

# Hydroids symbiotic with octocorals from the Sulawesi Sea, Indonesia

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*Hydroids symbiotic with octocorals in the Bunaken Marine Park and in the Lembeh Strait (North Sulawesi, Indonesia) were studied. Four species, Hydrichthella epigorgia, Ralpharia neira, Pteroclava krempfi and Zanclea timida sp. nov. were recorded and are described. The new species Z. timida is the only one of the genus associated with an octocoral. It is characterized by a naked hydrorhiza producing nematocyst knobs and by polyps which are able to retract into their own rigid, cup-shaped, basal region. The relationship between epibiotic hydroids and their octocoral hosts affects the morphology of both partners. The hydrorhiza of Hydrichthella epigorgia is naked when associated with Anthoplexaura dimorpha, but perisarc-covered when growing on other gorgonian host species. Vice versa, the hydroid is also able to affect the host morphology: Ralpharia neira induces Ellisella sp. to develop new branches, with the inner skeleton enveloping the hydroid stem.*

**Keywords:** symbiosis, hydroids, octocorals, Indonesia

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## INTRODUCTION

Many hydroids are symbiotic with other benthic organisms such as algae, sea grasses, sponges, cnidarians, molluscs, polychaetes, bryozoans, echinoderms, tunicates and vertebrates (Boero & Bouillon, 2005). Some of these epibionts live on the external skeletal structures of the host (e.g. several hydractiniids on the shells of gastropod molluscs, or *Proboscoidactyla* spp. on the rim of polychaete tubes), but others, like those symbiotic with bryozoans or sponges, settle directly on the living epithelium or inside the tissues of the host (Puce *et al.*, 2007).

Few hydroid species live in association with other cnidarians: the hydroid epibiosis on the perisarc of other hydroid species (e.g. *Hebella* spp., Lafoeidae and Campanulariidae) is the most common association. Moreover, several hydroids live as epibionts on dead cnidarians exploiting hard coral skeletons or the gorgonian axis as substrate (Gili *et al.*, 2006).

The symbiosis between hydroids and living anthozoans involves twelve athecate species belonging to six families (Ptilocodiidae, Coryniidae, Tubulariidae, Asyncoryniidae, Cladocoryniidae and Zancleidae): *Ptilocodium repens* Coward, 1909, *Hydrichthella epigorgia* Stechow, 1909, *Sarsia medelae* Gili *et al.*, 2006, *Ralpharia magnifica* Watson, 1980, *Ralpharia coccinea* Watson, 1984, *Ralpharia neira* Petersen, 1990, *Ralpharia gorgoniae* Petersen, 1990, *Ralpharia sanctisebastiani* (da Silveira & Migotto, 1984), *Ralpharia parasitica* (Korotneff, 1887), *Asyncoryne philippina* (Hargitt, 1924), *Pteroclava krempfi* (Billard, 1919) and *Zanclea gilii* Boero *et al.*, 2000.

*Zanclea gilii* is the only species living in association with a so far unidentified tabular hard coral (F. Boero, personal communication), while the remaining species are associated with octocorals. *Ptilocodium repens* was collected on the sea pen

*Ptilosarcus sinuosus* (Coward, 1909), *Ralpharia magnifica* and *R. coccinea* on the soft coral *Parerythropodium membranaceum* (Watson, 1980, 1984), *Hydrichthella epigorgia* on the gorgonian *Anthoplexaura dimorpha* and on the soft corals *Bellonella rigida* and *Dendronephthya* sp. (Hirohito, 1988), and *Pteroclava krempfi* on the soft coral *Cladiella krempfi* (Billard, 1919) and on unidentified gorgonians (Hirohito, 1988; Boero *et al.*, 1995).

Five species have always been observed in association with gorgonians: *R. neira* on *Melitodes ochracea* (Petersen, 1990), *R. gorgoniae* on *Gorgonia ventalina* (Petersen, 1990), *R. sanctisebastiani* on *Lophogorgia punicea* (da Silveira & Migotto, 1984), *R. parasitica* on an unidentified gorgonian (Korotneff, 1887; Petersen, 1990) and *S. medelae* on three different species, *Thouarella* sp., *Primnois* sp. and *Notisis* sp. (Gili *et al.*, 2006).

The aim of this work was to study the hydroids symbiotic with octocorals in Indonesian waters, focusing on the morphological modifications resulting from the symbiosis.

## MATERIALS AND METHODS

The samples were gathered by diving in the Bunaken Marine Park and in the Lembeh Strait (North Sulawesi, Indonesia) during the years 2004–2006.

The collected samples were fixed in 4% formaldehyde after examination under a stereomicroscope.

Drawings were made from fixed material, while the colours mentioned in the descriptions are from living material. The nematocysts were measured in fixed material. For scanning electron microscopy (SEM) analysis, some portions of colonies fixed in 4% formaldehyde were rinsed and gradually dehydrated in ascending ethanol concentrations. The samples were then dried in a critical point dryer, coated with gold-palladium in a Balzer Union evaporator, and examined with a Philips XL20 scanning electron microscope.

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Histological examinations were made in thin sections of resin-embedded samples. The specimens were dehydrated in a graded ethanol series (one-day steps), embedded in a cold-curing resin (Technovit 8100), and finally mounted on plastic supports. The sections obtained by a microtome were stained with toluidine blue, then analysed with a compound optical microscope.

Type material of the new species was deposited in the Museo di Storia Naturale di Genova, Italy (MSNG).

## SYSTEMATICS

Order FILIFERA Kühn, 1913

Family PTILOCODIIDAE Coward, 1909

Genus *Hydrichthella* Stechow, 1909

*Hydrichthella epigorgia* Stechow, 1909

(Figures 1 & 2)

*Hydrichthella epigorgia* Stechow, 1909, 1913, 1923; Yamada, 1959; Bouillon, 1967; Millard & Bouillon, 1973; Bouillon, 1978; Hirohito, 1988; Bouillon *et al.*, 1997, 2006.

*Hydrichthella doederleini* Stechow, 1926; Yamada, 1959.

### Material examined

One fertile colony on the soft coral *Siphonogorgia* sp., Bualo (Bunaken National Park, North Sulawesi, Indonesia); water depth: 15 m. Collected by C.G. Di Camillo & S. Puce, February 2005.

### Description

Polymorphic colony, pink-orange colour, growing on the soft coral surface (Figures 1A & 2A). The polyps arise from a dense reticular, encrusting hydrorhiza covered by perisarc. Each polyp has a short perisarc cup at its base. Gastrozooids (up to 1.7 mm high, up to 1 mm wide) sac shaped, with mouth, lacking tentacles (Figures 1A & 2A). Gonozooids (up to 1 mm high) similar to gastrozooids in shape, each bearing one gonophore (Figures 1B & 2B). Two types of dactylozooids: one (up to 4 mm high) with 4–20 capitate tentacles, the other filiform (up to 2 mm high) with a swollen tip (Figures 1A & 2A).

The gonophores develop into eumedusoids with eight red tentacular bulbs, four radial canals and velum (Figure 1B). Only female gonophores were observed: numerous pink coloured eggs developed around the manubrium of the attached medusoids. When released, the medusoids swam actively.

Cnidome: microbasic euryteles (12.5–16.5 × 6–8 μm undischarged, 12.5–14 × 6–8 μm discharged) abundant on all types of dactylozooids and on hydrorhiza, rare on gastrozooid mouth (Figures 1C & 2C,D); desmonemes 10–11 × 4.5–5 μm undischarged abundant on tentaculate dactylozooids (Figures 1D & 2C,D). The medusoid cnidome was indeterminable.

### Remarks

Bouillon (1978) described *Hydrichthelloides reticulata* from Papua New Guinea living on different types of substrate. The colony had two kinds of dactylozooids, tentaculate and filiform, and possessed a net of stolons surrounded by perisarc. Hirohito (1988) observed colonies of *Hydrichthella*

*epigorgia* growing on different substrate, such as the gorgonian *Anthoplexaura dimorpha*, the soft corals *Dendronephthya* sp. and *Bellonella* spp., and on rocks. The colonies growing on the gorgonian showed an encrusting hydrorhiza covered by naked coenosarc, while on other substrate the hydrorhiza was reticular and perisarc covered. The observation that the type of the hydrorhiza depends on the substrate lead Hirohito (1988) and Bouillon *et al.* (2006) to define the genus *Hydrichthelloides* as a junior synonym of *Hydrichthella*, and we concur with this consideration.

We attributed our Indonesian specimens to the species *H. epigorgia* owing to the production of eumedusoids with a velum and tentacular bulbs.

Bouillon (1967) hypothesized that *H. epigorgia* could perhaps release its gonophores as free, short-lived medusoids. Our observations confirm this hypothesis, showing that the gonophores are released and are able to swim actively before spawning.

*Hydrichthella epigorgia* has so far been recorded from Japan (Stechow, 1909; Hirohito, 1988) and the Seychelles (Bouillon, 1967). Our find represents the first record for the Indonesian area.

