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Source: Revue suisse de Zoologie, 125(1) : 137-147

Published By: Muséum d'histoire naturelle, Genève

URL: <https://doi.org/10.5281/zenodo.1196038>

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A swimming medusoid gonophore in the life cycle of *Ventromma halecioides* (Alder, 1859) (Hydrozoa: Leptothecata: Kirchenpaueriidae)

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Abstract: The swimming gonophore of *Ventromma halecioides* (Alder, 1859) is described for the first time. It is a short-lived cryptomedusoid, provided with a well-formed, elongated-ovoid umbrella with thick mesoglea which, in turn, lacks a gastrovascular system, tentacles and tentacle bulbs, as well as sense organs. Its solid spadix is attached laterally to the blastostyle, and is surrounded by a compact mass of gametes, filling completely the subumbrellar cavity. The bell margin is provided with a raised collar comprising numerous refringent granules, and a velum is present. Scattered pseudostenoteles occur on exumbrella, while transversely-set muscle cells line the subumbrella.

Keywords: Life cycle - medusoid - cryptomedusoid.

INTRODUCTION

The production of swimming medusoid gonophores [for details, see Boero & Bouillon (1989)] among many “unusual” families of thecate hydroids is poorly documented and relatively misunderstood, as their occurrence is still unpredictable and often unexpected when it is discovered. To date, the presence of such a dispersive stage was already described in the lovenellid genus *Hydranthea* (Hincks, 1868) (Boero & Sarà, 1987), the hebellid genus *Anthohebella* Boero *et al.*, 1997 (original account), the haleciid genus *Nemalecium* Bouillon, 1986 (Gravier-Bonnet & Migotto, 2000; Galea *et al.*, 2012), the sertulariid genera *Amphisbetia* L. Agassiz, 1862 (Motz-Kossowska, 1907), *Sertularia* Linnaeus, 1758 (Migotto, 1998) and *Sertularella* Gray, 1848 (Gravier-Bonnet & Lebon, 2002), the plumulariid genera *Dentitheca* Stechow, 1919 (Migotto & Marques, 1999; Galea *et al.*, 2012) and *Monothea* Nutting, 1900 (Motz-Kossowska, 1907), the halopteridid genus *Antennella* Allman, 1877 (Bourmaud & Gravier-Bonnet, 2005), and the aglaopheniid genus *Macrorhynchia* Kirchenpauer, 1872 (Bourmaud & Gravier-Bonnet, 2004). Additional indications of occurrence of medusoids in other genera and/or species are scattered in the literature, and need to be confirmed through accurate observations.

The main obstacle to the discovery of swimming gonophores is, by far, the study of fixed material, followed by the disregard of histological studies. Except for the gonophores of *Hydranthea* and *Anthohebella*,

all those described until now in the families mentioned above belong to the cryptomedusoid type [for definition and classification, see Bouillon *et al.* (2006)], characterized by the presence of a well-defined umbrella which, in turn, is devoid of tentacles and tentacle bulbs, gastro-vascular system, and sense organs. The spadix is eccentric, solid and, consequently, does not open distally into a mouth. The subumbrella is provided with muscle cells, and a velum is present in the majority of cases, allowing the gonophores to swim, although these appear to be likely absent in rare instances (Bourmaud & Gravier-Bonnet, 2005; Galea *et al.*, 2012). In all but one family (*viz.* Sertulariidae), the bell margin bears a raised collar comprising a belt of refringent corpuscles whose function is not as yet totally understood, though it is possibly involved in the medusoid buoyancy. These bodies are labile in many fixatives, except perhaps the alcohol. Indeed, Kirchenpauer (1872: 16), noted – for the first time – their presence in nearly all species of *Macrorhynchia* he studied, but erroneously interpreted them as being oocytes. Additional observations by Bale (1894: 106; 1914: 30) and Allman (1883: 34) were likely done on alcohol-preserved specimens. The occurrence of refringent corpuscles in the gonophores is, most probably, a good indication of the production of swimming medusoids. However, their absence in the Sertulariidae could be an impediment even when working with living material, unless the spawning is monitored. Leclère *et al.* (2009) have shown that swimming medusoid gonophores “are probably not secondary

simplified medusae but simple pelagic forms re-acquired independently from polyp-only ancestors”, provided with a set of morphological characters (e.g. umbrella with muscle cells, presence of a velum) gained subsequently after a previous lost.

Ventromma halecioides (Alder, 1859) is a well-known, nearly cosmopolitan species (Gravili *et al.*, 2015). Although its gonothecae were originally described and illustrated accurately by Alder (1859, pl. 12 fig. 4), the gonophore received lesser attention (“Pressed between plates of glass, the capsules showed the ova in a very early stage”). Some subsequent authors (e.g. Calder, 1997), reported the presence of fixed sporosacs, although Gravier-Bonnet & Migotto (2000) cite unpublished data of Migotto & Marques, according to which medusoids occur in this species.

Abundant, fertile colonies of this species were collected recently from the French coast of the Mediterranean Sea, allowing its reproduction to be documented.

MATERIAL AND METHODS

Colonies of *V. halecioides* growing on floating docks in the port of La Ciotat were collected by scraping. The material was brought to the laboratory in a cooler, within an hour. The colonies were placed in crystallizing dishes covered by a fine mesh, and immersed in two 5 L tanks filled with fresh seawater (from the collecting site) and supplied with aeration, either in the dark or exposed at the daylight, at *ca.* 25°C. The dishes were inspected every 15 minutes for the medusoid release under a Huvitz HSZ-TR30 trinocular stereomicroscope equipped with a Canon EOS 60D camera. Male and female individuals were immediately placed in separate dishes, and kept in the same conditions as stated above. Photomicrographs were taken using a Tucsen IS1000 CMOS (10 MPixel) camera mounted on a Optika B-500 trinocular compound microscope, with either transmitted light or darkfield illumination. The experiment was done four times. All studied material was subsequently fixed in Bouin’s liquid, and part of it was transferred to 70% ethanol for long-term storage, while another part was stained in Grenacher’s borax carmine according to the protocol given by Gibbons & Ryland (1989), and mounted on microslides. To test the tolerance of the refringent granules to the pH, 20 µL of a 1 M HCl or 1 M NaOH solutions were pipetted into the seawater containing a few medusoids placed on a depression slide covered with a coverslip, and their behavior was monitored under the microscope. Part of the material studied here was deposited in the collection of the *Muséum d’histoire naturelle* of Geneva, Switzerland (registration is indicated by MHNG-INVE- followed by a 5-digit number), while another part is housed in the private collection of the author (registered as HRG- followed by a 4-digit number).

RESULTS

Family Kirchenpaueriidae Stechow, 1921

Genus *Ventromma* Stechow, 1923

***Ventromma halecioides* (Alder, 1859)**

Figs 1-2

Plumularia halecioides Alder, 1859: 353, pl. 12.

