorbine tubeworms from Enewetak Atoll as well as from Kwajalein, Utirik and Rongelap Atolls. Twenty-one species of Serpulinae and seven species of Spirorbinae are described and illustrated with line drawings, colour and/or scanning electron microscopy photographs. Neodexiospira turrita *nom. nov. is proposed to replace* Neodexiospira preacuta. *Enewetak Atoll still represents the most species-rich atoll in the Marshall Islands but this is most likely the result of a greater sampling effort in this atoll for the last few decades.*

Keywords: atolls, tubeworms, Annelida, Serpulinae, Spirorbinae

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INTRODUCTION

Polychaete collections made between 1946 and 1958 at five atolls in the northern Marshalls (i.e. Bikini, Enewetak, Majuro, Rongelap and Rongerik atolls) contained over 130 species, including sixteen new species (Hartman, 1954; Reish, 1961, 1968; Woodwick, 1964). Few serpulines were identified, among them *Hydroides multispinosa* from Bikini Atoll (Hartman, 1954), *Hydroides albiceps* from Enewetak Atoll (Reish, 1968), *Salmacina incrustans* from Bikini, Enewetak, and Majuro atolls (Reish 1968; as *Salmacina* sp. in Hartman, 1954), *Serpula hartmanae* from Bikini and Enewetak atolls (Reish, 1968; as *Serpula* sp. in Hartman, 1954), *Spirobranchus giganteus* from Enewetak Atoll (Hartman, 1954; Reish, 1968), and *Vermiliopsis glandigerus* from Enewetak Atoll (Reish, 1968; as *Vermiliopsis* sp. in Hartman, 1954). Several other records of serpulines from Majuro Atoll are presented in Imajima & ten Hove (1984). However, few attempts were made to identify the spirorbine tubeworms, although dextral and sinistral forms were recorded by Hartman (1954) in Enewetak Atoll. Straughan (1969a) identified two spirorbine tubeworms from Enewetak, the sinistral *Vinearia koehleri* as the new species *Spirorbis (Pileolaria) polyoperculatus* Straughan 1969a and the dextral *Neodexiospira steueri* as *Spirorbis (Circeis) bellulus* Bush (in Moore & Bush, 1904).

Eight serpuline species representing seven genera and two spirorbines in two genera are included in a serpulid checklist from Enewetak Atoll, Marshall Islands (Devaney & Bailey-Brock, 1987). There are no records of tubeworms from Kwajalein, Rongelap and Utirik Atolls. Serpulids of west and south Pacific island groups are of interest to researchers evaluating faunal relationships of Indo-West Pacific regions including southern Japan and China (Imajima & ten Hove, 1984, 1986; Fiege & Sun, 1999), Hawaii, Fiji, Tonga and Guam (Bailey-Brock, 1985, 1987a, b, 1999) and biodiversity studies. Polychaetes are consumed by coral reef fish, so identification of prey species is useful for predator–prey studies (Sano *et al.*, 1984). Serpulids are important components of fouling communities and could be troublesome by their rapid colonization and secretion of calcareous tubes. Therefore, the understanding of the life history of several serpulid species has practical importance and was reviewed in Kupriyanova *et al.* (2001). Many species are brooders and have pelagic larvae that are transported by currents and in ballast water, and as adults serpulids may be dispersed on the hulls of ships and attached to flotsam (Allen, 1953; Thorp *et al.*, 1987).

Distributional records for twenty-one serpulines and seven spirorbines from Marshallese atolls are included here. A new name, *Neodexiospira turrita* nom. nov. is proposed to replace *Neodexiospira preacuta* by being the earliest available name. Variations of opercula, tubes and chaetae that are useful for taxonomic identification are discussed. Such regional differences of these diagnostic structures have been noted before by researchers in tropical serpulid taxonomy (ten Hove, 1970; Imajima & ten Hove, 1984, 1986; Fiege & Sun 1999; Pillai, 2009).

MATERIALS AND METHODS

Collections from Rongelap, Utirik and Kwajalein Atolls were made in July 1975 and Enewetak in September 1975 and

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January 1976 (Figure 1). Several localities were sampled on the south-east side of Enewetak Atoll. Enewetak, Elmer and Clyde islands represent respectively Stations 1, 2 and 3 (Figure 1). Station 1 represents samplings on nearby coral reefs or on pinnacles further in the lagoon side. Two sampling stations were selected in Kwajalein Atoll, Station 1 at the north side of Kwajalein Island and Station 2 in two Japanese pools at the south side of the same island (Figure 1). Three stations were selected on the south-east islands of Rongelap Atoll and three stations on the south-east islands of Utirik Atoll (Figure 1).

Tube worms were scraped from hard substrates or chiselled from rock, preserved in 10% formalin and stored in 70% ethanol. Worms were extracted from their tubes by carefully chipping away tube fragments from the aperture towards the narrow end of the tube until the worm was free. Tubes, opercula and chaetae were viewed with dissecting and phase contrast microscopy. Spirorbine tubes and chaetae were prepared for scanning electron microscopy (SEM). Tubes and chaetae were air dried, mounted on stubs and coated with gold/palladium. SEM observations were carried out using the Hitachi S-4800 at the Biological Electron Microscopy Facility (BEMF), University of Hawaii at Manoa. Voucher specimens were deposited in the Bernice Pauahi Bishop Museum (BPBM), Honolulu, Hawaii, USA.

SYSTEMATICS

Twenty-one species of Serpulinae and seven of Spirorbinae were collected (Table 1). Brief descriptions and habitat and collection information are provided. Full descriptions were made for poorly known species and those with wide morphological variation among habitats. The geographical range, especially in the Indo-Pacific region, is given for each species.

Family SERPULIDAE Rafinesque, 1815
Subfamily Serpulinae Rafinesque, 1815
Genus *Dasynema* Saint-Joseph, 1894
Dasynema chrysogyrus (Grube, 1876)
(Figure 2A–H)
Serpula chrysogyrus Grube 1876: 73.

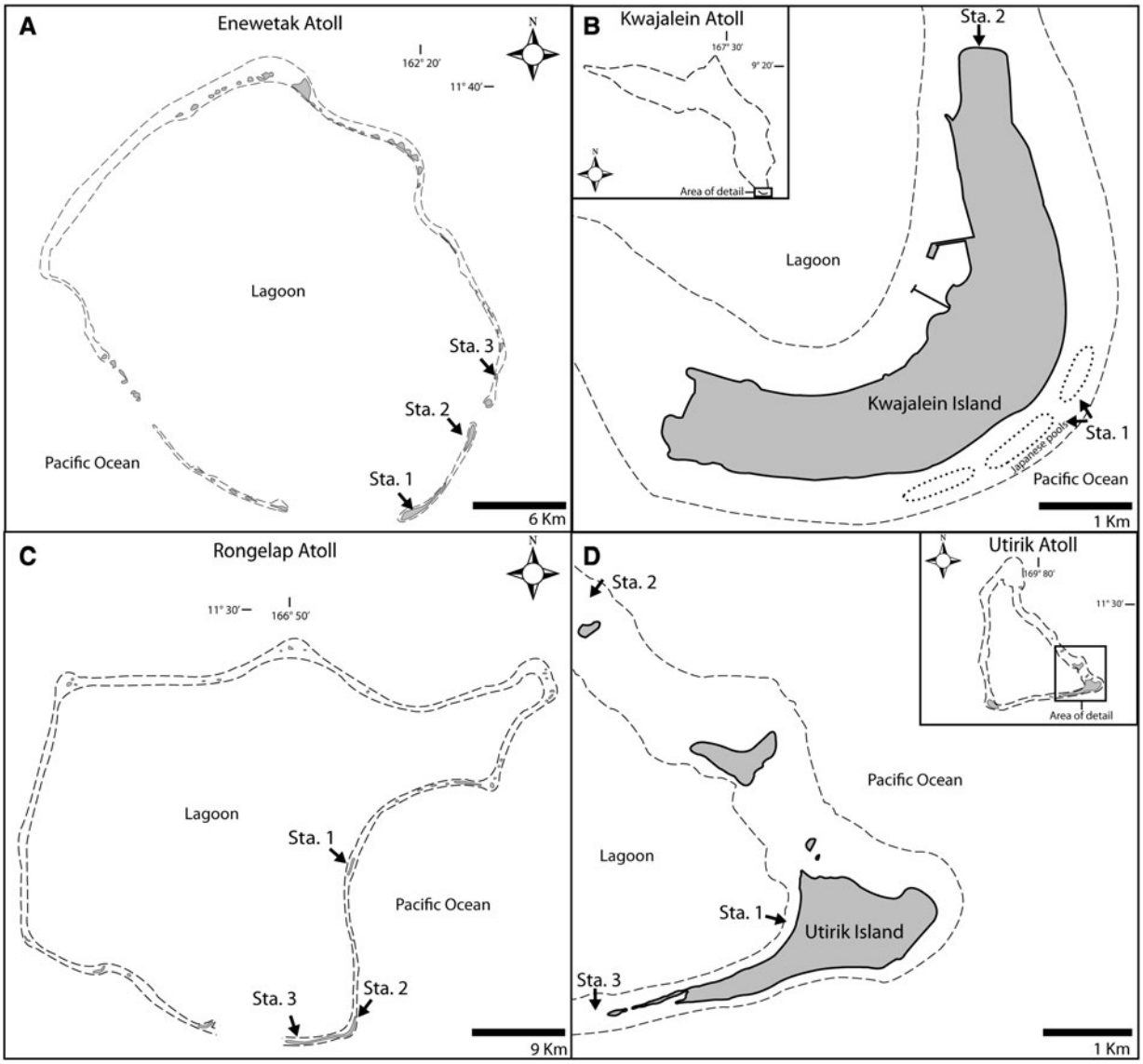

Fig. 1. Map showing collecting localities at: (A) Enewetak Atoll; (B) Kwajalein Atoll; (C) Rongelap Atoll; (D) Utirik Atoll.

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Table 1. Distribution of the tubeworm species found in the Marshall Islands.

	Bikini[1,2]	Enewetak[1,2,3,4,5]	Kwajalein[5]	Majuro[6]	Rongelap[5]	Utirik[5]
Serpulinae						
Crucigera tricornis Gravier, 1906				+		
Dasynema chrysogyrus (Grube, 1876)		+				
Hydroides albiceps (Grube, 1870)		+				
Hydroides brachyacanthus Rioja, 1941				+		
Hydroides diramphus Mörch, 1863		+				
Hydroides exaltatus (Marenzeller, 1884)					+	
Hydroides longispinosus Imajima 1976b		+			+	+
Hydroides minax (Grube, 1878)		+		+		
Hydroides multispinosus Marenzeller, 1885	+					
Hydroides spiculitubus Pillai, 2009		+		+		
Hydroides trivesiculosus Straughan, 1967b		+			+	
Hydroides tuberculatus Imajima, 1976a					+	+
Janita fimbriata (delle Chiaje, 1822)		+				
Pomatostegus actinoceras Mörch, 1863		+				
Protula sp.			+			+
Pseudovermilia pacifica Imajima, 1978		+				+
Salmacina sp.	+	+		+		
Serpula hartmanae Reish, 1968	+	+		+		
Serpula vermicularis Linnaeus, 1767				+		
Serpula cf. watsoni Willey, 1905		+		+		
Serpula willeyi Pillai, 1971		+				+
Spirobranchus decoratus Imajima, 1982		+		+		
Spirobranchus gaymardi (Quatrefages, 1866)		+		+	+	+
Spirobranchus polytrema type B *sensu* Imajima, 1977						+
Spirobranchus tetracerus (Schmarda, 1861)				+		
Vermiliopsis glandigerus Gravier, 1908		+		+		+
Vermiliopsis torquata Treadwell, 1943			+			
Spirorbinae						
Eulaeospira orientalis (Pillai, 1960)			+			
Neodexiospira nipponica (Okuda, 1934)						+
Neodexiospira steueri (Sterzinger, 1909)		+				
Neodexiospira turrita (Vine, 1972a)						+
Pileolaria pettiboneae Bailey-Brock, 1987b		+			+	+
Pileolaria pseudomilitaris (Thiriot-Quiévreux, 1965)		+				
Vinearia koehleri (Caullery & Mesnil, 1897)		+	+		+	+

[1]Hartman (1954); [2]Reish (1964); [3]Straughan (1969); [4]Devaney & Bailey-Brock (1987); [5]this study; [6]Imajima & ten Hove (1984).

Dasynema chrysogyrus—Saint-Joseph 1894: 262, 264; Bush 1905: 221–222; Imajima & ten Hove 1984: 55–58, figure 6a–t; ten Hove & Kupriyanova 2009: 36–39, figure 14.

MATERIAL EXAMINED

Enewetak Atoll: Station 1, Lagoon Pinnacles, 15–20 m (4), Station 3, Clyde Island, 5–7 m, September 1975, coll. R. Brock (2, BPBM R3495).

DIAGNOSIS

Tubes elaborated with five longitudinal ridges of tubercles; pale dull yellow with white ridges (Figure 2B–E). Radioles with slender external stylodes in a single row; paired eyespots occur at the base of stylodes. Operculum with light-brown chitinous cap with two slightly off-centre calcareous tiers (Figure 2A & F–H). Thoracic uncini become more numerous in posterior chaetigers; uncinigerous tori broadly fan-shaped. For a full description see Imajima & ten Hove (1984).

REMARKS

Dasynema chrysogyrus could be mistaken for *Vermiliopsis glandigerus* based on tube and opercular features. The external stylotes of *D. chrysogyrus* are diagnostic and have to be teased carefully away from the radiole to be seen in some preserved material.

DISTRIBUTION

Japan, Philippine Islands, Ponape and Indonesia (Imajima & ten Hove, 1984; ten Hove & Kupriyanova, 2009) and newly recorded for the Marshall Islands at Clyde Island, Enewetak Atoll.