### Relationship with the host

The hydroid grows on the host surface and the interaction is probably limited by the presence of the perisarc layer. The hydrorhiza net is dense and in preserved specimens detaches spontaneously as a film from the gorgonian surface. Apart from the formation of the perisarc covered hydrorhiza, no other mutual influences on the morphology were observed.

Order CAPITATA Kühn, 1913

Family TUBULARIIDAE Fleming, 1828

Genus *Ralpharia* Watson, 1980

*Ralpharia neira* Petersen, 1990

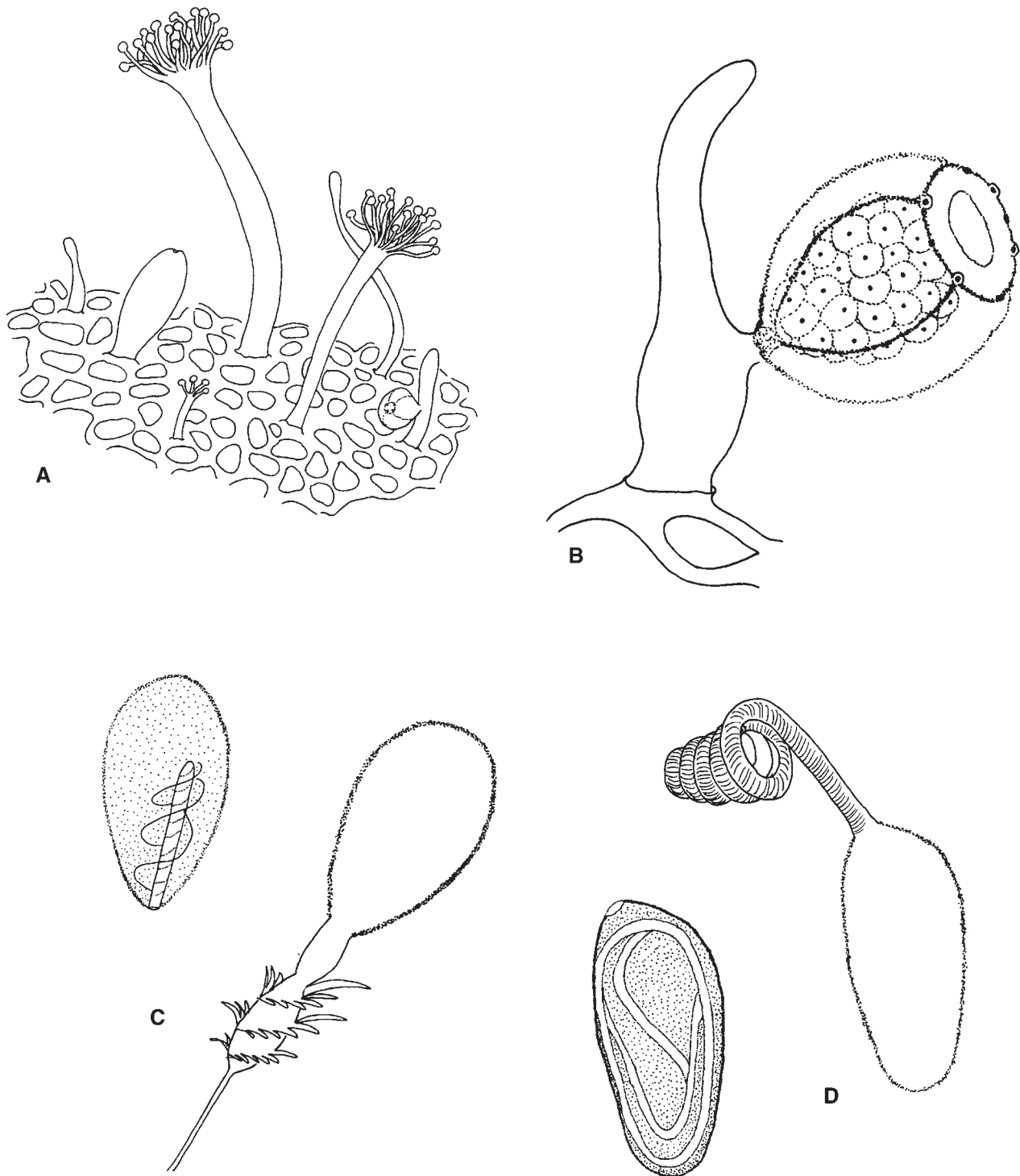
(Figures 3 & 4)

### Material examined

One fertile and three sterile polyps on the red gorgonian *Ellisella* sp., Lembeh Strait (North Sulawesi, Indonesia); water depth: 15 m. Collected by M. Boyer, May 2006.

### Description

Solitary polyp, or colony with up to two polyps, growing on the gorgonian that completely covers the hydrocaulus up to the neck region with its coenenchyme (Figures 3A & 4A, B). The hydrocaulus is enveloped by a thin layer of perisarc and in the largest specimens reaches 5 cm in height. In specimens still uncovered by the gorgonian coenenchyme, the hydrocaulus is deep orange in colour and reveals longitudinal ridges against the light (Figure 3A). The stem enlarges distally and has up to four transversal constrictions (Figure 3A). The coenosarc is parenchymatic with 8–10 longitudinal gastrovascular canals of variable diameter (Figure 4C). Living hydranths are deep orange in the basal cup, while the portion including the aboral and oral tentacles is milky white. At the base of the hydranth, there is a whorl of 25–26 filiform aboral tentacles, about 5 mm in length, tapering in diameter from about 180 μm to about 40 μm at the tip (Figures 3A & 4D). The hypostome is cone-shaped and the



**Fig. 1.** *Hydrichthella epigorgia*. (A) Colony; (B) gonozooid bearing medusoid; (C) undischarged and discharged microbasic eurytele; and (D) undischarged and discharged desmoneme. Scale: A, 2 mm; B, 500  $\mu\text{m}$ ; C, 15  $\mu\text{m}$ ; D, 10  $\mu\text{m}$ .

mouth is surrounded by 30–32 oral tentacles arranged in 4–5 irregular whorls (Figure 3A).

The large fertile polyp shows 5–6 well-developed blastostyles made up of a branched stalk bearing gonophores proximally and a group of nematophores distally (Figure 3A,B & 4E). In young hydranths, the blastostyles are absent while small groups of nematophores are already visible between the aboral tentacles. Immature gonophores (more than 20 at different stages of maturation) are orange, bell-shaped medusoids (up

to 600  $\mu\text{m}$  high and 400  $\mu\text{m}$  wide) with a circular canal, four radial canals and four white tentacle bulbs containing nematocysts (Figure 3B). Each group of nematophores (550–600  $\mu\text{m}$  in diameter) consists of 15–20 milky white elements (80  $\mu\text{m}$  high and 70  $\mu\text{m}$  wide), shaped like a garlic bulb, with four lobes armoured distally with about 20 nematocysts each (Figure 3C,D). Very young gonophores have a shape and dimension intermediate between a medusoid and nematophore (Figures 3B & 4E).