Material examined: MHNG-INVE-99622; France, La Ciotat, old harbor, 43.172512° 5.610192°, 0-0.3 m; 05, 07 and 11 Sep. 2017; fertile colonies, detached stolonial gonothecae, and medusoids in alcohol. – HRG-1342; France, La Ciotat, old harbor, 43.172512° 5.610192°, 0-0.3 m; 01 Sep. 2017; fertile colonies, detached stolonial gonothecae, and medusoids mounted on slides.

Systematics: Evidence from molecular work (Leclère *et al.*, 2007, 2009; Moura *et al.*, 2008; Peña Cantero *et al.*, 2010; Maronna *et al.*, 2016) indicate that this species should be assigned to the genus *Ventromma*, which forms a monophyletic group, different from *Kirchenpaueria* Jickeli, 1883, within the family Kirchenpaueriidae. Unlike the latter, with which it has been synonymized by a number of authors (e.g. Bouillon, 1985; Ansín Agís *et al.*, 2001), *Ventromma* is morphologically characterized by the presence of nematophores protected by nematothecae (Fig. 1A). A comprehensive synonymy of *V. halecioides* is provided by Ansín Agís *et al.* (2001).

Description: For a description of this species, refer to Calder (1997). Billard (1903) documented the morphological variations of its trophosome. Migotto (1996) noted the presence of two distinct regions, delimited by a transverse constriction, in the hydranth, an observation made earlier by Goette (1907: 322, pl. 12 fig. 258), and confirmed by the present study (Fig. 1B); however, their respective functions could not be ascertained at this stage.

The present material is fully fertile, with both cauline and stolonial gonothecae containing gonophores at various stages of development. Since the specimens could not be kept alive for more than 12 hours, the development of their gonophores could not be studied sequentially. However, their life history could be traced based on the present observations, and by homology with other species whose similar life cycles are well-characterized. Only gonothecae of one sex were borne on a given stem but, due to the high density of plumes and the likely occurrence of multiple colonies on the same substrate, it is impossible to state whether *V. halecioides* is a mono- or dioecious species. Male and female gonothecae are indistinguishable morphologically, although their respective gonophores are immediately identifiable under the stereomicroscope.

One large and, often, a second, basal and comparatively smaller gonophore occur per gonotheca (Fig. 1C). This is especially obvious when female gonothecae are

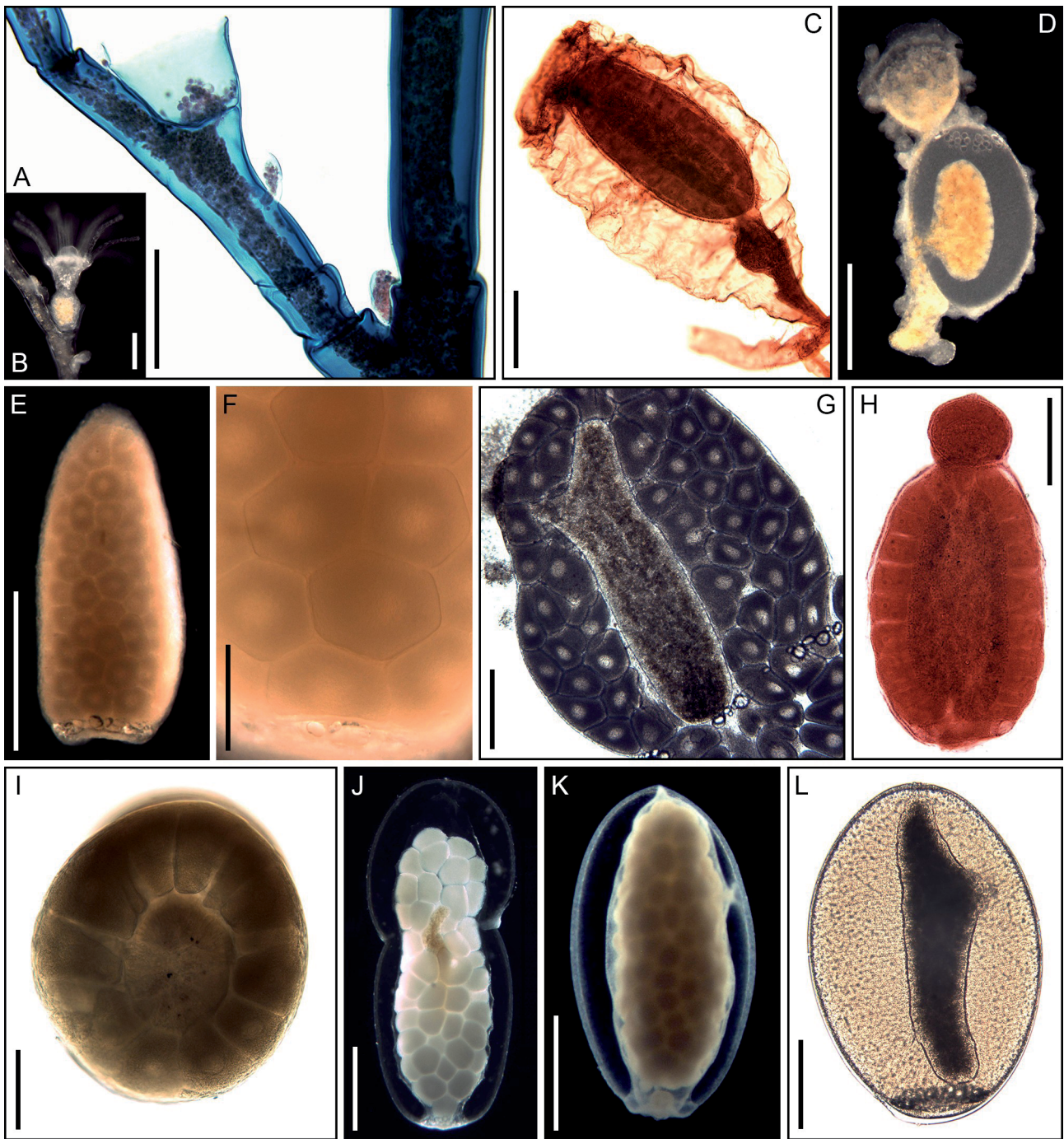


Fig. 1. (A) Portion of colony showing the cauline apophysis and its associated nematotheca, and proximal part of a cladium with first hydrothecate internode and its thecae. (B) Expanded hydranth, showing colors in life. (C) Gonotheca with female gonophore. (D) Whole young male gonophore extracted from its gonotheca. (E-F) Newly-liberated female medusoid (E) and close-up showing polygonal oocytes (F). (G) Squashed female medusoid showing Y-shaped spadix. (H-I) Stained (H) and cross-section (I) through female medusoid showing the spadix encircled by single layer of oocytes. (J-K) Female medusoid escaping from its protective membrane (J) and newly-liberated individual (K). (L) Male medusoid enveloped in membrane. Scale bars: 50 μm (B), 100 μm (A, F), 200 μm (C, G-I, L), 400 μm (D, E, J, K).