Genus *Hydroides* Gunnerus, 1768
Hydroides diramphus Mörch, 1863
(Figure 3A)
Hydroides (Eucarphus) dirampha Mörch 1863: 379, pl. 11, figure 10.

Hydroides diramphus—Bastida-Zavala & ten Hove 2002 and references therein: 161–164, figure 34a–p; Bastida-Zavala & ten Hove 2003 and references therein: 83–86, figure 10a–l; Bastida-Zavala 2008: 25, figure 6g; Ben-Eliahu & ten Hove 2011: 17–19, figures 4 & 5a–c.

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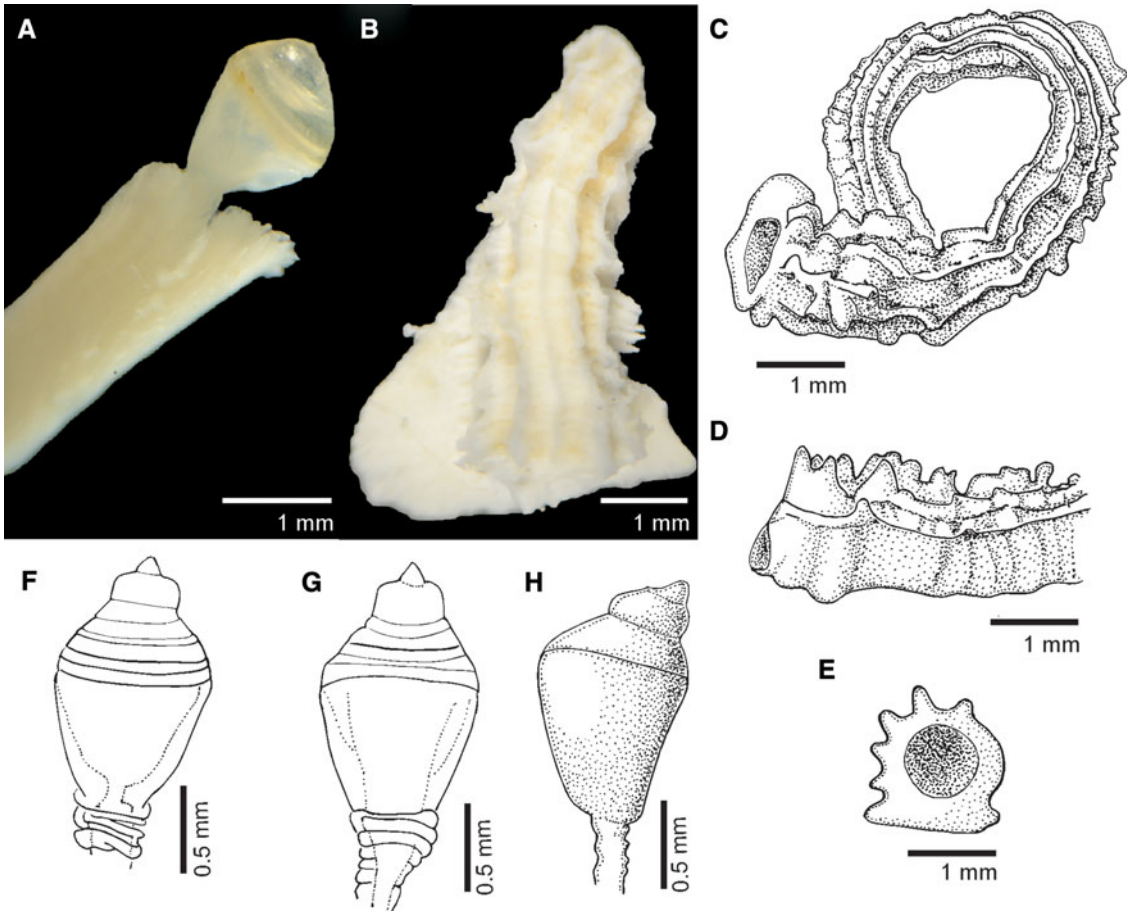

Fig. 2. *Dasynema chrysogyrus*: (A) operculum; (B) tube; (C) tube in dorso-lateral view; (D) tube in lateral view; (E) cross-section of tube; (F, G & H) opercula.

MATERIAL EXAMINED

Enewetak Atoll: Station 1, Lagoon Pinnacles, 23 m, on a clam shell, January 1976, coll. J.H. Bailey-Brock (2, BPBM R3496).

DIAGNOSIS

Verticil with 12–14 chitinous T-shaped spines, each crescentric in shape (Figure 3A); a small spine at the base of each T-shaped spine present. Opercular funnel comprised 28–30 radii with strongly pointed and darkly pigmented tips (Figure 3A). For full descriptions see Bastida-Zavala & ten Hove (2002, 2003).

REMARKS

Hydroides diramphus is most similar to *Hydroides microtis* Mörch, 1863 by having verticil spines with distal laterally expanded tips but the spines are T-shaped with flattened tip in *H. diramphus* and globular in *H. microtis* (Bastida-Zavala & ten Hove, 2002).

The specimens from Enewetak Atoll fit well the descriptions presented from material of the western Atlantic (Bastida-Zavala & ten Hove, 2002) and eastern Pacific including Hawaii (Bailey-Brock, 1987a; Bastida-Zavala & ten Hove, 2003). *Hydroides diramphus* is considered to be introduced by ship to the Hawaiian Islands (Carlton & Eldredge, 2009) and it is quite possible that this species has spread westerly into the Pacific region by human-mediated dispersal processes.

DISTRIBUTION

Circum(sub)tropical (Bastida-Zavala & ten Hove, 2002). In the western Pacific, *Hydroides diramphus* has been reported to occur in south Japan (Imajima, 1978) and the Hawaiian Islands (Hartman, 1966; Bailey-Brock, 1987a). The record of Enewetak Atoll in the Marshall Islands is new.

Hydroides exaltatus (Marenzeller, 1885)
(Figure 3B, C)

Eupomatus exaltatus Marenzeller 1885: 217, pl. 4, figure 3.

Eupomatus exaltatus—Willey 1905: 312–313, pl. VII, figure 182.

Hydroides exaltata—Imajima 1976a: 127–128, figure 4a–j; Imajima 1976b: 232–233; Imajima 1987: 77; Imajima & ten Hove 1984: 48; Imajima & ten Hove 1986: 4–5; Pillai 1960: 10–12, figure 4a–e; Mak 1982: 603; Wu & Chen 1985: 62, figure 11a, b.

Hydroides exaltatus—Dew 1959: 27–28, figure 6a; Fiege & Sun 1999: 116, figure 5d–f; Straughan 1967a: 220.

MATERIAL EXAMINED

Rongelap Atoll: Stations 1 (7, BPBM R3498) and 2 (1, BPBM R), July 1975, coll. R. Brock.

DESCRIPTION

Tube: white, thick, opaque, sub-trapezoidal in cross-section and with three low longitudinal ridges and several transverse ridges (Figure 3C).

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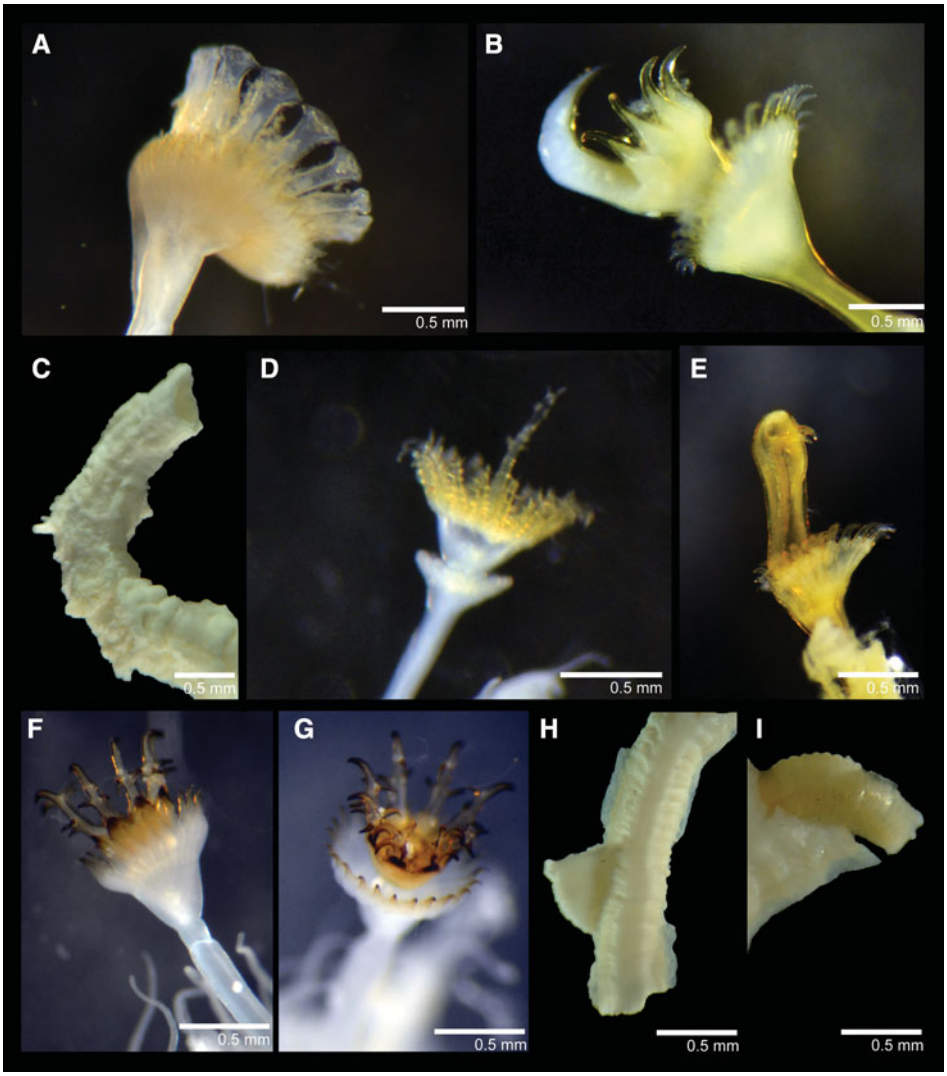

Fig. 3. (A) Operculum of *Hydroides diramphus*; (B) operculum of *Hydroides exaltatus*; (C) tube of *H. exaltatus*; (D) operculum of *Hydroides longispinosus*; (E) operculum of *Hydroides minax*; (F & G) opercula of *Hydroides spiculitubus*; (H) tube of *H. spiculitubus*; (I) posterior end of *H. spiculitubus* showing inner tube with chitinous spicules.

Branchiae: 10–12 radioles per lobe; branchial eyes and inter-radiolar membrane absent.

Peduncle: from left or right sides; cylindrical, smooth, with oblique constriction before opercular funnel. Pseudoperculum present at the right or left side.

Operculum: funnel with 26–28 marginal radii with pointed tips and curved outwards (Figure 3B). Verticil with 6–9 spines curving outwards and a large dorsal hook curved inwards (Figure 3B); one basal internal spinule present on each verticil spine.

Collar and thoracic membranes: collar smooth, tri-lobed, extending to the second row of thoracic uncini; apron present.

Thorax: with collar chaetiger and 6 uncinigerous chaetigers; collar chaetae two types: four bayonets with one or two blunt to conical teeth and four capillaries. Thoracic chaetae 6–8 same-length limbate capillaries. Thoracic uncini saw-shaped with 6–7 teeth including a simple anterior and large tooth.

Abdomen: abdominal uncini similar to thoracic ones with 5–6 teeth including a large anterior tooth. Abdominal chaetae flat-trumpets with 20 or more minute teeth. Posterior capillaries present in the last 5 chaetigers. Abdomen of 63 or more chaetigers.

Size: 5–17 mm in length, up to 1.0 mm width of thorax, operculum 0.5–1.2 mm length.

Colour of preserved specimens: pale yellow.

REMARKS

Hydroides exaltatus is similar to *H. brachyacanthus* Rioja 1941 and *H. deleoni* Bastida-Zavala & ten Hove 2003 by the presence of a large dorsal hook that is curved inwards; however, verticil spines are curved outwards in *H. exaltatus* and strongly curving inwards in *H. brachyacanthus* and *H. deleoni* (see Bastida-Zavala & ten Hove, 2003). The specimens from Rongelap Atoll agree well with Imajima's (1976a) description of material from south-west Japan. The internal verticil spinules are slender and slightly longer in the Rongelap material if compared to Imajima's illustrations (Imajima 1976a; figure 4a, b).

DISTRIBUTION

Japan, west and east coasts of Australia, Sri Lanka, Red Sea, Solomon Islands (Imajima, 1976a), south China Sea (Fiege & Sun, 1999) and newly recorded to Rongelap Atoll, Marshall Islands.

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Hydroides longispinosus Imajima 1976b
(Figure 3D)

Hydroides longispinosa Imajima 1976b: 240–246, figure 5a–q.

Hydroides longispinosus—Fiege & Sun 1999: 116–118, figure 6a, b; Imajima 1977: 95; Imajima 1982: 46; Imajima 1987: 78; Imajima & ten Hove 1984: 48; Imajima & ten Hove 1986: 3; Meng *et al.*, 1994: 46.

Hydroides centrospina Wu & Chen 1981: 354–355, figure 1a–i. syn. by Fiege & Sun 1999: 116–118; Meng *et al.*, 1994: 46, figure 3, 1–9.

MATERIAL EXAMINED

Enewetak Atoll: Station 1, East Pinnacle Lagoon, 12–18 m, September 1975, coll. R. Brock (1, BPBM R3499); Station 3, Clyde Island, September 1975, coll. R. Brock (1, BPBM R3502). Utirik Atoll: Station 2, July 1975, coll. R. Brock (1, BPBM R3501). Rongelap Atoll: Station 3, July 1975, coll. R. Brock (1, BPBM R3500).