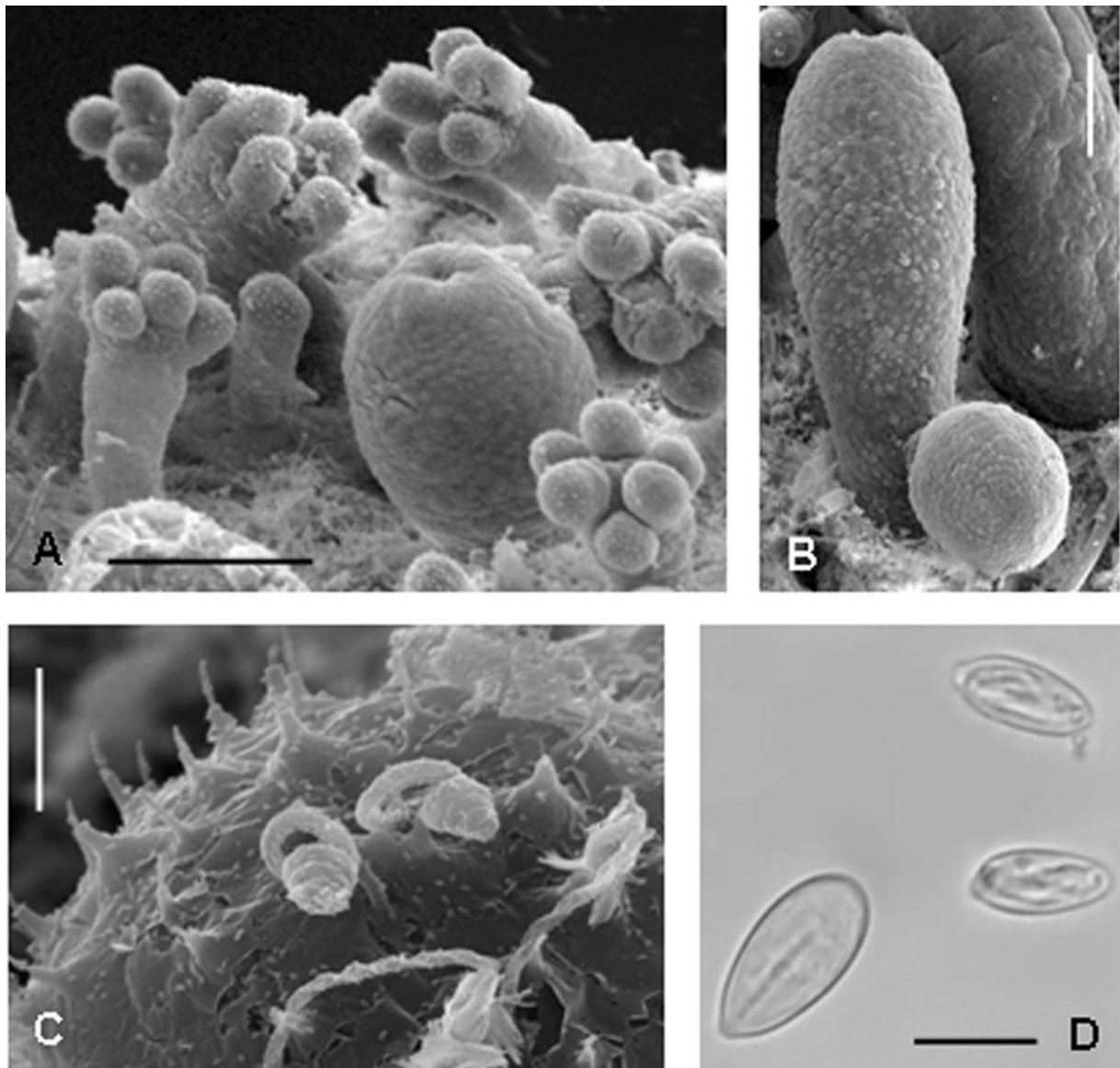


Fig. 2. *Hydrichthella epigorgia*. Scanning electron microscopy photographs of: (A) a colony; (B) a gonozooid; (C) tentacle capitation of a dactylozoid showing discharged microbasic euryteles and desmonemes; and (D) microphotograph of a microbasic eurytele and desmonemes. Scale: A, 200  $\mu\text{m}$ ; B, 100  $\mu\text{m}$ ; C, D, 10  $\mu\text{m}$ .

No medusoid release was observed.

Cnidome: oral tentacles: large stenoteles (10–12  $\times$  8–10  $\mu\text{m}$ ), small stenoteles (6–7.5  $\times$  4.5–5  $\mu\text{m}$ ), heterotrichous anisorhizas (8–10  $\times$  8–10  $\mu\text{m}$ ).

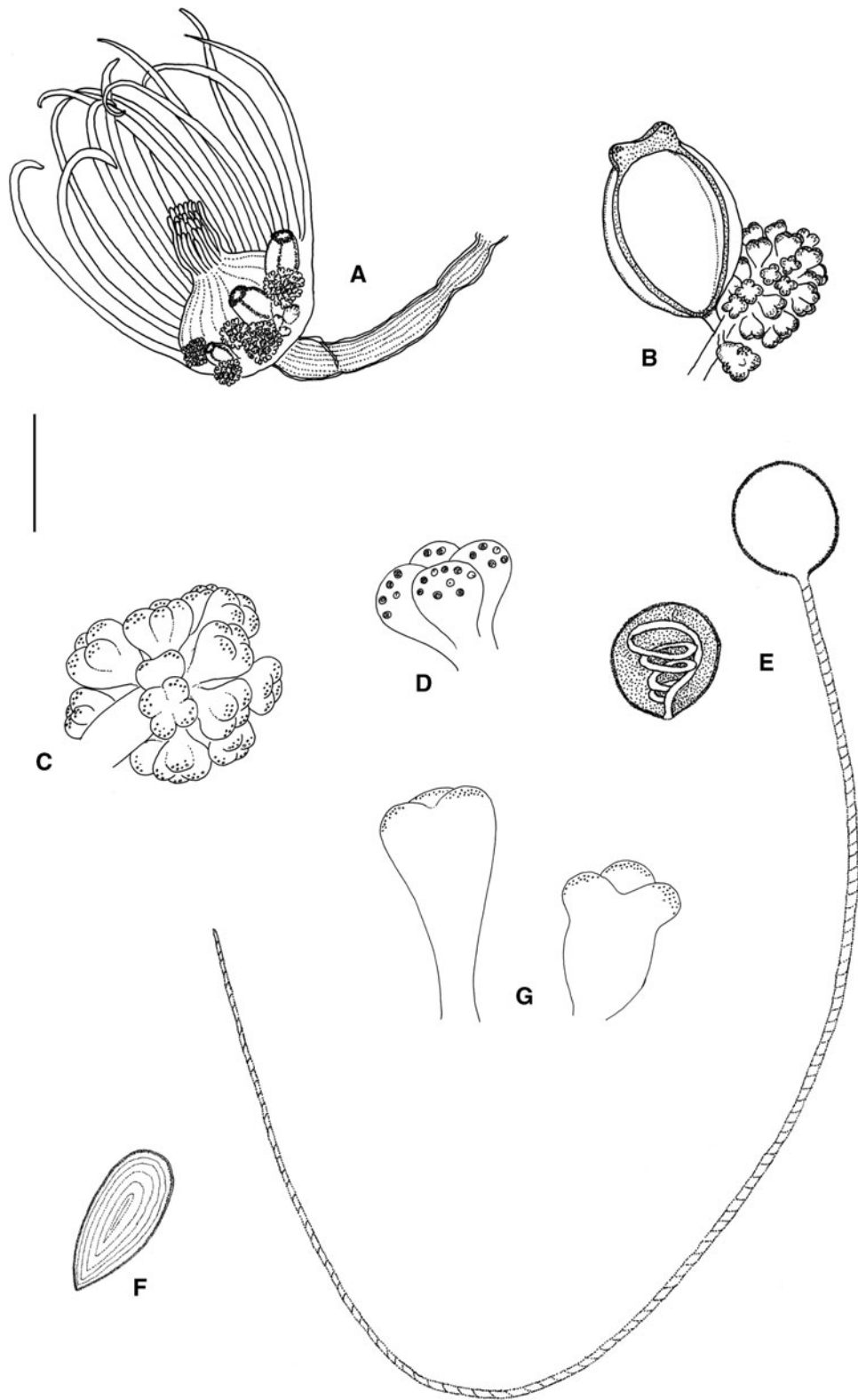
Aboral tentacles: large stenoteles (10–12  $\times$  8–10  $\mu\text{m}$ ), small stenoteles (6–7.5  $\times$  4.5–5  $\mu\text{m}$ ) (Figure 4F), heterotrichous anisorhizas (8–10  $\times$  8–10  $\mu\text{m}$ ), ?isorhizas (9–10  $\times$  4–5  $\mu\text{m}$ ) (Figures 3F & 4F).

Nematophores and immature medusoids: large stenoteles (10–12  $\times$  8–10  $\mu\text{m}$ ), heterotrichous anisorhizas (10–10  $\times$  8–10  $\mu\text{m}$  undischarged, 8–9.5  $\times$  8–9  $\mu\text{m}$  discharged, throat 150–170  $\mu\text{m}$ , 2  $\mu\text{m}$  wide proximally and 0.5  $\mu\text{m}$  distally) (Figures 3E & 4G,H).

## Remarks

The collected specimens of *Ralpharia* share with *R. sanctisebastiani*, *R. neira*, *R. gorgoniae* and *R. rosetta* the presence