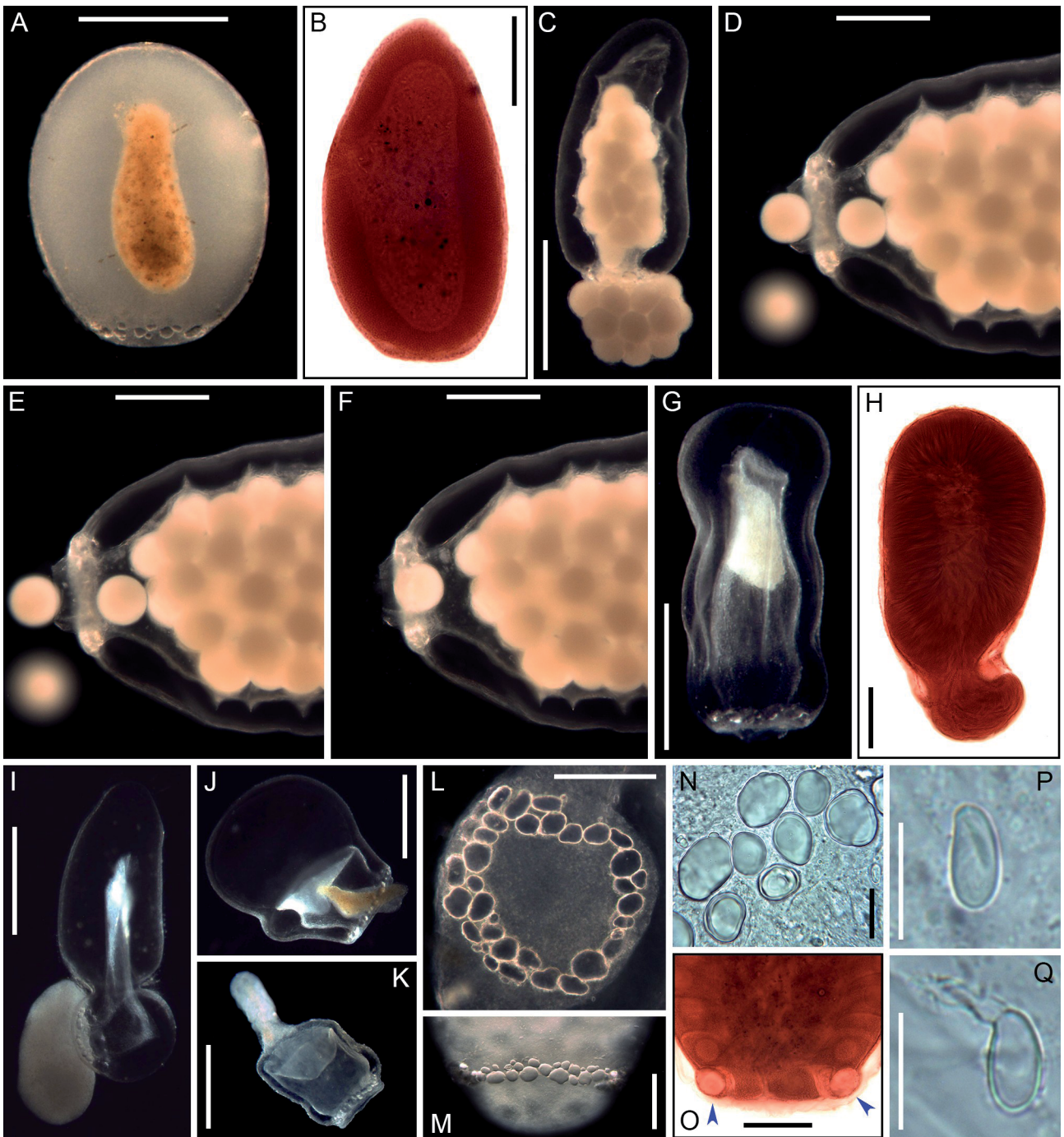


Fig. 2. (A-B) Male medusoid either showing colors in life (A), or stained (B) and displaying an Y-shaped spadix. (C) Partially spawned female medusoid with aggregate of oocytes. (D-F) Three steps of spawning (note presence of velum). (G) Emptied female medusoid. (H) Stained male medusoid partly liberating its gametes, showing directional arrangement of sperm cells. (I) Spawned male medusoid partly liberated from its membrane. (J, K) Spawned medusoids of unknown sex(es), the latter with the bell inside-out. (L-M) Belt of refringent corpuscles seen apically in a male medusoid (L) and laterally in a female (M). (N) Close-up of the refringent corpuscles. (O) Bell margin of a female medusoid showing large, vacuolated cells after the dissolution of the concretions (blue arrowheads). (P-Q) Pseudostenoteles from exumbrella either undischarged (P) or discharged (Q). Scale bars: 10 µm (P, Q), 20 µm (N), 100 µm (L, M, O), 200 µm (B, D-F, H), 400 µm (A, C, G, I-K).

examined, as the large oocytes are easily distinguishable from other cell types occurring in the gonophore. The main gonophore is budded off laterally from the lower half of a slender, tubular blastostyle running longitudinally from the proximal to the distal end of the gonotheca. In young thecae, the blastostyle ends up distally in a broad, globular, hollow apical plate (Fig. 1D), most likely involved in the building of the distal, and hence youngest, portion of the perisarcial sheet of the gonotheca. The more the gonotheca becomes morphologically complete and, simultaneously, its gonophore undergoes maturation, the more the apical plate becomes flattened (Fig. 1C), until it eventually disappears. Tall, columnar cells are easily noted on the side of the apical plate in contact with the inner gonothecal wall.

The very young gonophore is nearly spherical in shape and contains a globular spadix in its center (especially visible in males) linked laterally to the blastostyle. The latter assumes at this stage a sickle-shaped appearance, as it partly encircles the gonophore from one end to the other. A few conspicuous, refringent bodies form a belt towards the distal end of the gonophore. In males, the mass of spermatids is translucent while, in females, ovoid oocytes of various sizes encircle the spadix. The blastostyle, gonophore, and apical plate are enveloped together by a monostratified mantle. Numerous claw-like holdfasts emerge from the latter, anchoring – on one hand – the gonophore to the inner gonothecal wall, and – on the other hand – the border of the apical plate all the way around the insertion points of the future gonothecal operculum.

As the gonophore develops, it becomes gradually elongated, and its central spadix follows the same process. At these more advanced stages, one can easily note that the brownish spadix is linked to the blastostyle through a lateral “arm” (Fig. 1D). In the female gonophores, the oocytes aggregate around the spadix into a single layer (Fig. 1H, I); they assume a polygonal (penta- or hexagonal) shape, their cytoplasm is translucent, allowing large nuclei with visible nucleoli to be noted (Fig. 1F, G). The number of refringent bodies increases gradually until a belt of up to 3 superimposed whorls is formed (Fig. 2L, M).