DESCRIPTION

Tube: white, circular in cross-section with growth marks and without longitudinal ridges.

Branchiae: 8–11 radioles per lobe with very long terminal filament; branchial eyes and inter-radiolar membrane absent.

Peduncle: cylindrical, smooth, without constriction before opercular funnel. Pseudoperculum present at the left side.

Operculum: funnel with 20–22 marginal radii with obtuse tips. Verticil with 14–16 peripheral spines bearing 5–6 long lateral spinules equally arranged and few, smaller external and internal spinules; one central spine slightly to twice longer than peripheral ones without spinules or with a few on its distal half (Figure 3D).

Collar and thoracic membranes: collar smooth, tri-lobed, extending to the second row of thoracic uncini. Thoracic membrane conspicuous; apron absent.

Thorax: with collar chaetiger and 6 uncinigerous chaetigers; collar chaetae two types: six bayonets with two conical and pointed teeth, blades with small subapical denticulate and six capillaries. Thoracic chaetae 6–8 same-length limbate capillaries. Thoracic uncini saw-shaped with 5–6 teeth including a main fang.

Abdomen: abdominal uncini rasp-shaped with 5–6 teeth including a main fang. Abdominal chaetae flat-trumpet with several minute teeth. Posterior capillaries present in the last 5 chaetigers. Abdomen of 24 or more chaetigers.

Size: 3.5–5 mm in length, up to 0.4 mm width of thorax, operculum 0.3–0.45 mm in length.

Colour of preserved specimens: pale yellow.

REMARKS

Specimens from Enewetak, Utirik and Rongelap atolls agree well with the original description by Imajima (1976b) from Japanese specimens. However, the author did not describe the nature of the thoracic and abdominal uncini, which are saw-shaped and rasp-shaped respectively. The tubes of the Marshallese specimens did not present longitudinal ridges as did those from Japan (Imajima, 1976b), but Fiege & Sun (1999) describe tubes with two low longitudinal ridges for the Chinese material.

One of the three specimens examined presented a shorter opercular central spine, just slightly longer than the peripheral ones. This central spine is smooth, without spinules and could be due to regeneration after predation or growth related as Fiege & Sun (1999) also reported juveniles with a smooth central spine. For this reason, these authors synonimized *Hydroides centrospina* Wu & Chen, 1981 with *Hydroides longispinosus*.

Hydroides longispinosus is most similar to *H. multispinosus* Marenzeller, 1884 by the overall appearance of the operculum; however, the opercular central spine is long and with lateral spinules in *H. longispinosus* and short and smooth in *H. multispinosus*.

DISTRIBUTION

Known from southern Japan (Imajima, 1976b), Palau Islands, Ponape Island, Australia, Solomon Islands, Gilbert Islands (ten Hove & Imajima, 1986), South China Sea (Fiege & Sun, 1999) and newly recorded to Enewetak, Rongelap and Utirik Atolls in the Marshall Islands.

Hydroides minax (Grube, 1878)
(Figure 3E)

Serpula minax Grube 1878: 269–271, pl. 15, figure 5.

Eupomatus minax—Willey 1905: 314.

Hydroides minax—Fauvel 1939: 361–362; Fauvel 1953: 460, figure 241 f; Fiege & Sun 1999: 119–120, figure 9a–c; Imajima 1976a: 129–130, figure 5a–j; Imajima 1976b: 233–234; Imajima 1982: 42; Imajima 1987: 77; Imajima & ten Hove 1984: 48; Imajima & ten Hove 1986: 3–4; ten Hove 1994: 108; ten Hove & Ben-Eliahu 2005: figure 1h; Pillai 1960: 8–10, figure 3a–e; Pillai 1971: 110; Vine & Bailey-Brock 1984: 141.

MATERIAL EXAMINED

Enewetak Atoll: Station 1, Mid-Pacific Marine Laboratory, lagoon side, 5 m, September 1975, coll. R. Brock (1, BPBM R3503).

DIAGNOSIS

Funnel with several marginal radii with pointed tips and directed outwards. Verticil with 6–9 peripheral spines directed outwards and one very large and stout dorsal spine bent ventrally with two terminal hooks curved down. For a complete description see Imajima (1976a).

REMARKS

The specimen from Enewetak agrees well with the description of material from Japan (Imajima, 1976a) and Sri Lanka (Pillai, 1960). Funnel of the specimen from Enewetak with 30 marginal radii and vertical with 6 peripheral spines (Figure 3E).

Hydroides minax resembles only superficially to *Hydroides ancorispina* Pillai, 1971, *Hydroides albiceps* (Grube, 1870), *Hydroides bulbosus* ten Hove, 1990 and *Hydroides trivesiculosus* by the presence of a bulbous dorsal spine. It differs from all these similar species because the large and stout dorsal spine is bent ventrally and has terminal hooks that are curved down.

DISTRIBUTION

Hydroides minax is widely distributed in the Indo-West Pacific (ten Hove & Kupriyanova, 2009) including records from the Philippines, Red Sea, Mozambique, Southern Africa, Indian Ocean, Sri Lanka, Havannah and Heron Islands, Australia, Solomon Islands, Gambier Islands, French Polynesia, Japan (Imajima, 1976a), and newly recorded to Enewetak Atoll in the Marshall Islands.

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Hydroides spiculitubus Pillai, 2009
(Figure 3F–I)
Hydroides spiculitubus Pillai 2009: 125–128, figures 19a–e, 20a–g & 21a–i.

Hydroides tambalagamensis Pillai 1961—Imajima 1976a: 123–126, figure 2a–j; Imajima 1976b: 231–232; Imajima 1979: 167; Imajima & ten Hove 1984: 49; Imajima & ten Hove 1986: 4; Straughan 1967b: 33, figure 3g; Sun & Yang 2000: 128, figure 6k–s.

MATERIAL EXAMINED
Enewetak Atoll: Station 1, Henry Ocean Side, January 1976, 5–20 m, coll. R. Brock (1, BPBM R3504); Station 1, next to Oak crater, September 1975, 1–4 m, coll. R. Brock (1, BPBM R3506); Station 1, East Pinnacle Lagoon, January 1976, coll. R. Brock (1 loose operculum, BPBM R3505).

DIAGNOSIS
Funnel with 26–30 marginal radii with pointed tips and directed outwards (Figure 3F, G). Verticil with 8 peripheral spines each bearing on the middle 2 lateral spinules at each side, curved outwards, one superior internal spinule pointed down and one basal internal spinule also pointing to the base (Figure 3F, G); central tooth absent. For a complete description see Pillai (2009).

REMARKS
The two specimens and the one loose operculum examined agree well with the original description of this species by Pillai (2009) as well with Imajima's (1976a) description of *Hydroides tambalagamensis*. The inner tube with chitinous fine spicules and brown pigment band present anteriorly to each thoracic uncinal torus described by Pillai (2009) was also observed in the Enewetak specimens (see Figure 3H for tube of this species and Figure 3I for exposed inner tube). This species is most similar to *H. tambalagamensis* but differs on the position of the spinules from the peripheral spines; for instance, the pair of lateral spinules is external in *H. spiculitubus* and lateral in *H. tambalagamensis* (see also Pillai, 2009).

DISTRIBUTION
Indo-Pacific, originally described from Western Australia (Pillai, 2009) but reported before as *Hydroides tambalagamensis* Pillai, 1961 from southern Japan (Imajima, 1976a, 1979), Palau Islands and Majuro Atoll (Imajima & ten Hove, 1984), Solomon and Gilbert Islands (Imajima & ten Hove, 1986), China (Sun & Yang, 2000) and newly recorded to Enewetak Atoll in the Marshall Islands.

Hydroides trivesiculosus Straughan, 1967b
(Figure 4A)
Hydroides trivesiculosus Straughan 1967b: 33–34, figure 3h–j.

MATERIAL EXAMINED
Enewetak Atoll: Station 2, Elmers Pinnacles, 12–18 m, September 1975, coll. R. Brock (1, BPBM R3508). Rongelap Atoll: Station 1, July 1975, coll. R. Brock (3, BPBM R3507).

DESCRIPTION
Tube: white, massive, quadrangular in cross-section, with indistinct longitudinal ridges and transverse thickenings.

Branchiae: 11–14 radioles per lobe with very long terminal filament; branchial eyes and inter-radiolar membrane absent.

Peduncle: cylindrical, smooth, with constriction before opercular funnel. Pseudoperculum present at the right or left side.

Operculum: funnel asymmetrical with 22–23 marginal radii with clear or pale yellow T-shaped tips. Verticil with 6 T-shaped spines curved out. A single lobate spine with two lateral shoulder-like projections giving a trilobed appearance (Figure 4A). Lobate spine narrow and elongate in two specimens and bulbous and massive in two others.

Collar and thoracic membranes: collar smooth, tri-lobed. Thoracic membrane conspicuous; apron absent.

Thorax: with collar chaetiger and 6 uncinigerous chaetigers; collar chaetae two types: bayonets with two conical to blunt teeth, blades with apical denticulation and capillaries. Thoracic chaetae 8–10 same-length limbate capillaries. Thoracic uncini saw-shaped with 6–7 teeth including a main fang.

Abdomen: abdominal uncini saw-shaped with 4–5 teeth including a main fang. Abdominal chaetae flat-trumpets with a main fang and minute teeth on two thirds of length. Posterior capillaries present in the last 8 chaetigers. Abdomen of 60 or more chaetigers. Pygidium bilobed.

Size: 3–8 mm in length, up to 0.8 mm width of thorax, operculum 0.5–0.8 mm in length.

Colour of preserved specimens: pale yellow.

REMARKS
These specimens agree with Straughan's description (1967b) except for 6 small spines in the verticil (4 or 5 according to Straughan) and 22 radioles (24 in Straughan's specimens). These differences may be different growth stages or age of the specimens, or are due to natural variability within species. *Hydroides trivesiculosus* resembles *H. albiceps* Imajima, 1976a, which has more radii and verticil spines in the operculum, and bifid spines differ in shape. There are similar numbers of opercular radii and spines in *H. trivesiculosus* and *H. ancorispinus* Pillai, 1971 (19 funnel and 7 verticil spines), but the massive spine is a single lobe without any projections in *H. ancorispinus*.

DISTRIBUTION
Hydroides trivesiculosus is known from Queensland, Australia (Straughan, 1967b), Tanzania, Red Sea (ten Hove & Kupriyanova, 2009) and newly recorded to Enewetak and Rongelap Atolls in the Marshall Islands.

Hydroides tuberculatus Imajima, 1976a
(Figure 4B, C)
Hydroides tuberculata Imajima 1976a: 132–133, figure 7a–j.

Hydroides tuberculata—Bailey-Brock 1985: 210–211, figure 12a–c; Imajima 1976b: 233; Imajima 1978: 53; Imajima 1979: 168; Imajima 1982: 44; Imajima 1987: 77; Imajima & ten Hove 1984: 44–45; Imajima & ten Hove 1986: 5.

Hydroides tuberculatus—Fiege & Sun 1999: 121–123, figure 11a–c; Ishaq & Mustaquim 1996: 170–172, figure 6a–h; ten Hove 1994: 108.

MATERIAL EXAMINED
Rongelap Atoll: Station 1, July 1975, coll. R. Brock (1, BPBM R3509). Utirik Atoll: Station 2, July 1975, coll. R. Brock (2, BPBM R3510).

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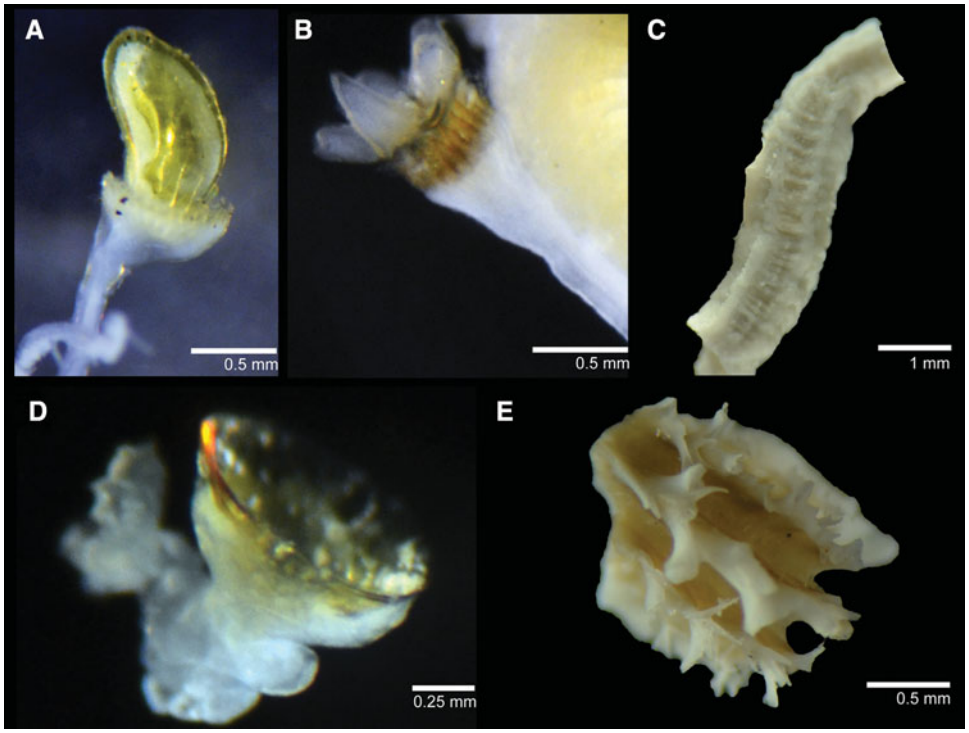

Fig. 4. (A) Operculum of *Hydroides trivesiculosus*; (B) operculum of *Hydroides tuberculatus*; (C) tube of *Hydroides tuberculatus*; (D) operculum of *Janita fimbriata*; (E) tube of *Janita fimbriata*.