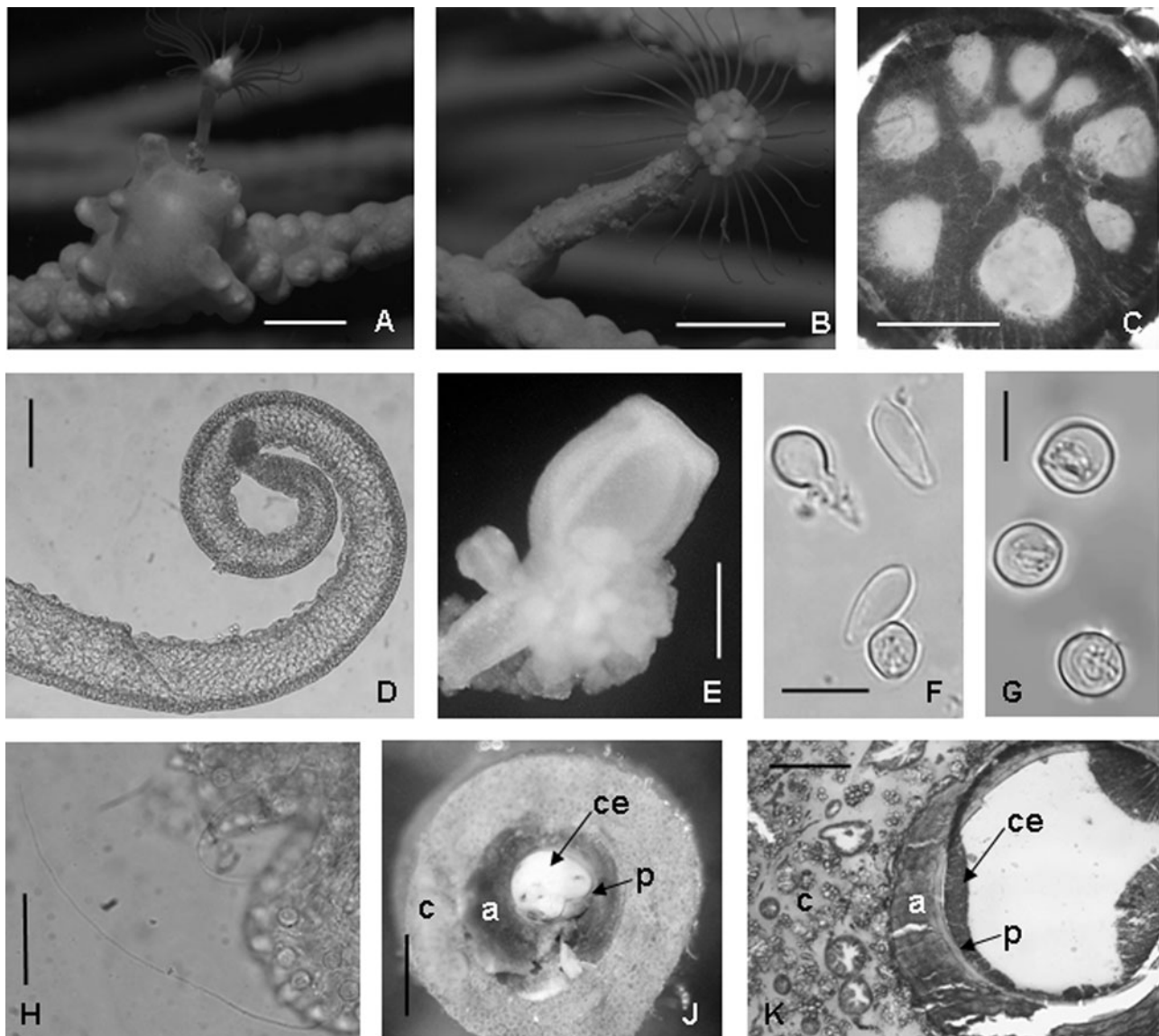
of grouped nematophores placed on the distal portion of the blastostyle. Nevertheless, they differ from *R. rosetta* in the blastostyle shape, which in this species is long, slender and unbranched, and in the host species (Watson, 1999). The nematophores of the studied specimens are garlic bulb-shaped with four lobes (Figure 3D), while those of *R. sanctisebastiani* are button-shaped (da Silveira & Migotto, 1984; Petersen, 1990). They also differ from those of *R. gorgoniae*, whose polyp is very large with tri-lobate to triangular or heart-shaped nematophores (Petersen, 1990) (Figure 3G). The general polyp shape and dimension and the nematophore shape agree with the description of *R. neira* given by Petersen (1990). Although Petersen did not mention the capsule here tentatively identified as ?isorhiza, we attributed it to *R. neira*. Petersen has perhaps overlooked this capsule type. Moreover, our specimens come from the same geographical region as *R. neira*. A comparison between the type material of *R. neira* and *R. gorgoniae* confirmed our initial identification. Petersen (1990) did not provide a catalogue number



**Fig. 3.** *Ralpharia neira*. (A) Fertile polyp; (B) medusoid with a nematophore group; (C) magnification of the nematophore group; (D) nematophore; (E) undischarged and discharged heterotrichous anisorhizas; (F) undischarged isorhizas; and (G) nematophores of the *Ralpharia gorgoniae* Petersen, 1990 type material. Scale: A, 3 mm; B, 400  $\mu$ m; C, 150  $\mu$ m; D, 70  $\mu$ m; E, 10  $\mu$ m; F, 6  $\mu$ m; G, 300  $\mu$ m.

for the holotype of *R. neira*. However, Petersen's material is kept by the Zoological Museum of Copenhagen which provided us with a sample labelled '*Ectopleura neira* Petersen, Th. Mortensen's Key Island Expedition, collected by

Th. Mortensen 1 June 1922, off Neira, Banda, Indonesia, 10 m depth'. In the tube there are numerous polyps detached from a branch of *Melithodes ochracea* (also present in the tube). All these data correspond to Petersen's description



**Fig. 4.** *Ralpharia neira*. Photographs *in situ*: (A) a polyp inducing a coenenchyme gall production; (B) a polyp with the hydrocaulus enveloped by the gorgonian coenenchyme; (C) microphotographs of the hydrocaulus coenosarc divided by gastrovascular canals; (D) an aboral tentacle; (E) a nematophore group and medusoids at different stages of development; (F) isorhizas and stenoteles from aboral tentacles; (G) undischarged heterotrichous anisorhizas from nematophores; (H) discharged heterotrichous anisorhizas from nematophores; (I) transversal section of the hydrocaulus enveloped by the gorgonian; a, gorgonian axis; c, gorgonian coenenchyme; ce, coenosarc; p, perisarc. Scale bars: A, 5 mm; B, 4 mm; C, L, 200  $\mu$ m; D, 100  $\mu$ m; E, 300  $\mu$ m; F, G, 10  $\mu$ m; H, 30  $\mu$ m; I, 600  $\mu$ m.

and therefore this specimen must be considered as the type material of *R. neira* (syntypes).

In the same collection there is also a tube labelled '*Gorgonia ventalina* (Linnaeus) (ref. no. 282). Collected by Chantal De Ridder, 19 August 1976, Galeta Reef, Panama (Atlantic side), on the edge of the reef at 1.5–2 m depth'. In the tube there is a portion of *Gorgonia ventalina* and a separate small tube without a label containing one fertile polyp. The morphology of this polyp corresponds to the description of *Ralpharia gorgoniae* Petersen, 1990. The data on the label also corresponds to Petersen's description of *R. gorgoniae*. Therefore, this polyp must be the holotype of *Ralpharia gorgoniae* Petersen, 1990.

In his description of *R. neira*, Petersen (1990, p. 189) observed 'The whole shape of the nematophore resembles a

medusa, and it is tempting to interpret these nematophores as transformed medusa buds'. The study of our specimens reveals the presence of the same nematocysts in the nematophore lobes and in the medusoid tentacular bulbs and of intermediate stages between medusoids and nematophores. These observations confirm Petersen's idea, indicating that nematophores are medusoids that do not reach maturity.

### Relationship with the host

The presence of the hydroid induces several modifications in the gorgonian. When the planula settles on the gorgonian surface, the gorgonian tissue reacts by producing a kind of gall that envelops the base of the young polyp (Figure 4A). The coenenchyme subsequently grows along the hydrocaulus

covering it up to the hydranth neck region (Figure 4B). The coenenchyme covering the hydroid does not form polyps (Figure 4B). The transversal section of the enveloped hydrocaulus revealed that the gorgonian skeletal axis enveloped the perisarc tube of the hydroid (Figure 4I & L). Progressing from the exterior to the interior, the coenenchyme, the skeletal axis, the hydroid perisarc and the hydroid coenosarc form consecutive layers (Figure 4I & L). The gorgonian skeleton is absent in the association involving *R. sanctisebastiani* and *Lophogorgia punicea* as reported by da Silveira & Migotto (1984).

Order CAPITATA Kühn, 1913  
 Family CLADOCORYNIDAE Allman, 1872  
 Genus *Pteroclava* Weill, 1931  
*Pteroclava krempfi* (Billard, 1919)  
 (Figures 5 & 6)

*Clava krempfi* Billard, 1919; Van Praët, 1979.

*Pteroclava krempfi*: Weill, 1931, 1934, 1936, 1937; Ranson, 1937; Leloup, 1937; Picard, 1957; Kramp, 1961; Vervoort, 1966; Bouillon, 1974; Petersen, 1979; Bouillon, 1985; Hirohito, 1988; Petersen, 1990; Boero *et al.*, 1995; Bouillon *et al.*, 2006.

? *Syncoryne crassa* Pictet, 1893; Hartlaub, 1905; Mayer, 1910; Prévot, 1959; Schuchert, 2003.

## Material examined

Fertile colony on the red gorgonian *Astrogorgia* sp., Siladen (Bunaken National Park, North Sulawesi, Indonesia); water depth: 12 m. Collected by C.G. Di Camillo & S. Puce, February 2005. Fertile colony on the red gorgonian *Astrogorgia* sp., Negeri (Bunaken National Park, North Sulawesi, Indonesia); water depth: 15 m. Collected by C.G. Di Camillo & S. Puce, February 2005.