In more advanced male and female gonophores, a thin, transparent, unicellular membrane surrounding them, and distinct from the mantle, could be noted. It is likely that it is formed simultaneously with the gonophore, but its presence is indiscernible at earlier developmental stages, unless demonstrated by histological sections. It is composed of elongated cells, with large nuclei, arranged in parallel, intercalating rows. Among them, a few scattered pseudostenoteles occur [undischarged capsules $(8.0-9.1) \times (3.6-4.2) \mu\text{m}$].

As the gonophores grow up in their already fully formed gonothecae, the apical plate regresses completely, leaving only the complex blastostyle-gonophore-mantle within the gonotheca. When fully formed, the gonophores escape

from the gonotheca through a narrow, arc-shaped passage created by the partial cleave of the apical perisarc. All gonophores obtained during the four experiments carried out were liberated from their gonothecae still enclosed in their thin, transparent membrane (Fig. 1L). On the other hand, the jagged mantle and remains of the blastostyle remain trapped within the gonotheca. There was no apparent correlation between the medusoid liberation and the exposure of the colonies to light or dark, as a similar number of individuals were obtained in both cases.

The male gonophores subsequently undergo a change in the appearance of their content: from translucent, they become opaque, most probably upon the maturation of spermatids into sperm cells. Similarly so, the nuclei of the oocytes are no more visible, and the cells change in shape from polygonal to spherical (Fig. 1J). In a few instances, medusoids of both sexes were seen getting free (Fig. 1J), or already free (Fig. 1K), from their envelope. At this point, their mesoglea, previously thin and unnoticeable, expanded significantly and the gonophores adopted the characteristic shape of medusoids.

Structurally, they are true cryptomedusoids, as no radial or ring canals, no tentacles or tentacular bulbs, and no sense organs could be noted. A few pseudostenoteles (Fig. 2P, Q) are scattered on the exumbrella. The female medusoids are up to $1165 \mu\text{m}$ long and $655 \mu\text{m}$ wide, and produce up to 90 oocytes, while their male counterparts are up to $820 \mu\text{m}$ long and $585 \mu\text{m}$ wide. No natatory behavior has been ever observed after the liberation of the medusoids from their protecting membrane.

Spawning has been documented in a couple of female medusoids. An oocyte, whose diameter is *ca.* $110 \mu\text{m}$, was released approximately every 2 minutes through a progressive contraction of the subumbrellar cavity, but not of the medusoid as a whole. Upon the passage of the oocytes through the bell aperture, the presence of a velum could be noted (Fig. 2D-F). The oocytes either fell individually to the bottom of the crystallizing dishes (Fig. 2D-F), or formed aggregates at the bell aperture (Fig. 2C). Male medusoids were not observed during the spawning, although one spent specimen (partially extracted from its envelope) was found (Fig. 2I). Similarly so, one spent female medusoid (Fig. 2G) was found in the crystallizing dish with female individuals. In addition, a couple of spent medusoids of unidentifiable sex(es) (Fig. 2J, K) were found among the hydroid colonies. One of them had its bell inside out (Fig. 2K), which allowed not only the presence of transverse muscle cells in the subumbrella to be noted, but also the absence of a mouth. The lack of the latter was also confirmed in the second spent medusoid, in which the spadix was partially extruded from the bell cavity (Fig. 2J). In addition, these two spent medusoids displayed jerking contractions of the bell, not noted in unspent individuals, probably due to the crowded condition of their gametes, completely filling the subumbrellar cavity. No correlation between the exposure to light or dark of the medusoids and their spawning was noted.

Table 1. List of species in which swimming medusoid gonophores presumably exist, or were described thoroughly.

Taxa	Reference(s)	Brief description and remarks
LOVENELLIDAE		
<i>Hydranthea margarica</i> (Hinks, 1863)	Motz-Kossowska (1911, as <i>Halecium billardi</i> sp. nov.); Boero & Sarà (1987: 134, fig. 5)	Spherical, 4 radial canals, ring canal, gonad surrounding the spadix, 8 statocysts, nematocysts scattered on exumbrella; no tentacles.
HEBELLIDAE		
<i>Anthoebella brevitheca</i> (Leloup, 1938)	Boero <i>et al.</i> (1997: 27, fig. 14)	Ovoid, 4 radial canals, 4 large atentaculate bulbs, velum present, spadix with 4 distinct interradiial gonads, mouth present, striated muscles in subumbrella.
<i>Anthoebella communis</i> (Calder, 1991)	Galea (2013: 13, fig. 3R)	Male medusoids with 4 radial canals; no other details discernible in fixed gonothecae.
<i>Anthoebella darwiniensis</i> Watson, 2000	Watson (2000: 8, fig. 5D)	4 vestigial radial canals; 4 long rudimentary tentacles contracted into a wavy pattern; no velum or manubrium.
<i>Anthoebella najimaensis</i> (Hirohito, 1995)	Hirohito (1995: 131, as <i>Scandia najimaensis</i>); Boero <i>et al.</i> (1997: 28, fig. 16C-D)	Spadix surrounded by gonad, without radial canals, ring canal or marginal tentacles.
<i>Anthoebella parasitica</i> (Ciamician, 1880)	Boero (1980: 136, fig. 5, as <i>Hebella parasitica</i>); Boero <i>et al.</i> (1997: 25)	Ovoid, 4 radial canals, ring canal, 4 perradiial bulbs with tentacle rudiments, 4 smaller interradiial atentaculate bulbs, gonad encircling spadix, ca. 200 oocytes/medusoid. Presence of mouth invalidated subsequently (Boero & Bouillon, 1989; Boero, <i>pers. comm.</i>) Swim vigorously. Life span: 3-4 days under laboratory conditions.
<i>Anthoebella tubitheca</i> (Millard & Bouillon, 1973)	Boero <i>et al.</i> (1997: 27, fig. 15)	Ovoid, gonads around spadix, 4 radial canals.
HALECHIDAE		
<i>Nemalecium lighti</i> (Hargitt, 1924)	Bouillon (1986: 77, pl. 2 figs 2 & 4, pl. 3); Gravier-Bonnet & Migotto (2000: 208, figs 1-2)	Histological study done by Bouillon (1986), who demonstrates the occurrence of medusoids within the gonothecae, and noted the presence of a velum, most probably allowing the gonophore to become free and lead a short free life. Observational data on this species artificially mixed up with those of a putative undescribed species (see below) by Gravier-Bonnet & Migotto (2000). Colonies dioecious. Gonotheca opens apically. Medusoid elongated-ovoid, (1050-1400) × (420-550) µm, female producing 40-62 oocytes (120-135 µm wide). Mesoglea thick; exumbrella with scattered microbasic mastigophores; subumbrella with muscle cells. Bell margin provided with ring of large, ciliated cells enclosing one to more refringent corpuscles within large vacuoles. Velum present; active swimmers.
<i>Nemalecium</i> sp.	Gravier-Bonnet & Migotto (2000: 208, figs 1-2)	Observational data on this species and <i>N. lighti</i> artificially mixed up. Colonies either mono- or dioecious. Release at dawn. Medusoids similar to those of <i>N. lighti</i> .
<i>Nemalecium gracile</i> Galea <i>et al.</i> (2012)	Galea <i>et al.</i> (2012: 48, fig. 3)	Colonies and individual stems either mono- or dioecious. Gonophores liberated at sunset through rupture of apical perisarc of the gonotheca; elongated-ovoid, male (730-1085) × (255-340) µm, female (1025-1305) × (355-400) µm and carrying 30-35 oocytes. Mesoglea thick. A belt of refringent corpuscles in 1-3 whorls. Exumbrella with scattered pseudostenoteles. Subumbrella with muscle cells. Velum present.
SERTULARIIDAE		
<i>Amphisbetia operculata</i> (Linnaeus, 1758)	Teissier (1922: 358, figs 1-4, as <i>Sertularia operculata</i>), Motz-Kossowska (1907: cxvi, fig. 3, as <i>S. operculata</i>)	Liberated at night. Elongated-ovoid, spadix eccentric, females carrying ca. 50 oocytes 150-180 µm wide. Muscle cells on subumbrella; velum present, provided with muscle cells; active swimmers. Life span 10 minutes.
<i>Sertularella diaphana</i> (Allman, 1885)	Gravier-Bonnet & Lebon (2002: 105, fig. 1)	Observational data on this and following species reportedly similar and, consequently, pooled together. Colonies dioecious. Release at dawn through opening of gonothecal operculum. Medusoids bell-shaped, male (2157-2431) × 1200 µm, female (1875-2513) × (863-1313) µm and containing ca. 77 oocytes (ca. 184 µm wide). Mesoglea relatively thin, subumbrella with muscle cells. No nematocysts on exumbrella, no refringent corpuscles around bell aperture. Velum present; active swimmers. Spawning within 12 minutes after release.