DESCRIPTION

Tube: white, sub-trapezoidal in cross-section, with longitudinal ridges and a dark membranous lining (Figure 4C). One specimen with large eggs in the tube.

Branchiae: 7–8 radioles per lobe with very long terminal filament; branchial eyes and inter-radiolar membrane absent.

Peduncle: cylindrical with constriction before opercular funnel. Pseudoperculum short, rudimentary and present at the left side.

Operculum: funnel with 20–22 marginal radii with brown pointed tips (Figure 4B). Verticil with four inflated spines and one large incurved dorsal spine, all with a dorsal blunt tubercle (Figure 4B).

Collar and thoracic membranes: darkly pigmented with brown speckles; collar smooth, tri-lobed. Thoracic membrane conspicuous; apron present.

Thorax: with collar chaetiger and 6 uncinigerous chaetigers; collar chaetae two types: bayonets with two conical to blunt teeth and 2–3 small accessory teeth and capillaries. Thoracic chaetae 8 same-length limbate capillaries. Thoracic uncini saw-shaped with 6–7 teeth including a main fang.

Abdomen: abdominal uncini saw-shaped with 4–5 teeth including a main fang. Abdominal chaetae flat-trumpets with a large tooth and several small serrations. Posterior capillaries present in the last chaetigers. Abdomen of 70 or more chaetigers.

Size: 7–13 mm in length, up to 0.5 mm width of thorax, operculum 0.5–0.7 mm in length.

Colour of preserved specimens: pale yellow with brown speckled on collar and thoracic membranes.

REMARKS

One specimen from Rongelap Atoll resembles *H. tuberculatus* except the operculum is incompletely developed. The massive opercular lobe is very thin, fragile and pale, and the smaller lobes inside it are visible through the wall. This specimen may have been regenerating so the opercular structures are not fully developed.

Hydroides tuberculatus superficially resembles *H. brachyacantus* on the shape of operculum, but the verticil spines are broad valves in *H. tuberculatus* without subapical hooks as in *H. brachyacanthus*. *Hydroides inermis* Monro, 1933 from the Galapagos also have inflated verticil spines but they lack dorsal blunt tubercles.

DISTRIBUTION

This species is widely distributed in the Indo-West Pacific (ten Hove & Kupriyanova 2009) including southern Japan, Ponape, Truk, Palau, Yap and Queensland, Australia (Imajima, 1976a; Imajima & ten Hove, 1984) and is newly recorded for Rongelap and Utirik Atolls in the Marshall Islands.

Genus *Janita* Saint-Joseph, 1894
Janita fimbriata (delle Chiaje, 1822)
(Figure 4D, E)

Omphalopomopsis fimbriata—Zibrowius 1968: 149–151, pl. 6, figures 13–21 and references therein.
Janita fimbriata—Zibrowius 1972: 122, figures 19 & 20; Zibrowius 1973: 59–61; Imajima 1979: 174–176, figure 7a–o; ten Hove & Kupriyanova 2009: 55–57, figure 24a–f.

MATERIAL EXAMINED

Enewetak Atoll: Station 1, Pinnacle Lagoon, removed from clam shell, September 1975, 23 m, coll. R. Brock (1, BPBM R3511).

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DIAGNOSIS

Elaborate tube with five longitudinal ridges raised into fins and spines (Figure 4E); tube light tan, raised ridges white (Figure 4E). Operculum golden-brown, cup-shaped plate with a hollow talon extending into the base (Figure 4D); the latter joins the wrinkled opercular peduncle and comprises three fleshy projections, two round and one angular (Figure 4D). For a full description see Imajima (1979).

REMARKS

The presence of distinct collar chaetae (*Spirobranchus* type, acicular and/or limbate) among and within populations has been discussed by several authors (e.g. Ben-Eliahu & Fiege, 1996; ten Hove & Kupriyanova, 2009) and might be of ontogenetic effect (ten Hove personal communication in Ben-Eliahu & Fiege, 1996). For instance, the single specimen collected from Enewetak Atoll presented two kinds of collar chaetae: five aciculars with proximal rasps and fine longitudinal striations and five limbate chaetae, lacking the *Spirobranchus* type.

DISTRIBUTION

Subtropical Atlantic, Mediterranean, Indo-West Pacific (ten Hove & Kupriyanova, 2009). In the western Pacific this species has been found in southern Japan (Imajima, 1979), Solomon Islands (Imajima & ten Hove, 1986) and newly recorded to Enewetak Atoll in the Marshall Islands.

Genus *Pomatostegus* Schmarda, 1861

Pomatostegus actinoceras Mörch, 1863

(Figure 5A–K)

Pomatostegus actinoceras Mörch 1863: 400, Pl. XI, figure 16.

Pomatostegus actinoceros—Willey 1905: 314–316, pl. VIII, figures 3 & 4; Pillai 2009: 109–112, figures 9a–e & 10a–e.

Pomatostegus stellatus (Abildgaard, 1789)—Dew 1959: 41–42, figure 14a–g; Fiege & Sun 1999: 131–133, figure 19a–f; Imajima 1977: 101–102, figure 7a–k; Imajima 1982: 51; Imajima 1987: 80; Imajima & ten Hove 1984: 54; Imajima & ten Hove 1986: 9; Mak 1982: 608; Nishi 1995: 29–31, figure 1h; Pillai 1960: 23–25, figure 9a–d; Pillai 1971: 94; Straughan 1967a: 238; Straughan 1967b: 38; Straughan 1967c: 224.

MATERIAL EXAMINED

Enewetak Atoll: Station 1, on coral rock and mollusc shells from lagoon pinnacles, 15–20 m, September 1975, coll. R. Brock (12, BPBM R3514; 5, BPBM R3515; 1, BPPM R3513); Station 3, Clyde Island, 0.5–6 m, September 1975, coll. R. Brock (7, BPBM R3512).

DESCRIPTION

Tube: thick, opaque, white, triangular in section (Figure 5B–D); a strong median keel with blunt teeth and two or more lateral rows of well-defined teeth present (Figure 5B, C).

Branchiae: each lobe with 20–22 radioles, inter-radiolar membrane present.

Peduncle: muscular peduncle broad and flat with lateral wings terminating in pointed tips.

Operculum: a column with 2–6 chitinous plates with frilled margins stacked one above the other (Figure 5A, E); diameter of plates decreases upwards (Figure 5A, E). Circlets of 10–12 spines present applied to the basis of each disk, except for the first chitinous plate (Figure 5A, E); spines curved downwards on first plates and then becoming straight on the distal whorls.

Collar and thoracic membranes: collar well developed, smooth, tri-lobed, continuing into short thoracic membranes extending to the second row of thoracic uncini. Apron present.

Thorax: with collar chaetiger and 6 uncinigerous chaetigers; collar chaetae two types: bayonets with serrated base (Figure 5F) and capillaries. Thoracic chaetae include simple blades (Figure 5G) and *Apomatus* chaetae (Figure 5H). Thoracic uncini saw-shaped with 11 teeth including a simple anterior tooth (Figure 5J).

Abdomen: abdominal uncini saw-shaped with 8 teeth including a simple anterior tooth (Figure 5K). Abdominal chaetae all flat geniculate with narrow blades and 36 or more rounded teeth (Figure 5I). Abdomen of 60 or more chaetigers.

Size: 8–30 mm in length, up to 2.0 mm width of thorax, operculum up to 3.2 mm length.

Colour of preserved specimens: white with a bronze coloured operculum.

REMARKS

Pomatostegus actinoceras opercula filled the stomachs of butterfly fish, *Chaetodon auriga*, collected from Enewetak lagoon patch reefs by E. Reese (Bailey-Brock, unpublished data). This species has been regarded as synonymous with *P. stellatus*, but the latter seems to be restricted to the tropical Atlantic (ten Hove & Kupriyanova, 2009).

DISTRIBUTION

This species has a broad Indo-West Pacific distribution (ten Hove & Kupriyanova, 2009), which includes southern Japan (Imajima, 1977, 1987; Nishi, 1995), Micronesia and Australia (Dew, 1959; Imajima 1982; Imajima & ten Hove, 1984, 1986; Straughan, 1967a, b, c; Pillai, 2009), China (Mak, 1982; Fiege & Sun 1999) and Ceylon (Pillai, 1960, 1971).

Genus *Protula* Risso, 1826

Protula sp.

(Figure 6A)

MATERIAL EXAMINED

Kwajalein Atoll: Station 1, July 1975, coll. R. Brock (1). Utirik Atoll: Station 1, Utirik harbour, July 1975, coll. R. Brock (23, BPBM R3516); Station 2, July 1975, 1–2 m, coll. R. Brock (7, BPBM R3517).

DESCRIPTION

Tube: white, opaque, fragile, irregularly coiled, circular in cross section with 2 well-developed longitudinal ridges and transversal growths (Figure 6A).

Branchiae: pectiniform paired lobes number 12–15 on each side with long terminal filament; branchial eyes absent; inter-radiolar membrane present.

Collar and thoracic membranes: collar smooth and tri-lobed. Thoracic membrane well developed, overlapping dorsally, ending posterior to last thoracic uncinigerous segment.

Thorax: with collar chaetiger and 6 uncinigerous chaetigers; collar and thoracic chaetae all limbate capillaries of two lengths organized in two rows of 10–12 short and 10–12 long capillaries. *Apomatus* chaetae present numbers 1–2 on chaetigers 5 to 7. Thoracic uncini rasp-shaped with very long basal process and about 20 or more teeth.

Abdomen: abdominal uncini also rasp-shaped; anterior abdominal uncini similar in shape and size to thoracic ones

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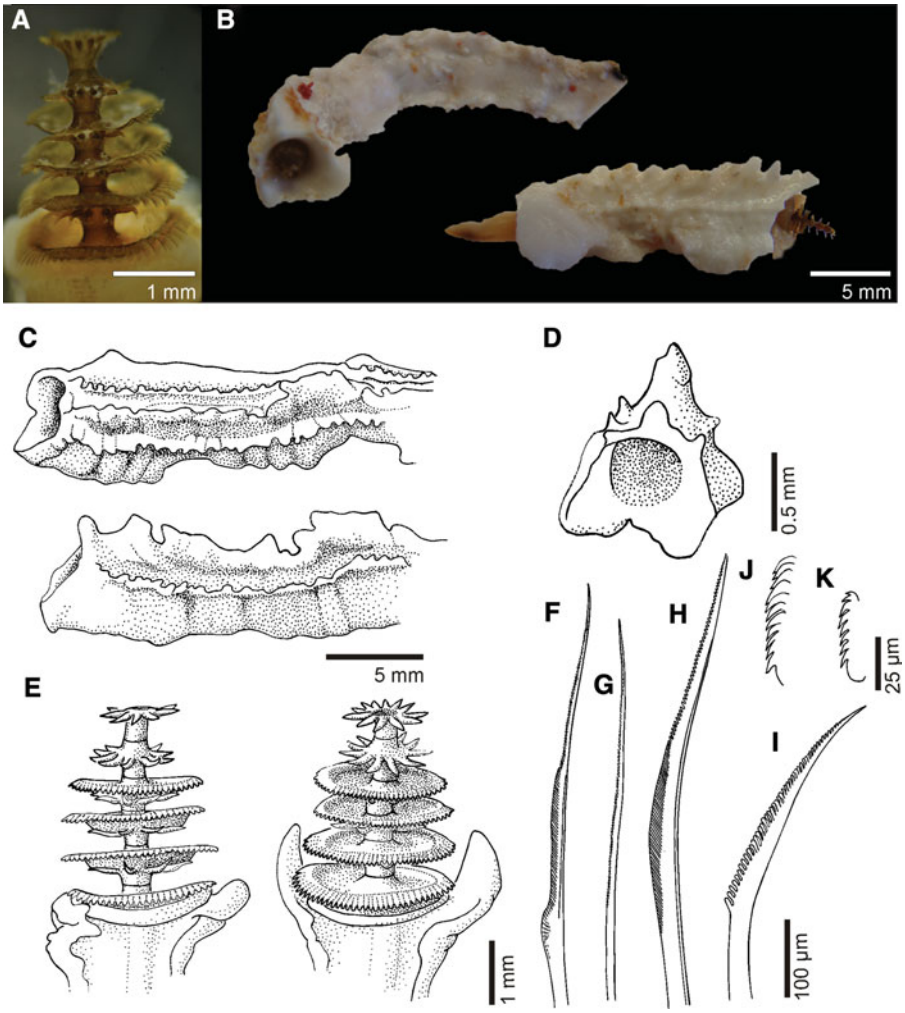

Fig. 5. *Pomatostegus actinoceras*: (A) operculum; (B) tubes in frontal and lateral view; (C) tubes in dorso-lateral and lateral views; (D) cross-section of tube; (E) opercula; (F) collar chaeta; (G) thoracic capillary chaeta; (H) *Apomatus* chaeta; (I) abdominal chaeta; (J) thoracic uncinus; (K) abdominal uncinus.

then become slightly longer and with more teeth. Anterior abdominal chaetae 3–4 geniculate blades, sickle-shaped, coarsely denticulate (teeth easily seen at 400×). Posterior abdominal chaetae 3–4 long and fine capillaries with curved tips.

Size: 3–9 mm in length, up to 2 mm width of thorax.

Colour of preserved specimens: pale yellow.

REMARKS

The specimens from Kwajalein and Utirik Atolls fit the description of Imajima (1977) for *Protula tubularia caeca*. However, the number of branchial radioles in the Utirik material is smaller (12) than in the Japanese material (15–19) but this could be age related, since the material analysed is also very small (up to 9 mm) and the type material analysed by Imajima (1977) was 25 mm in length.