## Description

Colony growing on gorgonians, with perisarc-covered hydrorhiza embedded in the host tissues (Figures 5A & 6A–C). Hydranths up to 2 mm high, borne on long pedicels covered by a distally enlarging perisarc tube; hydranth body elongated, with 4–5 moniliform oral tentacles and up to 25 moniliform scattered tentacles (Figures 5A & 6C,D); one to four patches of large nematocysts under the oral tentacles. Medusa buds single or in groups of up to three on short pedicels scattered in the mid-region of the hydranth (Figure 6B).

Medusa stage not observed.

Cnidome: macrobasic euryteles (40–41 × 15–17 μm undischarged, 37–38 × 14–15 μm discharged) in patches under oral tentacles (Figures 5B & 6E), and stenoteles of two sizes (10 × 9–10 μm and 5 × 4–5 μm undischarged) mainly on tentacles (Figure 6F).

## Remarks

Boero *et al.* (1995) noted the presence of a long pedicel in specimens inhabiting hosts rich in superficial spicules like gorgonians, while in specimens symbiotic with soft corals the pedicel is less evident. In accordance with these observations, the Indonesian specimens living on gorgonians have a long, perisarc-covered pedicel (Figures 5A & 6A–C).

This species has been recorded from Vietnam (Billard, 1919), Japan (Hirohito, 1988), Papua New Guinea (Boero *et al.*, 1995) and Réunion Island (Boero *et al.*, 1995). Our specimens represent the first record from Indonesia.

## Relationship with the host

Billard (1919) described the species with the hydrorhiza embedded in a soft coral tissue, while Hirohito (1988) observed the perisarc-covered hydrorhiza growing on a gorgonian host. The Indonesian specimens have polyps arising from a gorgonian tissue which completely hides the hydrorhiza. In fact, the longitudinal and transversal sections of a colonized gorgonian show the perisarc-covered hydrorhiza creeping below the gorgonian polyps and running along the host axis (Figure 6G) that sometimes tends to incorporate it (Figure 6H).

Order CAPITATA Kühn, 1913  
 Family ZANCLEIDAE Russell, 1953  
 Genus *Zanclaea* Gegenbaur, 1857  
*Zanclaea timida*, sp. nov.  
 (Figures 5 & 7)

## Type material

Holotype: sterile colony on the *Paratelesto* sp., Siladen (Bunaken National Park, North Sulawesi, Indonesia); water depth: 25 m; [MSG54191]. Collected by G. Bavestrello, July 2004.

## Diagnosis

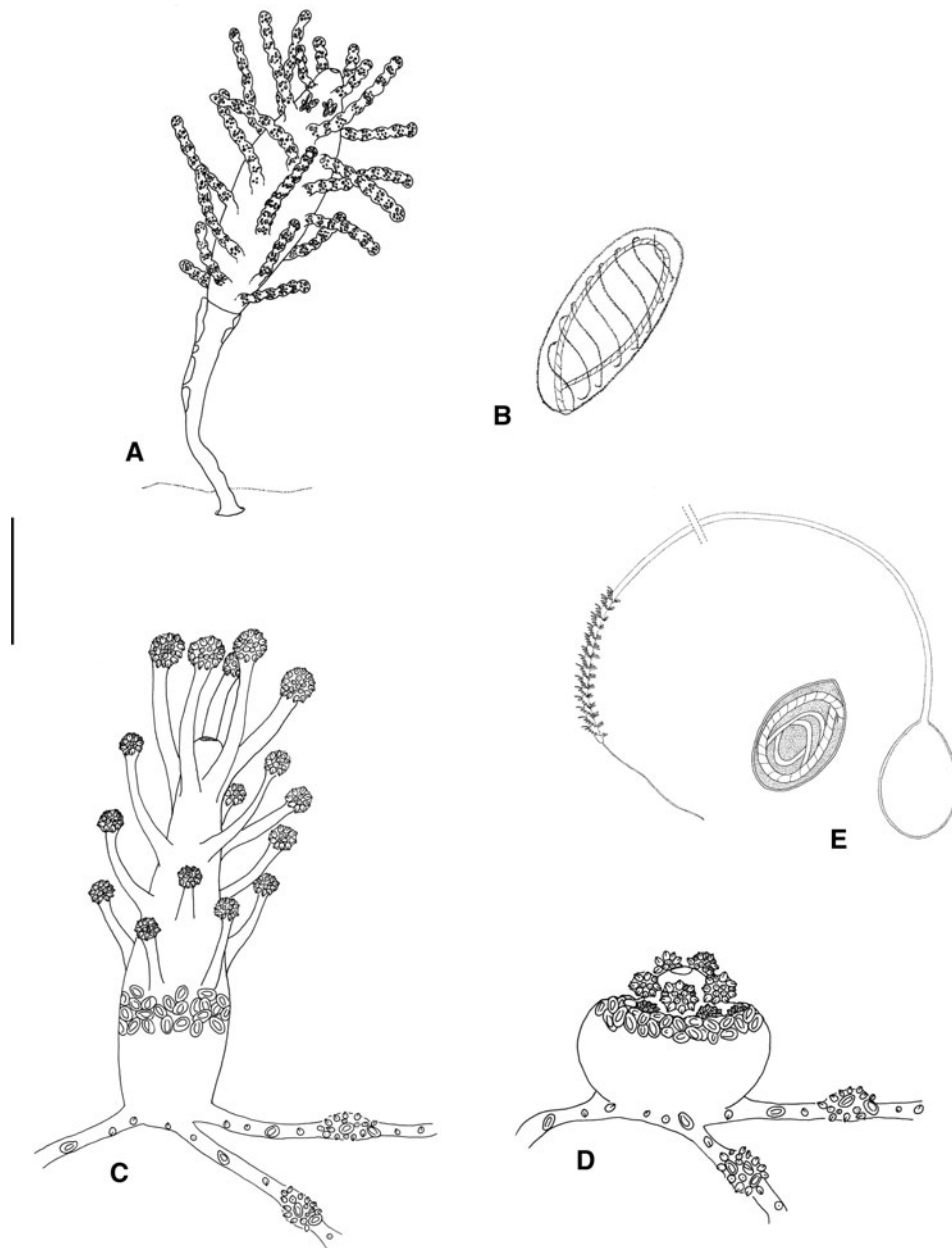
*Zanclaea* living on *Paratelesto* sp. Perisarc absent, hydrorhiza with frequent clusters of nematocysts. Hydranth with a rigid basal portion, cup-shaped, lacking tentacles. The tentaculate distal portion of the hydranth is able to completely retract inside the basal portion leaving the spherical ends of the tentacles outside. Telotrichous macrobasic, mastigophores in a ring on the distal part of the hydranth basal portion.

## Description

Colony characterized by a reticular hydrorhiza creeping on *Paratelesto* sp. and filling spaces between sclerite bundles. A perisarc is absent and the hydrorhiza is characterized by several globular cells and frequent clusters of nematocysts (Figures 5C,D & 7A,D). The polyps (up to 500 μm high) arise among the octocoral anthocodia. The hydranths are pear-shaped and show a short hypostome surrounded by 5–6 oral capitate tentacles (diameter of capitula 50 μm); 15–16 aboral capitate tentacles are scattered on the hydranth body (diameter of capitula 27, 5–30 μm) (Figures 5C & 7B). The basal portion of the hydranth is cup-shaped, semi-rigid, lacking tentacles and armoured distally by a large nematocyst ring (Figures 5C,D & 7B,C). The distal, tentaculate portion of the hydranth is able to retract completely inside the basal portion leaving the capitula of the oral tentacles outside (Figures 5D & 7C).

Medusa buds not observed.

Cnidome: egg-shaped telotrichous macrobasic mastigophores (undischarged capsule 20–21 × 15–15.5 μm, discharged capsule 18–19 × 15 μm, shaft 300 μm) in a ring on the distal part of the hydranth basal portion, on the



**Fig. 5.** *Pteroclava kremfi*. (A) Polyp; (B) macrobasal eurytele. *Zanclea timida* sp. nov.; (C) extended polyp; (D) contracted polyp; and (E) undischarged and discharged telotrichous macrobasal mastigophore. Scales: A, 200  $\mu\text{m}$ ; B, 25  $\mu\text{m}$ ; C, D, 100  $\mu\text{m}$ ; E, 20  $\mu\text{m}$ .

hydrorhiza scattered or arranged in clusters (Figures 5E & 7E–G); stenoteles of two sizes (undischarged capsule  $10\text{--}11 \times 9\text{--}10 \mu\text{m}$  and  $5\text{--}6 \times 5\text{--}6 \mu\text{m}$ ) on tentacle capitations, on the hydrorhiza both scattered and in clusters.