Taxa	Reference(s)	Brief description and remarks
<i>Sertularella</i> sp.	Gravier-Bonnet & Lebon (2002: 105, fig. 1)	Putative undescribed species. Medusoids similar to those of <i>S. diaphana</i> ; male (1765-2078) × (980-1375) μm, female (1875-2250) × (1188-1450) μm and containing 34-51 oocytes (ca. 235 μm wide).
<i>Sertularia loculosa</i> Busk, 1852	Unpublished data by Migotto cited by Gravier-Bonnet & Lebon (2002: 107)	Unpublished results.
<i>Sertularia marginata</i> Kirchenpauer, 1864	Migotto (1998: 5, fig. 2)	Colonies dioecious. Medusoid release after dusk, through narrow opening of gonothecal operculum; elongated-ovoid; male (852-1080) × (540-768) μm; female (960-1200) × (588-960) μm and producing 21-37 eggs. Mesoglea relatively thin; exumbrella with scattered microbasic mastigophores. No refringent corpuscles. Velum present; active swimmers.
<i>Sertularia turbinata</i> (Lamouroux, 1816)	Unpublished data by Migotto cited by Gravier-Bonnet & Lebon (2002: 107)	Unpublished results.
PLUMULARIIDAE		
<i>Dentitheca asymmetrica</i> (Bale, 1914)	Bale (1914: 30, as <i>Plumularia asymmetrica</i>)	“A cluster of rounded highly refractive granules near the aperture”.
<i>Dentitheca bidentata</i> (Jäderholm, 1920)	Migotto (1997: 170), Migotto & Marques (1999: 956, fig. 4)	Colonies either mono- or dioecious. Gonophore ovoid, (720-940) × (500-720) μm. Mesoglea thick; exumbrella with scattered microbasic mastigophores; refringent corpuscles in 2-3 irregularly-concentric rings. Velum present; active swimmers. Spawning 15 min after release; life span ca. 2 hours. Females producing 10-12 oocytes (deduced from fig. 4C), 130-145 μm wide.
<i>Dentitheca dendritica</i> (Nutting, 1900)	Galea <i>et al.</i> (2012: 44, fig. 1)	Colonies dioecious. Medusoids liberated at sunset; ovoid to spherical, female ca. 550 × 240 μm and producing up to 20 oocytes (diameter 110-150 μm), male ca. 415 × 250 μm. Mesoglea thin; belt of refringent corpuscles. Presence of velum and/or muscle cells in the subumbrella could not be confirmed. Spawning within gonotheca. No contractions of the bell have been noted.
<i>Monothecha obliqua</i> (Johnston, 1847)	Motz-Kossowska (1907: cxv, figs 1-2, as <i>Plumularia obliqua</i>)	Only males documented. Elongated-ovoid. Muscle cells on subumbrella. A well-developed velum, though reportedly devoid of muscle cells, although spawning accompanied by contractions of the bell.
<i>Monothecha margaretta</i> Nutting, 1900	Unpublished data by Migotto & Marques, cited by Gravier-Bonnet & Migotto (2000: 212)	Unpublished results.
KIRCHENPAUERIIDAE		
<i>Ventromma halecioides</i> (Alder, 1859)	Unpublished data by Migotto & Marques, cited by Gravier-Bonnet & Migotto (2000: 212); present study	Individual stems dioecious. The gonothecal operculum opens only partially to allow the escape of the medusoid; the latter is elongated-ovoid, ca. 820 × 585 μm in males, and ca. 1165 × 655 μm in females, the latter producing up to 90 oocytes, ca. 110 μm in diameter. Exumbrella with scattered pseudostenoteles; subumbrella with muscle cells; velum present. Marked contractions of the bell observed after spawning.
HALOPTERIDIDAE		
<i>Antennella</i> sp.	Bourmaud & Gravier-Bonnet (2005: 56, figs 1-2)	Colonies monoecious. Medusoid not released from gonotheca; ovoid to nearly spherical; mesoglea thin; female producing ca. 5 oocytes. No muscle cells on subumbrella, no velum, no nematocysts on exumbrella. Spawning during the night.
AGLAOPHENIIDAE		
<i>Aglaophenia latecarinata</i> Allman, 1877	Unpublished data by Migotto & Marques, cited by Gravier-Bonnet & Migotto (2000: 212)	Unpublished results.
<i>Aglaophenia</i> sp.	Unpublished data by Boero & Bouillon, cited by Boero & Bouillon (1989: 37)	Putative undescribed species from Papua New Guinea. Spadix “displaced towards bell margin”. No additional data available.
<i>Gymnangium ascidioides</i> (Bale, 1882)	Bale (1894: 106, pl. 5 fig. 1, as <i>Halicornaria ascidioides</i>)	“[...] a very distinct circle of highly refractive granules just below the aperture”.
<i>Gymnangium bryani</i> (Nutting, 1906)	Ronowicz <i>et al.</i> (2017: 30)	“Gonophores with medusoid inside (release not observed)”.
<i>Gymnangium ferlusi</i> (Billard, 1901)	Jarvis (1922: 355, fig. 5, as <i>Halicornaria ferlusi</i> var. <i>brevis</i>); unpublished data by Gravier-Bonnet, cited by Gravier-Bonnet & Migotto (2000: 212)	“The mouth is circular, surrounded by a double ring of highly refractive discs” (Jarvis, 1922).