DISTRIBUTION

Kwajalein and Utirik Atolls in the Marshall Islands.

Genus *Pseudovermilia* Bush, 1907

Pseudovermilia pacifica Imajima, 1978

(Figure 7A–M)

Pseudovermilia pacifica Imajima 1978: 57–59, figure 4a–n.

Pseudovermilia pacifica—Imajima 1979: 170; Imajima & ten Hove 1984: 58; ten Hove 1994: 110.

MATERIAL EXAMINED

Enewetak Atoll: Station 1, reef 8, 20 m, September 1975, coll. R. Brock (2, BPBM R3523); Station 1, 30–35 m, September 1975, coll. R. Brock (1, BPBM R3522). Utirik Atoll: Station 2, July 1975, coll. R. Brock (1, BPBM R3519; 1, BPBM R3520; 5, BPBM R3518); Station 3, July 1975, coll. R. Brock (1, BPBM R3521).

DESCRIPTION

Tube: white, triangular in section with median and two lateral ridges (Figure 7A–C); median ridge with a finely toothed margin (Figure 7A, B). One specimen with a raised transverse ridge (Figure 7A, B). Tube with lateral flanges where it meets the substrate (Figure 7A, B).

Branchiae: 10–12 radioles per lobe with long terminal filament; branchial eyes and inter-radiolar membrane absent.

Peduncle: with asymmetrical swelling at the distal end of opercular peduncle best seen in lateral view; peduncles of single plate specimens slightly wrinkled, but not conspicuously swollen. Pseudoperculum absent.

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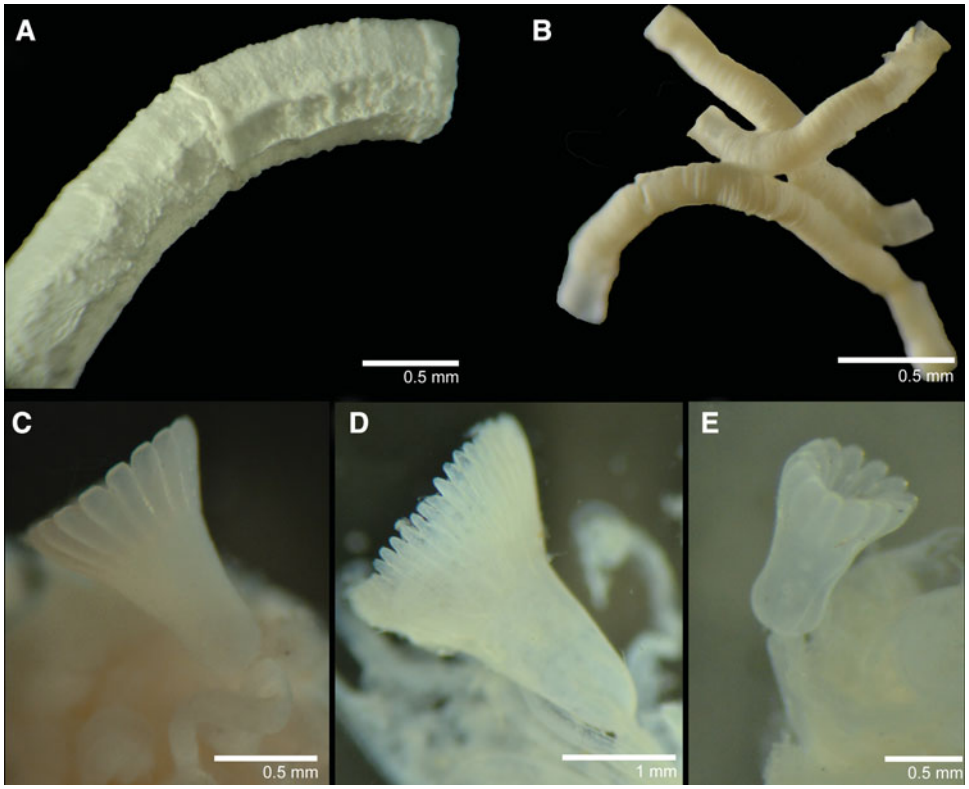

Fig. 6. (A) Tube of *Protula* sp.; (B) tubes of *Salmacina* sp.; (C) operculum of *Serpula hartmanae*; (D) operculum of *Serpula* cf. *watsoni*; (E) operculum of *Serpula willeyi*.

Operculum: three specimens with a flat plate and bell-shaped ampulla (Figure 7D), one specimen a rimmed plate and two others a stack of diabolo-like tiers with distinct margins (Figure 7E); all contained an opaque inclusion in ampulla (Figure 7D, E). Tiered and rimmed opercular plates faintly yellow and chitinous in appearance.

Collar and thoracic membranes: collar smooth, tri-lobed, with laciniate margin. Thoracic membranes ending posterior to first row of abdominal uncini.

Thorax: with collar chaetiger and 6 uncinigerous chaetigers (5 uncinigerous in the small specimen with a flat plate); collar chaetae two types: 3–4 simple blades (Figure 7G) and 1–2 capillaries. Chaetiger 2–3 with seven simple blades and chaetigers 3–7 each with 3–4 simple blades and 1–2 *Apomatus* chaetae (Figure 7F). Thoracic uncini with gouged bifid anterior tooth and single row of teeth (Figure 7K).

Abdomen: abdominal uncini shorter than thoracics and with bifid anterior tooth and multiple rows of teeth (Figure 7L, M). Achaetigerous region between thorax and abdomen present. Abdominal chaetae geniculate blades (Figure 8H) and capillary chaetae (Figure 8I). Anterior abdominal chaetigers with a pair of flat geniculate chaetae (Figure 8J), more posterior chaetigers a pair of capillaries. Abdomen of single plate specimen with 11 chaetigers.

Size: 3–3.5 mm in length, up to 0.2 mm width of thorax, operculum up to 0.8 mm in length.

Colour of preserved specimens: pale yellow.

REMARKS

Pseudovermilia pacifica resembles *Semivermilia uchidai* Imajima & ten Hove, 1986 and *P. fucostriata* ten Hove, 1975. All three species are small (less than 12 mm in length), have diabolo-tiered opercula, but the tubes differ. *P. fucostriata* has tubes with pits and spinous ridges marked by transverse brown bands. *S. uchidai* has a white tube with a median and two oblique lateral keels that are serrated. *Pseudovermilia pacifica* has white tubes, triangular in section, with a distinct median keel.

DISTRIBUTION

Indo-West Pacific (ten Hove & Kupriyanova, 2009) including southern Japan (Izu Islands), Ponape (Imajima, 1978; Imajima & ten Hove, 1984) and newly recorded from Enewetak and Utirik Atolls in the Marshall Islands.

Genus *Salmacina* Claparède, 1870

Salmacina sp.

(Figure 6B)

MATERIAL EXAMINED

Enewetak Atoll: Station 1, next to Oak crater, September 1975, 1–4 m, coll. R. Brock (3, BPBM R3551).

DESCRIPTION

Tube: white, slender, with fine transverse markings (Figure 6B).

Branchiae: 3–4 radioles per lobe; branchial eyes and interradiolar membrane absent.

Collar and thoracic membranes: collar smooth, tri-lobed. Thoracic membrane forming apron.

Thorax: with collar chaetiger and 6 uncinigerous chaetigers; collar chaetae two types: fin-and-blade and limbate capillaries. Chaetiger 2 with 1–2 *Apomatus* chaetae and 3–4 limbate

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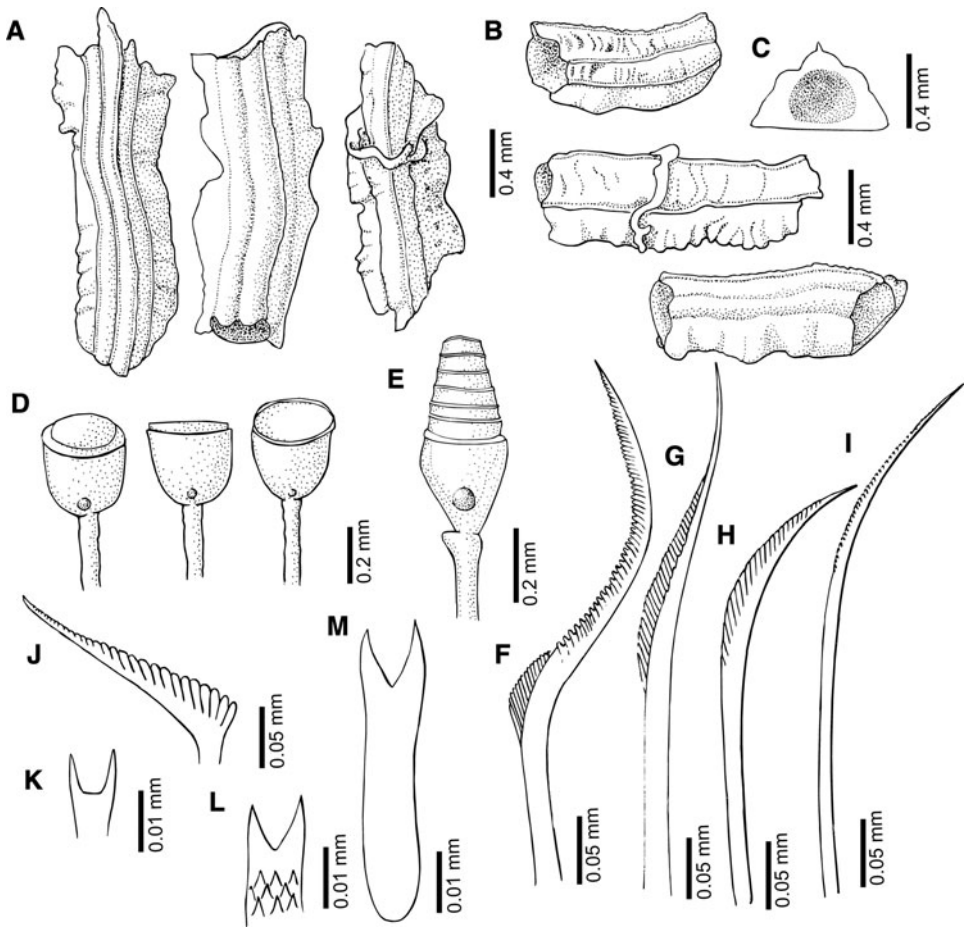

Fig. 7. *Pseudovermilia pacifica*: (A) tubes in dorsal view; (B) tubes in lateral view; (C) cross-section of tube; (D) opercula with flat plate and bell-shaped ampulla; (E) operculum with diabolo-like tiers; (F) *Apomatus* chaeta; (G) collar chaeta; (H) geniculate abdominal chaeta; (I) posterior abdominal capillary chaeta; (J) abdominal chaeta; (K) bifid anterior tooth of thoracic uncini; (L & M) abdominal uncini with bifid anterior tooth.

chaetae. Thoracic uncini rasp-shaped with 8–10 teeth including anterior pointed fang.

Abdomen: abdominal uncini similar to thoracic ones but with more teeth, about 10–12. Achaetigerous region between thorax and abdomen as long as 2 thoracic segments. Abdominal chaetae 1–2 flat geniculate blades.

Size: 1.8–2.0 mm in length, up to 0.3 mm width of thorax and up to 20 abdominal chaetigers.

Colour of preserved specimens: pale yellow.

REMARKS

Hartman (1954) reports the occurrence of *Salmacina* sp. from Enewetak Atoll and Reish (1964) and Devaney & Bailey-Brock (1987) assign it to *Salmacina incrustans* and expand the occurrence of this species to Majuro and Bikini Atolls. The specimens described herein probably belong to the same species as that reported by the authors above but it would be unwise to name it because a revision of the Pacific records is needed. The occurrence of *Salmacina incrustans* in the Pacific Ocean is questionable and it belongs to a complex of species (ten Hove & Kupriyanova, 2009).

DISTRIBUTION

Bikini, Enewetak and Majuro Atolls in the Marshall Islands.

Genus *Serpula* Linnaeus, 1758
Serpula hartmanae Reish, 1968
(Figure 6C)
Serpula sp. Hartman 1954: 641.

Serpula hartmanae Reish 1968: 228–229, figures 5 & 11–16.

Serpula hartmanae—Ben-Eliahu & ten Hove 2011: 72–83, figures 28–32; Gibbs 1971: 203; Imajima & ten Hove 1984: 36–38, figure 1a–d; Rullier 1972: 154.

MATERIAL EXAMINED

Enewetak Atoll: Station 1, Quarry on Fred, September 1975, coll. R. Brock (1, BPBM R3524).

DIAGNOSIS

Long opercular funnel with shallow cup, 12–18 blunt marginal radii and with a constriction between basal part of the funnel and peduncle (Figure 6C). For a complete description see the original description (Reish, 1968) and redescriptions (Imajima & ten Hove, 1984).

REMARKS

The single specimen collected has 18 blunt marginal radii (Figure 6C) and agrees with the descriptions by Reish (1968), Imajima & ten Hove (1984) and Ben-Eliahu & ten Hove (2011).