### Etymology

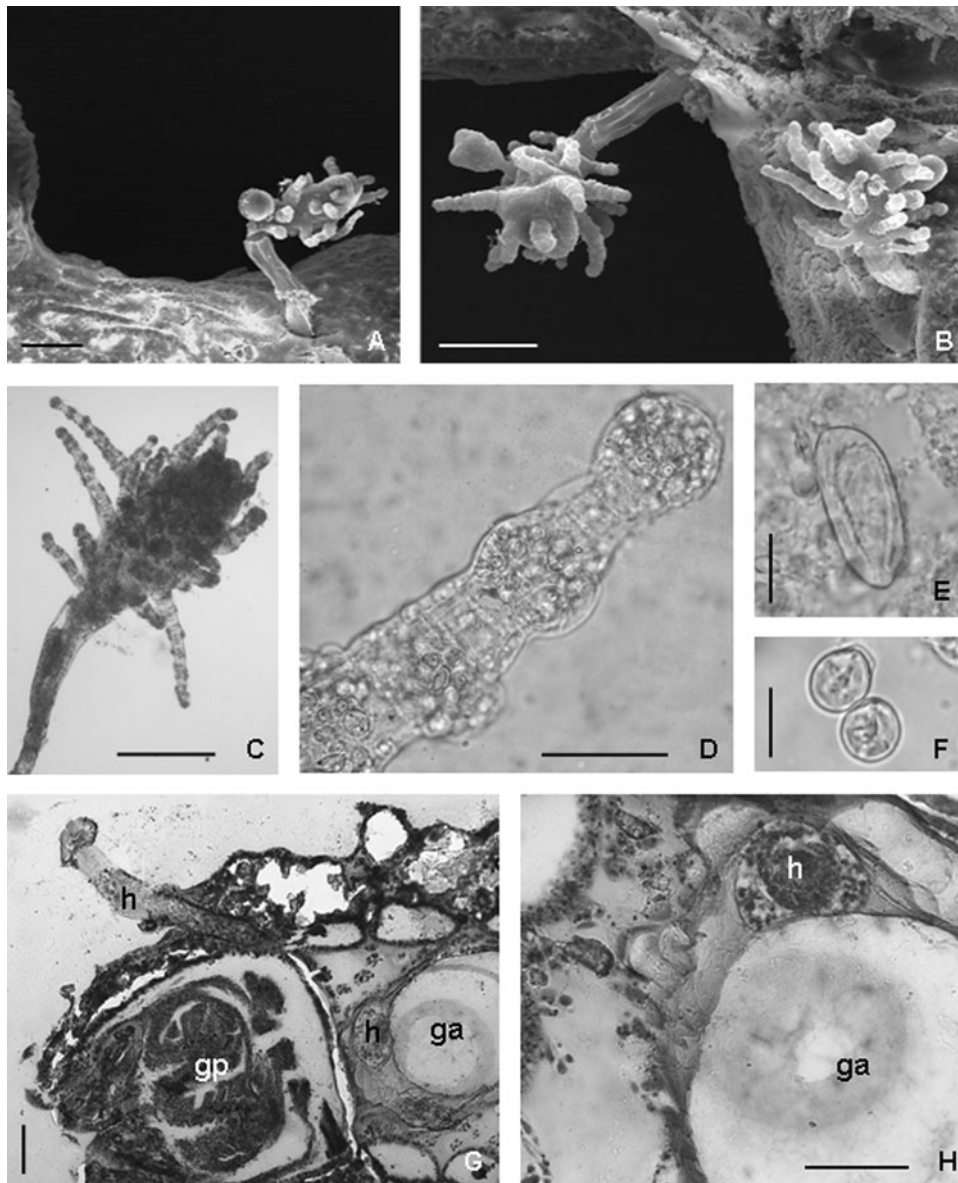
The specific name is derived from the latin word *timidus* meaning ‘shy’ and refers to the tendency of the polyps to retract frequently into the basal part of the hydranth.

### Remarks

*Zanclea timida* represents the only *Zanclea* species living in association with an octocoral. *Zanclea timida* differs from

the other described species by the presence of macrobasal mastigophores and by the hydranth differentiated into a rigid, cup-shaped basal portion and a narrow contractile tentaculate distal portion. A nematocyst ring marks the boundary between the basal and distal portion. While several species symbiotic with bryozoans can retract inside the skeleton of the hosts, *Z. timida* is able to retract inside its own basal ‘cup’. When retracted, the polyp becomes almost spherical and the capitula of the tentacles armed with nematocysts protrude out of the ‘cup’, whose rim is also surrounded by nematocysts (Figure 5D). Moreover, similarly to *Z. divergens* and *Zanclella diabolica* Boero *et al.*, 2000, whose hydrorhiza is also provided with nematocyst clusters emerging from the bryozoan skeleton (Boero *et al.*, 2000; Puce *et al.*, 2002), *Zanclea timida* presents frequent stolonal nematocyst clusters protecting its exposed stolons.





**Fig. 6.** *Pteroclava kremphi*. Scanning electron microscopy photographs of: (A) a polyp arising from the gorgonian; (B) magnification of polyps with gonophores; (C) microphotograph of polyp; (D) moniliform tentacle; (E) undischarged macrobasic eurytele; (F) undischarged stenoteles; (G) histological section of the gorgonian hosting the hydroid; and (H) magnification of the histological section showing the hydrorhiza near to the gorgonian axis. ga, gorgonian axis; gp, gorgonian polyp; h, hydrorhiza. Scale bars: A,C, 200  $\mu\text{m}$ ; B, 250  $\mu\text{m}$ ; D, 50  $\mu\text{m}$ ; E, 15  $\mu\text{m}$ ; F, 10  $\mu\text{m}$ ; G,H, 100  $\mu\text{m}$ .

### Relationship with the host

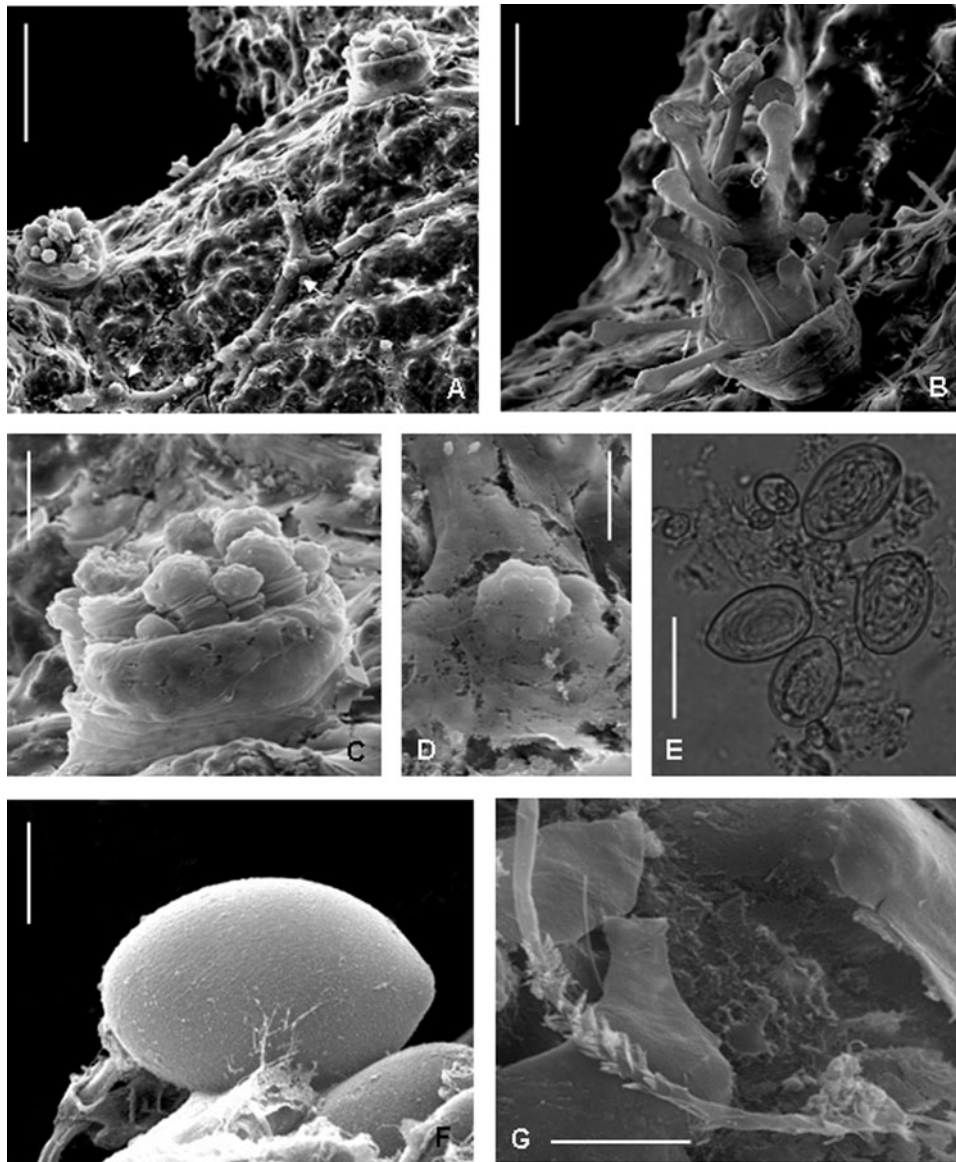
The hydrorhiza grows on the gorgonian surface and appears to be devoid of perisarc. The only protection against living enemies is provided by the stolonal nematocyst clusters. No specific tissue reactions owing to the association are evident either in the hydroid or in the octocoral. Several hydroids arise rather close to the *Paratelesto* polyps, suggesting a trophic relationship between the two. Boero *et al.* (1995) made a similar observation for the hydroid *Pteroclava kremphi* that occurred in close proximity to the polyps of the gorgonian host, even touching their tentacles.