Taxa	Reference(s)	Brief description and remarks
<i>Gymnangium hians</i> (Busk, 1852)	Unpublished data by Gravier-Bonnet, cited by Gravier-Bonnet & Migotto (2000: 212); Ronowicz <i>et al.</i> (2017: 30)	“Gonophores with free medusoids” (Ronowicz <i>et al.</i> , 2017).
<i>Lytocarpia angulosa</i> (De Lamarck, 1816)	Allman (1883: 34, pl. 20 fig. 3, as <i>Anthocladium huxleyi</i>)	“gonophore [...] encircled just below its summit by a wreath of refringent spherules”.
<i>Macrorhynchia filamentosa</i> (De Lamarck, 1816)	Kirchenpauer (1872: 43, pl. 2 fig. 21, as <i>Aglaophenia ligulata</i>); Kirchenpauer (1872: 44, pl. 2 fig. 23, as <i>Aglaophenia patula</i>)	Medusoids undoubtedly depicted in pl. 2 fig. 21 (as <i>A. ligulata</i>) and pl. 2 fig. 23 (as <i>A. patula</i>), with their characteristic belt of refringent corpuscles.
<i>Macrorhynchia philippina</i> Kirchenpauer, 1872	Kirchenpauer (1872: 17, Fig.; pl. 2 fig. 26, as <i>A. philippina</i>); Kirchenpauer (1872: 46, pl. 2 fig. 27, as <i>A. urens</i>); Bale (1888: 787, pl. 21 figs 6-7, as <i>Lytocarpus philippinus</i>); Gravier (1970: 255, fig. 1B, C); Watson (2000: 68, fig. 53D); Bourmaud & Gravier-Bonnet (2004: 368, figs 1-2)	Colonies monoecious. Gonotheca opens wide into two valves; release at dusk. Gonophore ovoid, ca. 1315 × 950 µm [deduced from fig. 1C in Gravier (1970)]; female producing ca. 40 oocytes. Mesoglea relatively thin; exumbrella with pigment cells and scattered microbasic mastigophores; subumbrella with muscle cells. Marginal belt composed of 2-3 whorls of refringent corpuscles, soluble in acid. Velum present; active swimmers. Spawning within 1-2 minutes; life span of the medusoid ca. 2 hours.
<i>Macrorhynchia racemifera</i> (Allman, 1883)	Allman (1883: 41, pl. 13 fig. 5, as <i>Lytocarpus racemiferus</i>)	“The gonophore occupies the centre of the gonangium, from whose walls it is separated by a clear space, across which may be seen a wreath of highly refringent spherules, by which the summit of the gonophore is encircled”.
<i>Macrorhynchia</i> sp.	Unpublished data by Gravier-Bonnet, cited by Gravier-Bonnet & Migotto (2000: 212)	Any data available on this species from Madagascar.
<i>Taxella eximia</i> Allman, 1874	Allman (1876: 278, pl. 22 fig. 2, as <i>Halicornaria saccaria</i>)	“[...] sporosac encircled near its summit by a band of refringent roundish corpuscles”.

As noted above, there is a belt of refringent bodies around the bell aperture in the medusoids of both sexes. Their shape ranges from nearly spherical to irregularly elongated, and their size varies from 10 to 33 µm long (Fig. 2N). They are likely of a mineral nature, and dissolve within less than 30 seconds in an acidic medium (though without obvious effervescence), but remain unaffected in an alkaline solution. Stained and mounted medusoids, in which the marginal bodies have dissolved, show an accumulation of quite large, polygonal cells around the bell margin that seem to delimit large “compartments” for housing these structures, possibly vacuolated cells. Two such diametrically opposed compartments may be mistakenly taken for a ring canal (Fig. 2O, arrowheads). Whether these compartments are represented by large, vacuolated cells could not be established at this stage, and a histological study is expected to clarify the case.

Remarks: The so-called “sketch of ring canal” noted by Bouillon (1986) in sections of medusoids of *N. lighti* likely correspond to the “ring of large cells enclosing [the] refringent corpuscles” observed by Gravier-Bonnet & Migotto (2000) in the same species. A similar histological structure may be also met with in the medusoid of *V. halecioides*, with the large “compartments” mentioned above corresponding to these vacuolated cells.

Watson (2011) created a new species, *V. bellarensis*, from southern Australia, and distinguished it from *V. halecioides* through the constant absence of ahydrothecate

internodes on cladia. Given that her description was based on a single colony only and, taking into account that many authors (*e.g.* Naumov, 1969; Migotto, 1996; Ansin Agís *et al.*, 2001) described – besides the otherwise “distinctive” heteromeric segmentation of cladia – the occurrence of only hydrothecate internodes, or a combination of both, in *V. halecioides*, it is assumed that *V. bellarensis* is no more than a junior synonym of Alder’s (1859) species.

ACKNOWLEDGMENTS

Prof. Ferdinando Boero (University of Salento, Italy) and Dr. Henry H.C. Choong (Royal British Columbia Museum, Canada) are thanked for their thorough reading of the manuscript and their helpful suggestions.

REFERENCES

- Agassiz L. 1862. Contributions to the Natural History of the United States of America. Second monograph, vol. 4. Little, Brown & Co., Boston, 380 pp.
- Alder J. 1859. Descriptions of three new species of sertularian zoophytes. *Annals and Magazine of Natural History* (3)3(17): 353-356.
- Allman G.J. 1874. [Diagnosis of new genera and species of hydroids]. *Nature, London* 11(270): 179.
- Allman G.J. 1876. Diagnoses of new genera and species of hydroids. *Journal of the Linnean Society of London. Zoology* 12: 251-284.