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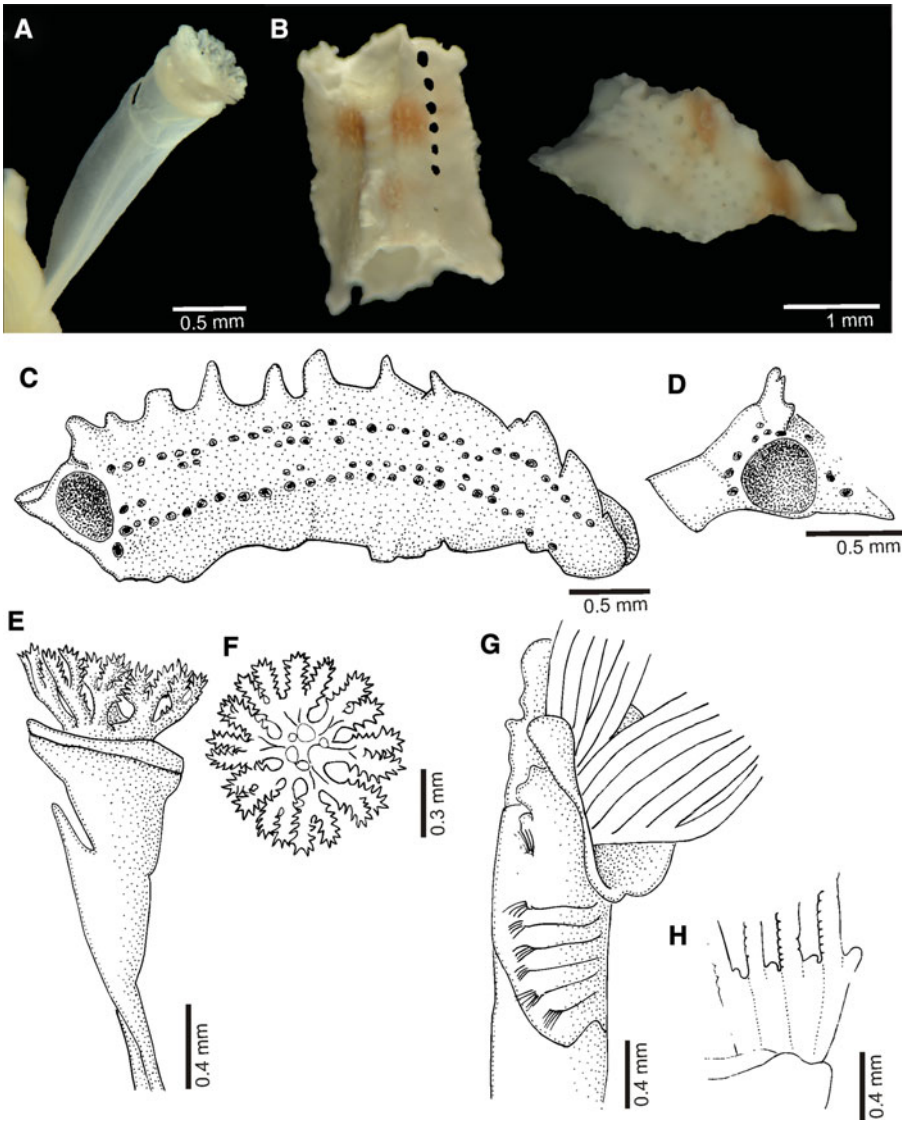

Fig. 8. *Spirobranchus decoratus*: (A) operculum; (B) tubes in dorsal and lateral views; (C) tube in lateral view; (D) tube in cross-section; (E) operculum; (F) opercular crown with branching spines; (G) collar and thoracic region in lateral view; (H) inter-radiolar membranes.

DISTRIBUTION

Indo-West Pacific (ten Hove & Kupriyanova, 2009) reported to occur in the Solomon Islands, New Caledonia, Palau Islands, Truk Islands, Ponape Islands (Imajima & ten Hove, 1986) but originally described from Bikini Atoll in the Marshall Islands (Reish, 1968) and also occurs in Majuro (Imajima & ten Hove, 1984) and Enewetak atolls. Ben-Eliahu & ten Hove (2011) report this species in the Red Sea.

Serpula cf. *watsoni* Willey, 1905
(Figure 6D)

Serpula watsoni Willey 1905: 317, pl. VII, figure 187, pl. VIII, figure 6.

Serpula watsoni—Imajima 1977: 91–92, figure 2a–j; Imajima 1982: 40; Imajima 1987: 78; Imajima & ten Hove 1984: 38–39, figure 2; Imajima & ten Hove 1986: 2; Mak 1982: 609; Pillai 2009: 140–143, figures 32a–n & 33a–n; Straughan 1967a: 207, figure 3b; Sun & Yang 2001: 194, figure 6g–m.

MATERIAL EXAMINED

Enewetak Atoll: Station 3, Clyde Patch, January 1976, 4–6 m, coll. R. Brock (1, BPBM R3525).

DIAGNOSIS

Long opercular funnel with deep hollow and 44–46 blunt marginal radii with a few tubercles on distal margin (Figure 6D). See Imajima (1977) and Pillai (2009) for complete description of this species.

REMARKS

The specimens from Enewetak Atoll agree very well with the descriptions of Imajima (1977) and Pillai (2009) of the operculum and thoracic and abdominal chaetae and uncini. However, the tube of Enewetak's specimen has two longitudinal ridges as described in Pillai (2009) and not 5 longitudinal ridges as illustrated and described by Imajima (1977).

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DISTRIBUTION
This species has an Indo-West Pacific distribution (ten Hove & Kupriyanova, 2009), which includes Sri Lanka (Willey, 1905), southern Japan (Imajima, 1977), Australia (Straughan, 1967a; Pillai, 2009), Palau, Truk and Ponape Islands (Imajima & ten Hove, 1984), Solomon Islands (Imajima & ten Hove, 1986) and Majuro (Imajima & ten Hove, 1984) and Enewetak Atolls in the Marshall Islands.

Serpula willeyi Pillai, 1971
(Figure 6E)
Serpula willeyi Pillai 1971: 101–102, figure 4a–d.

MATERIAL EXAMINED
Enewetak Atoll: Station 1, from dead Helmet shell, September 1975, 10–20 m, coll. R. Brock (2, BPBM R3527). Utirik Atoll: Station 3, July 1975, coll. R. Brock (1, BPBM R3526).

DIAGNOSIS
Long opercular funnel with deep hollow, 13 blunt marginal radii with a constriction between basal part of the funnel and peduncle (Figure 6E). For a complete description see Pillai (1971).

REMARKS
The single specimen sampled agrees well with Pillai's description.

DISTRIBUTION
Pearl Banks, Sri Lanka (Pillai, 1971) and newly recorded to Enewetak and Utirik Atolls, Marshall Islands.

Genus *Spirobranchus* de Blainville, 1818
Spirobranchus decoratus Imajima, 1982
(Figure 8A–H)

Spirobranchus tricornigerus decoratus Imajima 1982: 48–50, figure 5a–m.

Spirobranchus tricornigerus var. *decoratus* Pillai 1971: 99–100, figure 3e.

Spirobranchus decoratus—Fiege & Sun 1999: 125–126, figure 14a–d; Imajima 1987: 79; Imajima & ten Hove 1984: 52–53, figure 5d; Imajima & ten Hove 1986: 8.

MATERIAL EXAMINED
Enewetak Atoll: Station 1, reef near Oak crater on coral rubble and live coral, September 1975, 1–4 m, coll. R. Brock (4, BPBM R3528).

DIAGNOSIS
Tubes pink or pink and white, broadly triangular in section with lateral flanges and a median keel divided into coarse spines (Figure 8B–D). A spine protrudes over the mouth and one or two rows of circular holes and four rows of pits occur on either side of keel, sometimes occluded by encrusting foraminiferans and coralline algae (Figure 8B–D). Operculum with a long flattened stalk with elaborate wings each ending in a single process (Figure 8A, E, F). Opercular ampula globular, calcareous plate thick and flat bearing a crown of 5–6 branching spines (Figure 8A, E, F). Spines branch dichotomously from centre and bear small paired denticles along their length (Figure 8F). Spines all in same plane giving a finely pinnate, stellate appearance to the opercular plate (Figure 8F). For a complete description see Imajima (1982) and Imajima & ten Hove (1984).

REMARKS
These specimens agree with Imajima's description except that one small specimen had five spine bases on the opercula ampulla instead of six.

DISTRIBUTION
Spirobranchus decoratus is known from Palau, Ponape, Truk (Imajima & ten Hove, 1984), the Gilbert and Solomon Islands, Majuro, Marshall Islands and South China Sea (Fiege & Sun, 1999).

Spirobranchus gaymardi (Quatrefages, 1866)
(Figure 9A)

Spirobranchus gaymardi—Fiege & ten Hove 1999 and references therein: 356–362, figures 1–3.

Spirobranchus giganteus (Pallas 1766)—Hartman 1954: 629; Reish 1968: 229.

MATERIAL EXAMINED
Enewetak Atoll: north-western reefs near Mike and Koa craters, September 1975, 1–2 m, coll. R. Brock (1, BPBM R3554; 3, BPBM R3555). Recorded from Rongelap and Utirik Atolls on live corals.

DIAGNOSIS
See Fiege & ten Hove (1999) for a full description of this species.

REMARKS
Although numerous individuals of this species were observed on pinnacles and live coral heads in the lagoon at Enewetak, Rongelap and Utirik only a few were collected to avoid destroying live coral. Opercula of this species were found in the guts of chaetodontid fish speared in the lagoon during an analysis of chaetodon diets (Bailey-Brock, unpublished data). *Spirobranchus gaymardi* was recorded from Enewetak by Hartman (1954) and Reish (1968) as *S. giganteus*.

DISTRIBUTION
This species is widely distributed in the Indo-West Pacific (ten Hove & Kupriyanova, 2009), including Japan, South China Sea, Philippines, Indonesia, India, New Caledonia, Australia (Fiege & ten Hove, 1999) and Enewetak, Rongelap and Utirik Atolls in the Marshall Islands.

Spirobranchus polytrema type B *sensu* Imajima, 1977
(Figure 9B)
Spirobranchus polytrema type B Imajima 1977: 104–106, figure 9a–o.
Spirobranchus polytrema type B—Fiege & Sun 1999: 128–129, figure 16f, g.

MATERIAL EXAMINED
Utirik Atoll: Station 3, shallow reefs near Lone Palm Island, July 1975, coll. R. Brock (5, BPBM R3529).

DIAGNOSIS
Tubes white to pink with a pink interior, triangular in section with a median ridge forming a tooth over the mouth; with a row of perforations on either side of the ridge. Operculum

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with ampulla and calcareous cap which may be a tall cone or dome with a flared distal part with two lapel-shaped knobs (Figure 9B). Opercular peduncle flattened, finely tapered with single wings that do not bifurcate (Figure 9B). For a complete description see Imajima (1977).

REMARKS

These specimens agree with Imajima's description of *Spirobranchus* cf. *polytrema* type B (Imajima, 1977; Fiege & Sun, 1999). The smallest specimen (probably juvenile) has a calcareous cap without any ornamentation.

DISTRIBUTION

Spirobranchus polytrema type B is known from southern Japan (Imajima, 1977), south China Sea (Fiege & Sun, 1999), Cyprus and Israel (Ben-Eliahu & Payiatas, 1999) and newly recorded to Utirik Atoll in the Marshall Islands.

Genus *Vermiliopsis* Saint-Joseph, 1894
Vermiliopsis glandigerus Gravier, 1906
(Figure 9C–E)

Vermiliopsis glandigerus Gravier 1906: 121, pl. VIII, figures 290 & 291, text-figures 476–481.

Vermiliopsis infundibulum/glandigera-complex—Fiege & Sun 1999 and references therein: 133–135, figure 21a–3.

Vermiliopsis glandigera—Pillai 2009: 103–108, figures 5a–e, 6a-l & 7 a–n.

MATERIAL EXAMINED

Enewetak Atoll: Station 3, Clyde Patch, January 1976, coll. R. Brock (1, BPBM R3535); Station 1, from dead Helmet, September 1975, 8–12 m, coll. R. Brock (4, BPBM R3533); Station 1, next to Oak crater, September 1975, 1–4 m, coll R. Brock (14, BPBM R3534). Utirik Atoll: Station 2, July 1975, coll. R. Brock (3, BPBM R3530; 2, BPBM R3531); Station 1, Utirik harbour, July 1975, 2 m, coll. R. Brock (16, BPBM R3532).

DIAGNOSIS

Tubes massive with five ill-defined longitudinal ridges (Figure 9E). Operculum with a fleshy bulbous part basally and chitinized terminal cap with 6–12 dark brown rings (Figure 9C, D); shape of terminal cap very variable but usually conical in Enewetak's material. See Pillai (2009) for a full description of this species.

REMARKS

Pillai (2009) provides a great description of this species and also clarifies the differences between *V. glandigerus* and *V. infundibulum* (Philippi, 1844).

DISTRIBUTION

Red Sea, Indo-West Pacific (ten Hove & Kupriyanova, 2009) including Australia (Pillai, 2009), southern Japan (Imajima, 1976a, 1977, 1979), Micronesia (Imajima, 1982), Gilbert and Solomon Islands (Imajima & ten Hove, 1986), Majuro and Ponape Atolls and Truk Islands (Imajima & ten Hove, 1984), newly recorded to Utirik and Enewetak Atolls in the Marshall Islands.

Vermiliopsis torquata Treadwell, 1943
(Figure 10F)
Vermiliopsis torquata Treadwell, 1943: 4, figures 16 & 17.

Vermiliopsis torquata—Straughan, 1969b: 233, 235, figure 2b; Bailey-Brock, 1987a: 426, figure 3.II.200.

Vermiliopsis hawaiiensis Treadwell, 1943: 3, 4, figures 14 & 15.

Vermiliopsis multiannulata—Hartman 1966: 239.