### DISCUSSION

With the exception of *Zanclaea gilii*, growing in a hard coral, all hydroid species associated with anthozoans are symbiotic

with octocorals. *Pteroclava kremphi* and *Hydrichthella epigorgia* are able to colonize both soft corals and gorgonians and the hydroid morphology depends on the different hosts. *Pteroclava kremphi*, inhabiting hosts rich in spicules, such as gorgonians, forms a long pedicel, while the pedicel is less pronounced in specimens living in soft corals (Boero *et al.*, 1995). The hydrorhizal net of *H. epigorgia* is naked in colonies associated with the gorgonian *Anthoplexaura dimorpha*, but covered by perisarc in specimens living on other octocorals (Hirohito, 1988). A similar phenomenon occurs in the symbiosis between hydroids and bryozoans, where the bryozoan reaction to the presence of different hydroid species leads to different hydrorhizal covering patterns (Puce *et al.*, 2007).

Most of the hydroid species associated with anthozoans show a perisarc-covered hydrorhiza which separates the coenosarc from the host tissue, although *Ptilocodium repens*,



**Fig. 7.** *Zanclea timida* sp. nov. Scanning electron microscopy (SEM) photographs of: (A) colony showing polyps and hydrorhiza with clusters of nematocysts (arrows); (B) extended polyp; (C) contracted polyp; (D) magnification of nematocyst cluster; microphotograph of (E) undischarged telotrichous macrobasic mastigophore; SEM photographs of (F) capsule of discharged telotrichous macrobasic mastigophore; and (G) shaft end of telotrichous macrobasic mastigophore. Scale bars: A, 200  $\mu\text{m}$ ; B, 100  $\mu\text{m}$ ; C, 50  $\mu\text{m}$ ; D,E, 20  $\mu\text{m}$ ; F, 5  $\mu\text{m}$ ; G, 10  $\mu\text{m}$ .

some *H. epigorgia* specimens, *Z. gillii* and *Z. timida* lack a distinct perisarc. Thus, in several symbiotic genera belonging to different families (e.g. *Hydrichthys*, *Proboscicactyla*, *Zanclea* and *Eutima*), the perisarc loss appears to be related to the symbiotic life. In several *Zanclea* species associated with bryozoans the stolons lack a perisarc sheath. The protection provided by the bryozoan skeletons seems to make the perisarc covering superfluous (Puce *et al.*, 2002, 2007). The tendency of the *Zanclea* species to suppress perisarc formation is also evident in the anthozoan inhabiting *Zanclea*. In *Z. gillii* the hydrorhiza is completely embedded in the coral tissue and naked (Boero *et al.*, 2000). It can probably exploit the protection offered by its host, while in *Z. timida* the stolons grow in grooves in the surface of the octocoral. Although being thus quite exposed, the presence of nematocyst clusters

on the stolons seems to offer enough protection to eliminate the need for a perisarc covering.

In hydroids inhabiting bryozoans, the polyps are able to retract into the bryozoan skeleton and only the tentacular capitations armed with nematocysts remain exposed on the surface (Boero *et al.*, 2000; Puce *et al.*, 2002, 2007). Similarly, the polyps of *Z. timida* retract into their basal cup whose edge is surrounded by a nematocyst ring and from which only the tentacular nematocyst clusters stick out (Figures 5D & 7C). A similar reaction was described by Schuchert (2007) for the filiferan hydroid *Garveia grisea*.

The presence of the hydroid can modify the octocoral morphology, inducing the production of new branches whose skeleton totally or partially envelops the hydrocaulus. *Lophogorgia punicea* covers the hydrocaulus of *Ralpharia sanctisebastiani* only with a coenenchyme layer without

a supporting axial skeleton (da Silveira & Migotto, 1984). *Ellisella* sp. produces its axial skeleton around the *Ralpharia neira* stem (Figure 4I & L). Although the hydrocaulus of *Pteroclava kremphi* is exposed, the hydrorhiza is deeply embedded in the gorgonian tissue, creeping along the gorgonian axis (Figure 6G,H).

The possible behavioural interactions between hydroids and octocorals are still undescribed, but there are some indications of existing trophic relationships. In fact, the polyps of *P. kremphi*, *Sarsia medelae* and *Z. timida*, appear to be denser in the areas at the base of the octocoral polyps (Boero *et al.*, 1995, Gili *et al.*, 2006). Moreover, Boero *et al.* (1995) observed preserved polyps in the act of touching the gorgonian tentacles, suggesting a trophic behaviour similar to that reported for numerous other symbiotic hydroids (Boero & Hewitt, 1992; Piraino *et al.*, 1992; Bavestrello *et al.*, 2000; Boero *et al.*, 2000; Puce *et al.*, 2002, 2007).

The symbiosis with anthozoans evolved independently in six athecate hydroid families. However, while *S. medelae* and *P. kremphi* are the only known species of their respective families, Ptilocodiidae and Zancleidae each contain two species associated with anthozoans. Most *Zanclaea* species are in fact closely associated with other marine invertebrates, mainly with bryozoans (Boero *et al.*, 2000; Puce *et al.*, 2002, 2007), but also with bivalves (Cerrano *et al.*, 1997), hexacorals (Boero *et al.*, 2000), octocorals (present paper) and sponges (unpublished). Likewise, of seven known *Ralpharia* species, six are symbiotic with octocorals.

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## REFERENCES

- Allman G.J. (1872) *A monograph of the gymnoblastic or tubularian hydroids*. London: The Ray Society.
- Bavestrello G., Puce S., Cerrano C. and Balduzzi A. (2000) Life history of *Perarella schneideri* (Hydrozoa, Cytaeidae) in the Ligurian Sea. In Mills C.E. *et al.* (eds) *Trends in hydrozoan biology—IV*, pp. 141–146. [*Scientia Marina*, 64.]
- Billard A. (1919) Note sur une espèce nouvelle d'hydroïde gymnoblastique (*Clava kremphi*), parasite d'un Alcyonaire. *Bulletin du Muséum National d'Histoire Naturelle, Paris* 25, 187–188.
- Boero F. and Bouillon J. (2005) Cnidaria and Ctenophora (cnidarians and comb jellies). In Rhode K. (ed.) *Marine parasitology*. Collingwood, Australia: CABI Publishing, CSIRO Publishing, pp. 177–182.
- Boero F., Bouillon J. and Gravier-Bonnet N. (1995) The life cycle of *Pteroclava kremphi* (Cnidaria, Hydrozoa, Cladocorynidae), with notes on *Asyncoryne philippina* (Asyncorynidae). *Scientia Marina* 59, 65–76.
- Boero F., Bouillon J. and Gravili C. (2000) A survey of *Zanclaea*, *Halocoryne* and *Zanclella* (Cnidaria, Hydrozoa, Anthomedusae, Zancleidae) with a description of new species. *Italian Journal of Zoology* 67, 93–124.
- Boero F. and Hewitt C.L. (1992) A hydrozoan, *Zanclella bryozoophila* n.gen., n.sp. (Zancleidae), symbiotic with a bryozoan, with a discussion of the Zancleidae. *Canadian Journal of Zoology* 70, 1645–1651.
- Bouillon J. (1967) Révision de la famille des Ptilocodiidae avec la description d'un nouveau genre et d'une nouvelle espèce. *Bulletin de l'Académie Royale de Belgique* 53, 1106–1131.
- Bouillon J. (1974) Description de *Teissiera milleporoides*, nouveau genre et nouvelle espèce de Zancleidae des Seychelles (Hydrozoaires; Athécates—Anthomédues), avec une révision des hydroïdes Pteronematoïdes. *Cahiers de Biologie Marine* 15, 113–154.
- Bouillon J. (1978) Sur un nouveau genre et une nouvelle espèce de Ptilocodiidae, *Hydrichthelloides reticulata* et la super-famille des Hydractinoïdes (Hydroïdes—Athécates). Station Biologique Leopold II, Laing Island. Contribution No. 1. *Steenstrupia* 5, 53–67.
- Bouillon J. (1985) Essai de classification des Hydropolypes—Hydromédues (Hydrozoa—Cnidaria). *Indo-Malayan Zoology* 2, 29–243.
- Bouillon J., Gravili C., Pagès F., Gili J.M. and Boero F. (2006) *An introduction to Hydrozoa*. Paris: Publications Scientifiques du Muséum.
- Bouillon J., Medel D. and Peña Cantero A. (1997) The taxonomic status of the genus *Stylactaria* Stechow, 1921 (Hydrimedusae, Anthomedusae, Hydractiniidae), with the description of a new species. *Scientia Marina* 61, 471–486.
- Cerrano C., Amoretti D. and Bavestrello G. (1997) The polyp and medusa of *Zanclaea costata* Gegenbaur (Cnidaria, Hydrozoa). *Italian Journal of Zoology* 64, 177–180.
- Coward W.E. (1909) On *Ptilocodium repens* a new gymnoblastic hydroid epizoic on a Pennatulid. *Verslagen der Zittingen van de Wis-en Natuurkundige Afdeling der Koninklijke Akademie van Wetenschappen, Amsterdam, Section of Sciences* 11, 635–641.
- Fleming J. (1828) *A history of British animals, exhibiting the descriptive characters and systematical arrangement of the genera and species of quadrupeds, birds, reptiles, fishes, Mollusca, and Radiata of the United Kingdom*. Edinburgh: Ball & Bradford.
- Gegenbaur C. (1857) Versuch eines Systemes der Medusen mit Beschreibung neuer oder wenig gekannter Formen; zugleich ein Beitrag zur Kenntniss der Fauna des Mittelmeeres. *Zeitschrift für Wissenschaftliche Zoologie* 8, 202–273.
- Gili J.M., Lopez-González P.J. and Bouillon J. (2006) A new Antarctic association: the case of the hydroid *Sarsia medelae* (n. sp.) associated with gorgonians. *Polar Biology* 29, 624–631.
- Hargitt C.W. (1924) Hydroids of the Philippine Islands. *Philippine Journal of Science* 24, 467–507.
- Hartlaub C. (1905) Die Hydroiden der Magalhaensischen Region und chilenischen Küste. In *Fauna chilensis. Zoologische Jahrbuecher, Supplement* 6, 497–714.
- Hirohito Emperor Showa (1988) Athecata. In *The hydroids of Sagami Bay*. Tokyo: Biological Laboratory Imperial Household, pp. 1–179.
- Korotneff A. de (1887) Zwei neue Coelenteraten. *Zeitschrift für Wissenschaftliche Zoologie*, 45, 468–490.
- Kramp P.L. (1961) Synopsis of the medusae of the world. *Journal of the Marine Biological Association of the United Kingdom* 40, 1–469.
- Kühn A. (1913) Entwicklungsgeschichte und Verwandtschaftsbeziehungen der Hydrozoen, I. Teil: Die Hydroiden. *Ergebnisse und Fortschritte der Zoologie* 4, 1–284.