- Allman G.J. 1877. Report on the Hydroida collected during the exploration of the Gulf Stream by L. F. de Pourtalès, Assistant United States Coast Survey. *Memoirs of the Museum of Comparative Zoölogy at Harvard College* 5(2), 1-66.
- Allman G.J. 1883. Report on the Hydroida dredged by H.M.S. *Challenger* during the years 1873-76. Part I. – Plumulariidae. *Report on the Scientific Results of the Voyage of H.M.S. Challenger during the year 1873-76, Zoology* 7(20): 1-55.
- Allman G.J. 1885. Description of Australian, Cape, and other Hydroida, mostly new, from the collection of Miss H. Gatty. *Journal of the Linnean Society of London, Zoology* 19: 132-161.
- Ansín Agís J., Ramil F., Vervoort W. 2001. Atlantic Leptolida (Hydrozoa, Cnidaria) of the families Aglaopheniidae, Halopterididae, Kirchenpaueriidae and Plumulariidae collected during the CANCAP and Mauritania-II expeditions of the National Museum of Natural History, Leiden, the Netherlands. *Zoologische Verhandelingen, Leiden* 333: 1-268.
- Bale W.M. 1882. On the Hydroida of south-eastern Australia, with descriptions of supposed new species, and notes on the genus *Aglaophenia*. *Journal of the Microscopical Society of Victoria* 2(1): 15-48.
- Bale W.M. 1888. On some new and rare Hydroida in the Australian Museum collection. *Proceedings of the Linnean Society of New South Wales* 2(3)2: 745-799.
- Bale W.M. 1894. Further notes on Australian hydroids, with descriptions of some new species. *Proceedings of the Royal Society of Victoria* 6: 93-117.
- Bale W.M. 1914. Report on the Hydroida collected in the Great Australian Bight and other localities. *Fisheries. Zoological (and Biological) Results of the Fishing Experiments carried out by F.I.S. "Endeavour", 1909-1910* 2(1): 1-62.
- Billard A. 1901. Note sur la *Polyplumaria flabellata* G.O. Sars et sur l'*Halicornaria ferlusi*. *Bulletin du Muséum d'Histoire naturelle de Paris* 7: 117-121.
- Billard A. 1903. Note sur les variations du *Plumularia halecioides* Alder. *Bulletin du Muséum d'Histoire Naturelle de Paris* 9(1): 57-62.
- Boero F. 1980. *Hebella parasitica* (Cnidaria, Hydrozoa): a thecate polyp producing an anthomedusa. *Marine Biology* 59: 133-136.
- Boero F., Bouillon J. 1989. An evolutionary interpretation of anomalous medusoid stages in the life cycle of some Leptomedusae (Cnidaria) (pp. 37-41). In: Ryland J.S., Tyler P.A. (eds). *Reproduction, Genetics and Distributions of Marine Organisms: 23rd European Marine Biology Symposium, School of Biological Sciences, University of Wales, Swansea. Olsen & Olsen, Fredensborg, Denmark*, 469 pp.
- Boero F., Sarà M. 1987. Motile sexual stages and evolution of Leptomedusae (Cnidaria). *Bollettino di Zoologia* 54: 131-139.
- Boero F., Bouillon J., Kubota S. 1997. The medusae of some species of *Hebella* Allman, 1888, and *Anthohebella* gen. nov. (Cnidaria, Hydrozoa, Lafoeidae), with a world synopsis of species. *Zoologische Verhandelingen, Leiden* 310: 1-53.
- Bouillon J. 1985. Essai de classification des Hydroméduses-Hydroméduses (Hydrozoa-Cnidaria). *Indo-Malayan Zoology* 1: 29-243.
- Bouillon J. 1986. *Nemalécium* gen. nov., genre nouveau de Haleciidae (Thecata-Leptomedusae, Hydrozoa, Cnidaria). *Indo-Malayan Zoology* 3(1): 71-80.
- Bouillon J., Gravili C., Pagès F., Gili J.M., Boero, F. 2006. An introduction to Hydrozoa. *Mémoires du Muséum national d'Histoire naturelle, Paris* 194: 1-591.
- Bourmaud C., Gravier-Bonnet N. 2004. Medusoid release and spawning of *Macrorhynchia philippina* Kirchenpauer, 1872 (Cnidaria, Hydrozoa, Aglaopheniidae). *Hydrobiologia* 530/531: 365-372.
- Bourmaud C. & Gravier-Bonnet N. 2005. Non-released cryptomedusoid in the life cycle of *Antennella* sp. (Cnidaria, Hydrozoa, Halopterididae) from La Réunion, Indian Ocean. *Invertebrate Reproduction and Development* 48(1-3): 55-62.
- Busk G. 1852. An account of the Polyzoa, and sertularian zoophytes collected in the voyage of the "Rattlesnake" on the coast of Australia and the Louisiade Archipelago, etc. (pp. 343-402). In: Macgillivray J. (ed). *Narrative of the voyage of H.M.S. Rattlesnake, commanded by the late Captain Owen Stanley, R.N., F.R.S. &c. during the years 1846-1850. Including discoveries and surveys in New Guinea, the Louisiade Archipelago, etc. To which is added the account of Mr. E.B. Kennedy's expedition for the exploration of the Cape York Peninsula. Vol. 1. Boone T. & W., London*, 402 pp.
- Calder D.R. 1991. Shallow-water hydroids of Bermuda: the Thecatae, exclusive of Plumularioidea. *Royal Ontario Museum Life Sciences Contributions* 154: 1-140.
- Calder D.R. 1997. Shallow-water hydroids of Bermuda: superfamily Plumularioidea. *Royal Ontario Museum Life Sciences Contributions* 161: 1-84.
- Ciamician J. 1880. Ueber *Lafoëa parasitica* n. sp. *Zeitschrift für wissenschaftliche Zoologie* 33(4): 673-676.
- De Lamarck J.B.M. 1816. Histoire naturelle des animaux sans vertèbres, présentant les caractères généraux et particuliers de ces animaux, leur distribution, leurs classes, leurs familles, leurs genres, et la citation des principales espèces qui s'y rapportent; précédée d'une Introduction offrant la Détermination des caractères essentiels de l'Animal, sa distinction du végétal et des autres corps naturels, enfin, l'Exposition des Principes fondamentaux de la Zoologie. Tome 2. *Verdière, Paris*, 568 pp.
- Galea H. R. 2013. New additions to the shallow-water hydroids (Cnidaria: Hydrozoa) from the French Lesser Antilles: Martinique. *Zootaxa* 3686(1): 1-50.
- Galea H.R., Ferry R., Bertot J.M. 2012. Medusoids in the life cycle of *Dentitheca dendritica* (Nutting, 1900) and *Nemalécium gracile* sp. nov. (Cnidaria: Hydrozoa). *Zootaxa* 3527: 43-54.
- Gibbons M.J., Ryland J.S. 1989. Intertidal and shallow water hydroids from Fiji. I. Athecata to Sertulariidae. *Memoirs of the Queensland Museum* 27(2): 377-432.
- Goette A. 1907. Vergleichende Entwicklungsgeschichte der Geschlechtsindividuen der Hydropolypen. *Zeitschrift für Wissenschaftliche Zoologie* 87: 1-335.
- Gravier N. 1970. Libération de médusoïdes par *Macrorhynchia philippina* Kirchenpauer, 1872 (Hydroida, Plumulariidae). *Recueil des Travaux de la Station Marine d'Endoume. Fascicule hors-série suppl.* 10: 253-257.
- Gravier-Bonnet N., Lebon M.L. 2002. Swimming medusoid gonophores in two species of *Sertularella* (Cnidaria, Hydrozoa, Sertulariidae) from Reunion Island, Indian Ocean. *Invertebrate Reproduction and Development* 41(1-3): 101-108.
- Gravier-Bonnet N., Migotto A.E. 2000. Gonangium develop-