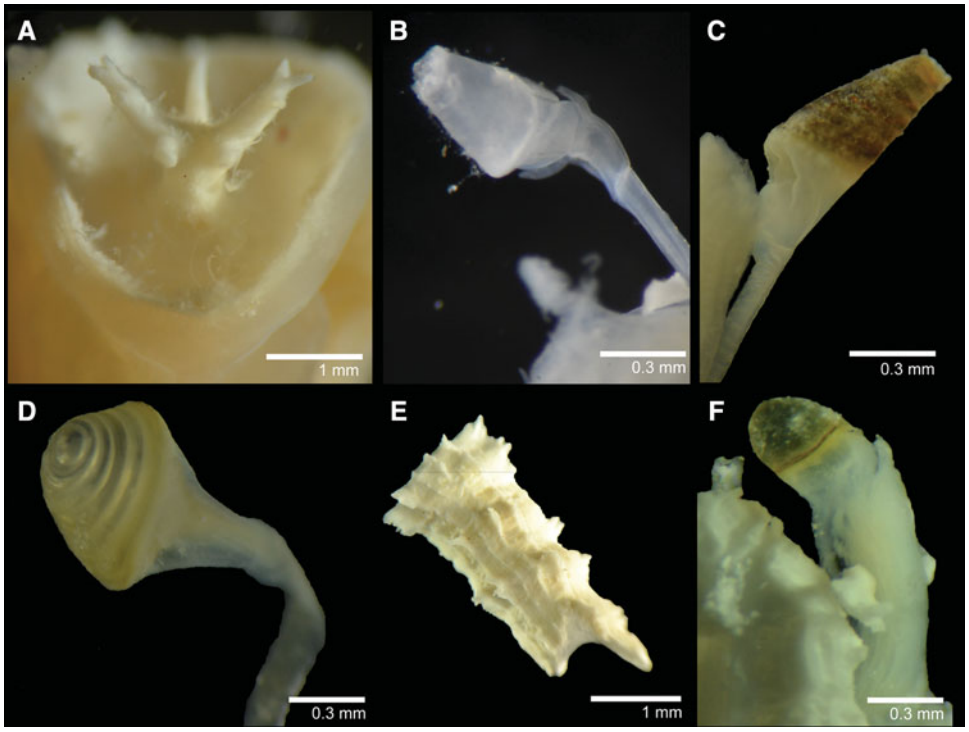

Fig. 9. (A) Operculum of *Spirobranchus gaymardi*; (B) operculum of *Spirobranchus polytrema* type B; (C & D) opercula of *Vermiliopsis glandigerus*; (E) tube of *Vermiliopsis glandigerus*; (F) operculum of *Vermiliopsis torquata*.

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MATERIAL EXAMINED
Kwajalein Atoll: Station 1, July 1975, coll. R. Brock (4, BPBM R3536).

DIAGNOSIS
Tubes massive, white and longitudinally ridged. Peduncle wrinkled, slightly swollen at base of ampulla; operculum with a ringed and brown chitinous cap (Figure 9F). See Treadwell (1943), Straughan (1969b) and Bailey-Brock (1987a) for description of this species.

REMARKS
The unique specimen is similar to Hawaiian material and agrees well with descriptions in Treadwell (1943), Straughan (1969b) and Bailey-Brock (1987a). Hartman (1966) synonymized this species with *V. multiannulata* (Moore, 1923) because both species have brown chitinous opercula but Straughan (1969b) clarifies that the tips of the branchiae are free in *V. multiannulata* only. However, the specimen from Kwajalein Atoll and also comparative material from Hawaii (Mamala Bay, Oahu) have long and free radiole tips. Type material of both species should be closely compared.

DISTRIBUTION
This species was believed to be endemic to the Hawaiian Islands but now seems to have a north-western Pacific distribution occurring also in the Marshall Islands at Kwajalein Atoll.

Subfamily SPIRORBINAE Chamberlin, 1919
Genus *Eulaeospira* Pillai, 1970
Eulaeospira orientalis (Pillai, 1960)
(Figure 10A, B)
Spirorbis (Laeospira) orientalis Pillai 1960: 37, figure 14d–j.

Eulaeospira orientalis—Pillai 1970: 138, Vine 1972a: 178–180, figure 1a–j; Bailey-Brock 1985: 213–214, figure 17a, b; Vine & Bailey-Brock 1984: 147; Bailey-Brock 1987a: 429, figure 3.II.201.

MATERIAL EXAMINED
Kwajalein Atoll: Station 2, July 1975, coll. R. Brock (2, BPBM R3552; 1, BPBM R3553).

DIAGNOSIS
Tubes with sinistral coiling and a single longitudinal ridge (Figure 10B); ascending portion lacks longitudinal ridge, circular in cross-section and with peristomial marks (Figure 10A). Operculum an inverted cone with a transparent collar-like rim. See Pillai (1960) and Vine (1972a) for a full description and illustration of this species.

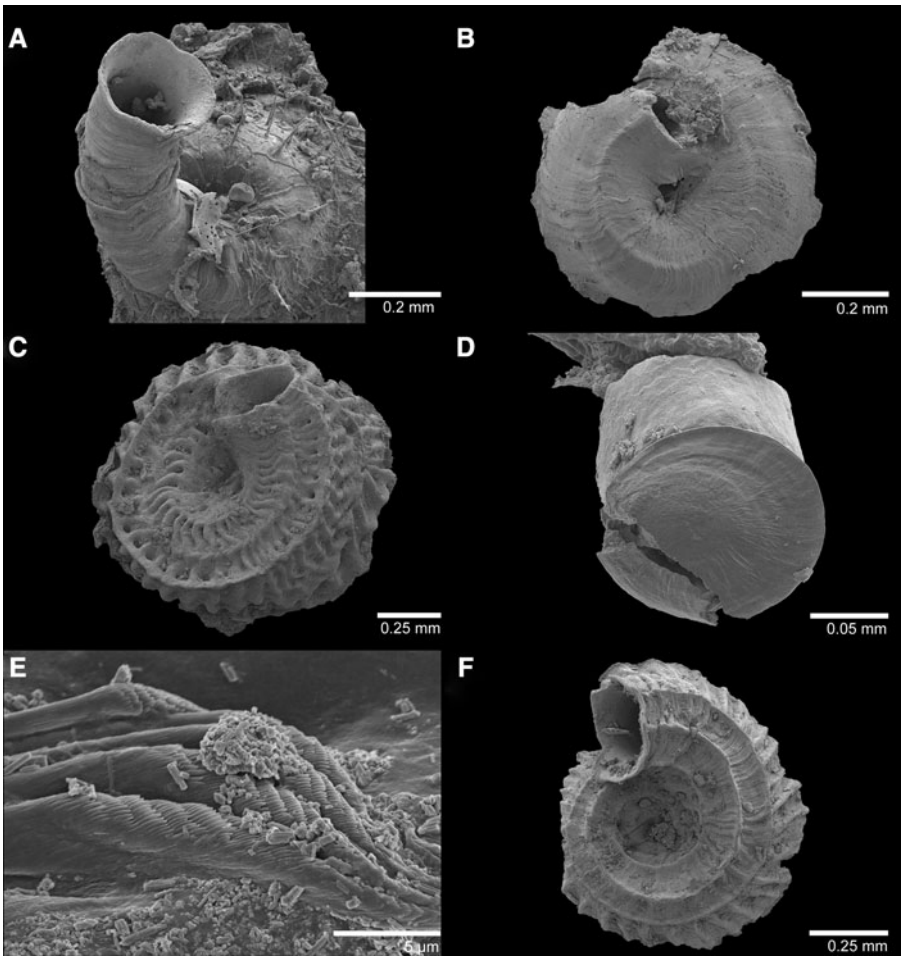

Fig. 10. (A & B) Tubes of *Eulaeospira orientalis*; (C) tube of *Neodexiospira nipponica*; (D) mature operculum of *N. nipponica*; (E) collar chaetae of *N. nipponica*; (F) tube of *Neodexiospira steueri*.

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REMARKS
Specimens agree well with the Pillai (1960) description. Several tubes presented ascending portions with 1–2 peristomial marks.

DISTRIBUTION
Known from Ceylon (Pillai, 1960), Red Sea (Vine, 1972a; Vine & Bailey-Brock, 1984), Fiji (Bailey-Brock, 1985), Hawaii (Bailey-Brock, 1987a) and newly recorded to the Marshall Islands at Kwajalein Atoll.

Genus *Neodexiospira* Pillai, 1970
Neodexiospira nipponica (Okuda, 1934)
(Figure 10C–E)
Spirorbis (Dexiospira) nipponicus Okuda 1934: 242–244, figures 8–11.

Janua (Dexiospira) nipponica—Knight-Jones *et al.*, 1979: 433–434, figure 4d; Knight-Jones *et al.*, 1975: 110–111, figures 4c & 5a; Vine *et al.*, 1972: 170–172, figure 12a–j.

Neodexiospira nipponica—Bailey-Brock 1987a: 431, figure 3.II.215 i, j; Bailey-Brock 1999: 189.

MATERIAL EXAMINED
Utirik Atoll: Station 2, July 1975, coll. R. Brock (4, BPBM R3537; 6, BPBM R3538).

DIAGNOSIS
Tubes with dextral coiling, 3 longitudinal ridges and transverse bars between them, appearing to be indentations in the surface of the tube (Figure 10C). Opercular plate flat to concave with a wedge-shaped peripheral talon (Figure 10D). See Vine *et al.* (1972) and Bailey-Brock (1987a) for a full description and illustration of this species.

REMARKS
The material analysed agrees well with the Hawaiian specimens described by Vine *et al.* (1972) and Bailey-Brock (1987a).

DISTRIBUTION
This species is known from Japan (Okuda, 1934), South Africa as *D. foraminosus* (Vine *et al.*, 1972), Hawaii (Vine *et al.*, 1972; Bailey-Brock, 1987a) and newly recorded to Utirik Atoll in the Marshall Islands.

Neodexiospira steueri (Sterzinger, 1909)
(Figure 10F)

Janua (Dexiospira) steueri— Knight-Jones *et al.*, 1974: 140–141, figure 14a–p; Vine *et al.*, 1972: 168–170, 11a–j.

Janua (Dexiospira) steueri var. *steueri*—Vine 1972b: 188–189, figure 6a–j.

Neodexiospira steueri—Bailey-Brock 1999: 189.

MATERIAL EXAMINED
Enewetak Atoll: Station 3, Clyde patch, 1–6 m, January 1976, coll. R. Brock (1, BPBM R3539; 5, BPBM R3540).

DIAGNOSIS
Tubes dextral with 3 longitudinal ridges on the top and one on the side forming blunt projections and with deep indentations between the ridges (Figure 10F). Opercular plate slightly concave with a peripheral and bifid talon bearing lateral wings. See Vine *et al.* (1972) and Bailey-Brock (1987a) for a full description and illustration of this species.

REMARKS
The records referred to *Neodexiospira foraminosa* (Moore & Bush, 1904) in the north-western Pacific (Bailey-Brock, 1987a for Hawaii; Bailey-Brock, 1976 for Johnston Atoll; Bailey-Brock, 1985 for Fiji; Bailey-Brock, 1987b for Tonga) actually belong to this species.

DISTRIBUTION
This species is widely distributed in the western Pacific, including Australia (Knight-Jones *et al.*, 1974), Hawaii (Vine *et al.*, 1972; Bailey-Brock, 1976, 1987a), Fiji (Bailey-Brock, 1985), Tonga (Bailey-Brock, 1987b), Guam and Saipan (Bailey-Brock, 1999, 2003) and newly recorded to Enewetak Atoll in the Marshall Islands.

Neodexiospira turrita nom. nov. (Vine, 1972a)
(Figure 11A, B)

Janua (Dexiospira) turrita Vine 1972a: 145–147, figure 4a–p.

Janua (Dexiospira) preacuta Vine 1972b: 186–188, figure 5a–k.

Neodexiospira preacuta—Bailey-Brock 1987a: 431–432, figure 3.II.206.

MATERIAL EXAMINED
Utirik Atoll: Station 2, from *Tridacna* shell, July 1975, coll. R. Brock (9, BPBM R3541).

DIAGNOSIS
Tubes with 3 longitudinal ridges, transversal growths and dextral coiling (Figure 11A). Opercular plate slightly concave with a long talon with an asymmetrically pointed end (Figure 11B). See Vine (1972a, b) and Bailey-Brock (1987a) for a full description and illustration of this species.

REMARKS
Drs E.W. Knight-Jones and P. Knight-Jones in correspondence dated 15 May 1973 to J.H.B-B., stated that after close comparison of *Janua (D.) preacuta* from the Red Sea and *J. (D.) turrita* from Hawaii, they could not find significant differences and considered *J. (D.) preacuta* to be the senior synonym. However, the species *J. (D.) turrita* is the earliest available name being published in April 1972 (Vine, 1972a), while *J. (D.) preacuta* was published in May 1972 (Vine, 1972b). Therefore, *J. (D.) turrita*, now accepted as *Neodexiospira turrita* nom. nov. should be considered to be the senior synonym.

DISTRIBUTION
This species is widely distributed in the Indo-West Pacific, including in the Red Sea (Vine, 1972b), Hawaii (Vine, 1972a; Bailey-Brock, 1976, 1987a), Fiji (Bailey-Brock, 1985), Tonga (Bailey-Brock, 1987b), Guam and Saipan (Bailey-Brock 1999, 2003) and newly recorded to Utirik Atoll in the Marshall Islands.

Genus *Pileolaria* Claparède, 1868
Pileolaria pettiboneae Bailey-Brock, 1987b
(Figure 11C–F)
Pileolaria pettiboneae Bailey-Brock 1987b: 286, 288, figure 6a–m.