- Leloup E.** (1937) Hydropolypes et Scyphopolypes recueillis par C. Dawydoff sur les côtes de l'Indochine française. *Mémoires du Musée Royal d'Histoire Naturelle de Belgique* 12, 1–73.
- Mayer A.G.** (1910) Medusae of the world. *Publications, Carnegie Institution of Washington* 109, 1–735.
- Millard N.A.H. and Bouillon J.** (1973) Hydroids from the Seychelles (Coelenterata). *Annales du Musée Royal de l'Afrique Centrale, Série in-8a, Sciences Zoologiques* 206, 1–106.
- Petersen K.W.** (1979) Development of coloniality in Hydrozoa. In Larwood G. and Rosen B.R. (eds) *Biology and systematics of colonial organisms. Systematics Association Special Volume No. 11*. London, New York: Academic Press, pp. 105–139.
- Petersen K.W.** (1990) Evolution and taxonomy in capitate hydroids and medusae. *Zoological Journal of the Linnean Society* 100, 101–231.
- Picard J.** (1957) Étude sur les hydroïdes de la superfamille Pteronematoidea, 1. Généralités. *Bulletin de l'Institut Océanographique de Monaco* 1106, 1–12.
- Pictet C.** (1893) Étude sur les hydres de la Baie d'Amboine. *Revue Suisse de Zoologie* 1, 1–64.
- Piraino S., Bouillon J. and Boero F.** (1992) *Halocoryne epizoica* (Cnidaria, Hydrozoa), a hydroid that 'bites'. In Bouillon J. (ed.) *Aspects of hydrozoan biology*. Barcelona, Spain: Instituto de Ciencias del Mar, C.S.I.C., pp. 141–147 [*Scientia Marina* vol. 56].
- Prévot E.** (1959) Morphologie et évolution des structures tentaculaires chez les hydres Gymnoblastes Capitata. *Recueil des Travaux de la Station Marine d'Endoume* 2917, 91–126.
- Puce S., Bavestrello G., Di Camillo C.G. and Boero F.** (2007) Symbiotic relationships between hydroids and bryozoans. *Symbiosis* 44, 137–143.
- Puce S., Cerrano C., Boyer M., Ferretti C. and Bavestrello G.** (2002) *Zanlea* (Cnidaria: Hydrozoa) species from Bunaken Marine Park (Sulawesi Sea, Indonesia). *Journal of the Marine Biological Association of the United Kingdom*, 82, 943–954.
- Ranson G.** (1937) Cnidactines et cnidothylacies chez les anthoméduses. *Bulletin de la Société Zoologique de France* 42, 318–329.
- Russell F.S.** (1953) *The medusae of the British Isles. Anthomedusae, Leptomedusae, Limnomedusae, Trachymedusae and Narcomedusae*. London: Cambridge University Press.
- Schuchert P.** (2003) Hydroids (Cnidaria, Hydrozoa) of the Danish expedition to the Kei Islands. *Steenstrupia* 27, 137–256.
- Schuchert P.** (2007) The European athecate hydroids and their medusae (Hydrozoa, Cnidaria): Filifera. Part 2. *Revue Suisse de Zoologie* 114, 195–396.
- Silveira F.L. da and Migotto A.E.** (1984) *Serehyba sanctisebastiani* n. gen., n. sp. (Hydrozoa, Tubulariidae), symbiont of a gorgonian octocoral from the southeast coast of Brazil. *Bijdragen tot de Dierkunde* 54, 231–242.
- Stechow E.** (1909) Beiträge zur Naturgeschichte Ostasiens: hydroid-polypen der japanischen Ostküste. *Abhandlungen der Bayerischen Akademie der Wissenschaften (Mathematisch-Physikalischen Klasse)* 1, 1–111.
- Stechow E.** (1913) Beiträge zur Naturgeschichte Ostasiens: hydroid-polypen der japanischen Ostküste. *Abhandlungen der Bayerischen Akademie der Wissenschaften (Mathematisch-Physikalischen Klasse)* 3, 1–162.
- Stechow E.** (1923) Die Hydroidenfauna der japanischen Region. *Journal of the College of Science, Imperial University of Tokyo* 44, 1–23.
- Stechow E.** (1926) Einige neue Hydroiden aus verschiedenen Meeresgebieten. *Zoologischer Anzeiger* 68, 96–108.
- Van Praët M.** (1979) Les types de polypes d'Hydres conservés au Muséum national d'Histoire naturelle de Paris. *Bulletin du Muséum National d'Histoire Naturelle de Paris*, 4e série, 1, section A (4), 871–940.
- Vervoort W.** (1966) Skeletal structure in the Solanderiidae and its bearing on hydroid classification. In Rees W.J. (ed.) *The cnidaria and their evolution. Symposia of the Zoological Society of London* 16, 372–396.
- Watson J.E.** (1980) The identity of two tubularian hydroids from Australia with a description and observations on the reproduction of *Ralpharia magnifica* gen. et sp. nov. *Memoirs of the National Museum of Victoria* 41, 53–63.
- Watson J.E.** (1984) Two new species of tubularian hydroids from southern Australia. *Memoirs of the National Museum of Victoria* 45, 7–12.
- Watson J.E.** (1999) Hydroids (Hydrozoa: Anthoathecata) from the Beagle Gulf and Darwin Harbour, Northern Australia. *The Beagle, Records of the Museum and Art Galleries of the Northern Territory* 15, 1–21.
- Weill R.** (1931) Le genre *Pteroclava* n. gen., l'interprétation systématique des Pteronemidae (Hydres) et la valeur taxonomique du cnidome. *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences de Paris* 192, 60–62.
- Weill R.** (1934) Contribution à l'étude des Cnidaires et de leurs nématocystes. I. Recherches sur les nématocystes. Morphologie × Physiologie—Développement. *Travaux de la Station Zoologique de Wimereux* 10, 1–347.
- Weill R.** (1936) Au sujet de la définition et de la validité du genre *Güntherella* Weill 1934 (Hydrozoaires). *Bulletin de la Société Zoologique de France* 61, 526–532.
- Weill R.** (1937) Contribution à l'étude des Pteronemida (Hydrozoaires). Le cnidome de *Cladocoryne floccosa* Rotsch et son interprétation (d'après les documents laissés par feu M. Philbert). *Bulletin de l'Institut Océanographique de Monaco* 719, 1–11.

and

**Yamada M.** (1959) Hydroid fauna of Japanese and its adjacent waters. *Publications from the Akkeshi Marine Biological Station* 9, 1–101.

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