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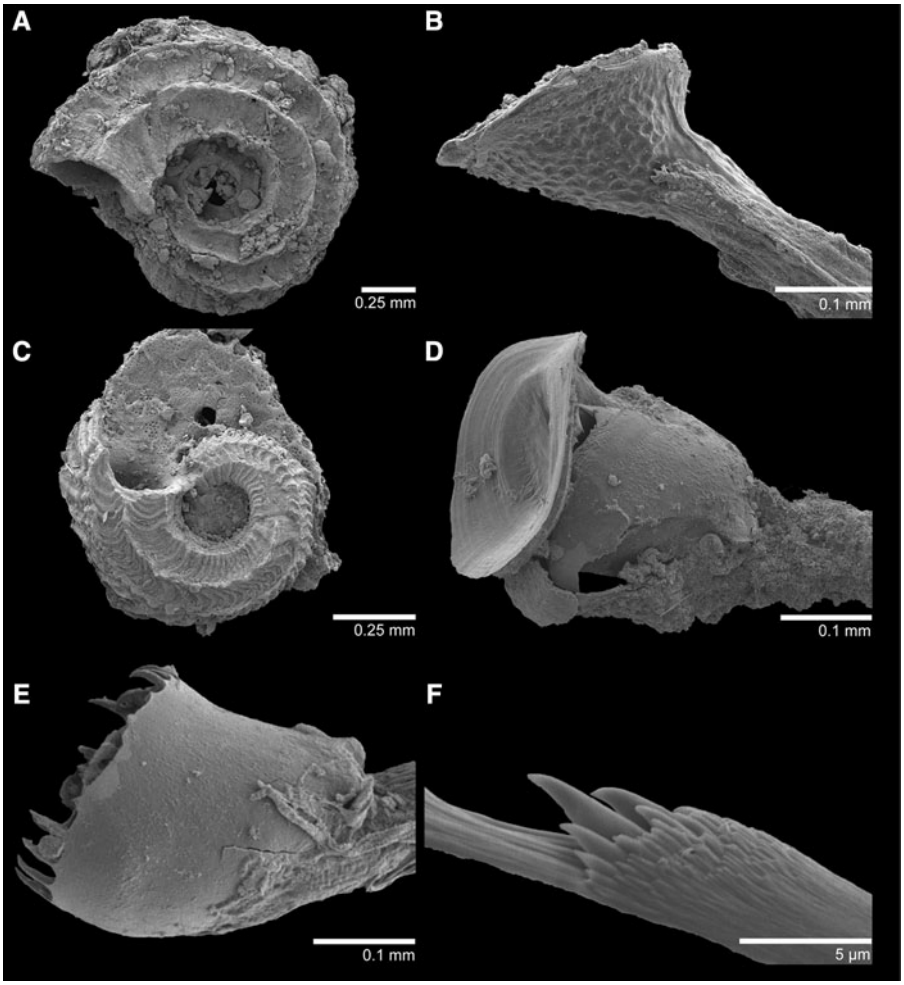

Fig. 11. (A) Tube of *Neodexiospira turrita*; (B) primary operculum of *N. turrita* in lateral view; (C) tube of *Pileolaria pettiboneae*; (D) primary operculum of *P. pettiboneae*; (E) mature operculum of *P. pettiboneae*; (F) collar chaeta of *P. pettiboneae*.

MATERIAL EXAMINED

Enewetak Atoll: Station 1, reef 8, September 1975, 30–35 m, coll. R. Brock (1, BPBM R3544; 3, BPBM R3542); same locality 1–5 m (2, BPBM R3545; 2, BPBM R3543); Station 2, Elmers Pinnacles, September 1975, 12–18 m, coll. R. Brock (3, BPBM R3556).

DIAGNOSIS

Tubes with 3 longitudinal ridges, transversal growths and sinistral coiling (Figure 11C). Primary opercula with delicate concave plates with a smooth and slender peg talon extending from the base of the cup-shaped plate (Figure 11D). Mature opercula domed calcareous chambers, open on one side and ornamented with spines (Figure 11E). See Bailey-Brock (1987b) for a full description and illustration of this species.

REMARKS

These specimens analysed here comprised part of those reported in Bailey-Brock (1987b) from Enewetak, Utirik and Rongelap Atolls in the Marshall Islands as unpublished notes.

DISTRIBUTION

Tonga, Enewetak, Utirik and Rongelap Atolls (Bailey-Brock, 1987b).

Pileolaria pseudomilitaris (Thiriot-Quiévreux, 1965)

Pileolaria (Laeospira) pseudomilitaris Thiriot-Quiévreux, 1965: 495–502, figures 1a–c, 2a–c & 3.

Pileolaria (Laeospira) pseudomilitaris—Zibrowius 1968: 207.

Spirorbis (Pileolaria) pseudomilitaris—Bailey 1969a: 369–371, figure 5a–d.

Pileolaria (Simplicaria) pseudomilitaris—Vine *et al.*, 1972: 158, 160–161, figure 6a–i; Knight-Jones *et al.*, 1974: 126–128, figure 9a–m; Knight-Jones *et al.*, 1979: 441.

Spirorbis regalis Bailey & Harris 1968: 172–174, figure 11a–j.

MATERIAL EXAMINED

Enewetak Atoll: Station 1, reef 8, January 1976, 30–35 m, coll. R. Brock (2 juveniles, BPBM R3546).

DIAGNOSIS

Tubes with transverse growth lines and sinistral coiling. Primary opercula with concave plates and small eccentric talon. Mature opercula with helmet-shaped calcified chamber with convex plate bearing several spines and incomplete rim with short spines. For a complete description see Vine *et al.* (1972) and Knight-Jones *et al.* (1974).

REMARKS

The primary opercula of the two juveniles found agree well with descriptions of material from Hawaii (Vine *et al.*, 1972) and Australia (Knight-Jones *et al.*, 1974).

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DISTRIBUTION

Described from the Mediterranean (Thiriot-Quiévreux, 1965; Zibrowius, 1968) but reported to occur in the West Indies (Bailey, 1970), Malta, Mozambique, Angola, Cape Verde Islands (Knight-Jones *et al.*, 1974). This species is broadly distributed in the Pacific Ocean including the Galapagos Islands (Bailey & Harris, 1968), Hawaii (Vine *et al.*, 1972), New Zealand (Vine, 1977), Australia and Japan (Knight-Jones *et al.*, 1974).

Genus *Vinearia* Knight-Jones, 1984
Vinearia koehleri (Caullery & Mesnil, 1897)
(Figure 12A–F)

Spirorbis (Laeospira) koehleri—Zibrowius 1968: 197–198, pl. 12, figures 15–20, pl. 14, figure h.

Spirorbis (Pileolaria) koehleri—Bailey 1969: 373, figure 8a–l.

Pileolaria (Duplicaria) koehleri—Vine *et al.*, 1972: 161–163, figure 7a–j.

Pileolaria koehleri—Vine & Bailey-Brock 1984: 147.

Vinearia koehleri—Bailey-Brock 1987a: 436–437, figure 3.II.214a–c, figure 3.II.215a; Bailey-Brock 1987b: 288; Bailey-Brock 1985: 213, figure 15.

Spirorbis (Pileolaria) polyoperculatus Straughan 1969a: 151–153, figure 1a–c.

MATERIAL EXAMINED

Enewetak Atoll: Station 2, Elmers Pinnacle, September 1975, 10–15 m, coll. R. Brock (28, BPBM R3550). Kwajalein Atoll: Station 2, July 1975, coll. R. Brock (13, BPBM R3549). Rongelap Atoll: Station 1, July 1975, coll. R. Brock (34, BPBM R3547). Utirik Atoll: Station 3, near leeward reef on pinnacle, July 1975, 10-12 m, coll. R. Brock (12, BPBM R3548).

DIAGNOSIS

Tubes with one well-defined longitudinal ridge, transverse ridges and sinistral coiling (Figure 12A). Operculum composed of 2–4 concave plates interlocking by a peg-and-socket arrangement and also supported by lateral wings on talon (Figure 12B, C); brood chambers develop underneath opercular plates (Figure 12B). See Vine *et al.* (1972) as *Pileolaria (Duplicaria) koehleri* and Bailey-Brock (1987a) for a full description and illustration of this species.

REMARKS

A few specimens from Rongelap Atoll presented up to 4 opercular plates but description from material found elsewhere reports the presence of only 2–3 opercular plates.

DISTRIBUTION

This species is widely distributed in the Mediterranean and Indo-West Pacific, including Hawaii (Vine *et al.*, 1972;

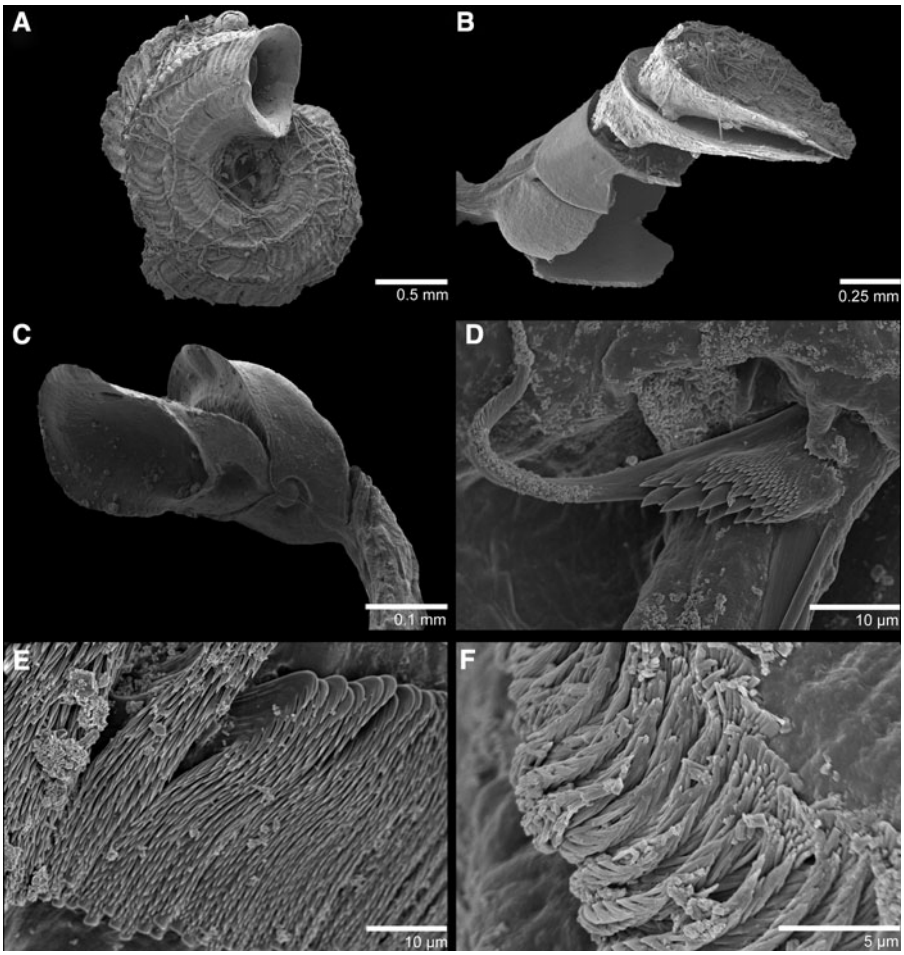

Fig. 12. *Vinearia koehleri*: (A) tube; (B & C) opercula with interlocking concave plates; (D) collar chaeta; (E) thoracic uncini; (F) abdominal uncini.

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Bailey-Brock, 1987a), Fiji (Bailey-Brock, 1985), Tonga (Bailey-Brock, 1987b) and newly recorded from Kwajalein, Utirik and Rongelap Atolls in the Marshall Islands.

DISCUSSION

Serpulid tubeworms are conspicuous components of polychaete faunas of west Pacific Islands. Twenty-five species are known from Palau and Yap, 24 from the Solomon Islands, 18 from Ponape, 13 from Truk, 13 from Majuro Atolls (Marshall Islands) and nine from the Gilbert Islands (Imajima & ten Hove 1984, 1986). We report 20 species from Enewetak (16 serpulines and four spirorbines), four from Kwajalein (two serpulines and two spirorbines), seven from Rongelap (five serpulines and two spirorbines) and 12 from Utirik Atolls (eight serpulines and four spirorbines). From countries further south, eight species were collected from both Fiji and Guam, 12 from Tonga (Bailey-Brock 1985, 1987b, 1999), although these records do not reflect a sampling effort solely for serpulids. A general trend of decreasing species richness from west to east, with increasing distance from the centre of the Indo-West Pacific region appears typical for serpulids as it is for other marine fauna (Kay & Palumbi, 1987). The relationship of serpulids from southern Japan with the Indo-Polynesian province has been well documented (Imajima & ten Hove, 1984). Differences between serpulid faunas of Guam, New Caledonia and Marshallese atolls need to be substantiated with more collections from these locations.

The ornate tubes of many serpulids are conspicuous on reef rock, harbour structures and shallow bench habitats. The brightly coloured branchial crowns of the Christmas tree worm (*Spirobranchus gardineri*), emerge from tubes overgrown by live coral. Tubeworms are part of the diet of coral reef fish. Gut contents of chaetodontids (7 spp.), labrids (2 spp.) and a pseudochromid species from Okinawa contained 12–15% serpulid parts (Sano *et al.*, 1984). Guts of 6% of *Canthigaster solandri* (sharp-backed puffer) from Bikini and Enewetak contained serpulids (Hiatt & Strasburg, 1960). E. Reese collected *Chaetodon auriga* guts at Enewetak which were full of *Pomatostegus actinoceras* opercula (Bailey-Brock, unpublished data). Operculate serpulids associated with live corals may deter coral predators. The coral eating sea star, *Acanthaster planci* avoids eating polyps adjacent to the tube openings of *S. giganteus corniculatus* (De Vantier *et al.*, 1986). These authors suggest that tube and opercular spines irritate the sea star causing it to move away and so preventing predation on the tubeworm and adjacent coral polyps. Tubeworms associated with live corals may have a competitive advantage over those living in cryptic habitats and being in a superficial position on coral heads is more beneficial for suspension filter feeding. In some cases these genera have evolved well-developed eyes and respond to shadows from fish passing over them, most likely predators, and spiny tubes and opercula that deter predators from feeding on their tissues.

ACKOWLEDGEMENTS

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