- ment and medusoid of *Nemalecium lighti* (Hargitt, 1924) (Cnidaria, Hydrozoa, Haleciidae). *Scientia Marina* 64 (Suppl. 1): 207-213.
- Gravili C., De Vito D., Di Camillo C.G., Martell L., Piraino S., Boero F. 2015. The non-siphonophoran Hydrozoa (Cnidaria) of Salento, Italy with notes on their life-cycles: an illustrated guide. *Zootaxa* 3908(1): 1-187.
- Gray J.E. 1848. List of the specimens of British animals in the collection of the British Museum. Part 1. Centroniae or radiated animals. *Trustees of the British Museum, London*, 173 pp.
- Hargitt C.W. 1924. Hydroids of the Philippine Islands. *Philippine Journal of Science* 24(4): 467-507.
- Hincks T. 1863. On some new British hydroids. *Annals and Magazine of Natural History* (3)11(8): 45-47.
- Hincks T. 1868. A history of British hydroid zoophytes. *John van Voorst, London*, LXVIII+338 pp.
- Hirohito, Emperor of Japan. 1995. The hydroids of Sagami Bay. II. Thecata. *Publications of the Biological Laboratory, Imperial Household, Tokyo*, 244 pp.
- Jäderholm E. 1920. On some exotic hydroids in the Swedish Zoological State Museum. *Arkiv för Zoologi* 13(3): 1-11.
- Jarvis F.E. 1922. The hydroids from the Chagos, Seychelles and other islands and from the coasts of British East Africa and Zanzibar. *Transactions of the Linnean Society of London, Zoology* (2)18(1): 331-360.
- Jickeli C.F. 1883. Der Bau der Hydroidpolypen. II. Über den histiologischen Bau von *Tubularia* L., *Cordylophora* Allm., *Cladonema* Duj., *Coryne* Gärtn., *Gemmaria* M'Crady, *Perigonimus* Sars, *Podocoryne* Sars, *Camponopsis* Claus, *Lafoëa* Lam., *Campanularia* Lam., *Obelia* Pér., *Anisocola* Kirchenp., *Isocola* Kirchenp., *Kirchenpaueria* Jick. *Morphologisches Jahrbuch* 8: 580-680.
- Johnston G. 1847. A history of the British zoophytes. Vol. 1. Second edition. *Van Voorst, London*, VIII + 488 pp.
- Kirchenpauer G.H. 1864. Neue Sertulariden aus verschiedenen Hamburgischen Sammlungen, nebst allgemeinen Bemerkungen über Lamouroux's Gattung *Dynamena*. *Verhandlungen der Kaiserlichen Leopoldino-Carolinischen deutschen Akademie der Naturforscher* 30: 1-16.
- Kirchenpauer G.H. 1872. Ueber die Hydroidenfamilie Plumularidae, einzelne Gruppen derselben und ihre Fruchtbehälter. I. *Aglaophenia*, Lx. *Abhandlungen aus dem Gebiete der Naturwissenschaften, Hamburg* 5(3): 1-58.
- Lamouroux J.V.F. 1816. Histoire des polypiers coralligènes flexibles vulgairement nommés zoophytes. *F. Poisson, Caen*, 560 pp.
- Leclère L., Schuchert P., Manuel M. 2007. Phylogeny of the Plumularioidea (Hydrozoa, Leptothecata): evolution of colonial organization and life cycle. *Zoologica Scripta* 36: 371-394.
- Leclère L., Schuchert P., Cruaud C., Couloux A., Manuel M. 2009. Molecular phylogenetics of Thecata (Hydrozoa, Cnidaria) reveals long term maintenance of life history traits despite high frequency of recent character changes. *Systematic Biology* 58(5): 509-526.
- Leloup E. 1938. Quelques hydropolypes de la baie de Sagami, Japon. *Bulletin du Musée royal d'Histoire naturelle de Belgique* 14(28): 1-22.
- Linnaeus C. 1758. *Systema naturae per regna tria naturae, secundum classes, ordines, genera, species cum characteribus, differentiis, synonymis, locis. Editio decima, reformata. L. Salvii, Holmiae*, 823 pp.
- Maronna M.M., Miranda T.P., Peña Cantero A.L., Barbeitos M.S., Marques A.C. 2016. Towards a phylogenetic classification of Leptothecata (Cnidaria, Hydrozoa). *Nature, Scientific Reports* 6, 18075. <http://dx.doi.org/10.1038/srep18075>
- Migotto A.E. 1996. Benthic shallow-water hydroids (Cnidaria, Hydrozoa) of the coast of São Sebastião, Brazil, including a checklist of Brazilian hydroids. *Zoologische Verhandlungen, Leiden* 306: 1-125.
- Migotto A.E. 1997. Aspects of the reproduction of *Dentitheca bidentata* (Cnidaria, Hydrozoa): a monoic plumulariid that releases medusoids. *Resumos expandidos do VII Congresso Latino-Americano sobre ciencias do mar* 2: 170-171.
- Migotto A.E. 1998. The life cycle of *Sertularia marginata* Kirchenpauer, 1864 (Cnidaria: Hydrozoa: Sertulariidae): a medusoid-producing sertulariid. *Journal of Natural History* 32: 1-12.
- Migotto A.E., Marques A.C. 1999. Redescription of *Dentitheca bidentata* (Cnidaria: Hydrozoa, Plumulariidae), with notes on its life cycle. *Journal of Natural History* 33: 949-960.
- Millard N.A.H., Bouillon J. 1973. Hydroids from the Seychelles (Coelenterata). *Annales du Muséum royal de l'Afrique Centrale* 206: 1-105.
- Motz-Kossowska S. 1907. Sur les gonophores de *Plumularia obliqua* Saunders et *Sertularia operculata* L. *Archives de Zoologie Expérimentale et Générale* (4)7(notés et revue 4): cxiv-cxviii.
- Motz-Kossowska S. 1911. Contribution à la connaissance des hydriaires de la Méditerranée occidentale. II. – Hydriaires calyptoblastiques. *Archives de Zoologie Expérimentale et Générale* (5)6(10): 325-352.
- Moura C.J., Harris D.J., Cunha M.R., Rogers A.D. 2008. DNA barcoding reveals cryptic diversity in marine hydroids (Cnidaria, Hydrozoa) from coastal and deep-water environments. *Zoologica Scripta* 37: 93-108.
- Naumov D.V. 1969. Hydroids and hydromedusae of the USSR. Translated from Russian. *Israel Program for Scientific Translation, Jerusalem*, V + 631 pp.
- Nutting C.C. 1900 American hydroids. Part I. The Plumularidae. *Special Bulletin of the United States National Museum* 4(1): 1-285.
- Nutting C.C. 1906. Hydroids of the Hawaiian Islands collected by the Steamer Albatross in 1902. *Bulletin of the United States Fish Commission* 23(3): 931-959.
- Peña Cantero A.L., Sentandreu V., Latorre, A. 2010. Phylogenetic relationships of the endemic Antarctic benthic hydroids (Cnidaria, Hydrozoa): what does the mitochondrial 16S rRNA tell us about it? *Polar Biology* 33(1): 41-57.
- Ronowicz M., Boissin E., Bourmaud C.A.F., Gravier-Bonnet N., Schuchert P. 2017. Modern alongside traditional taxonomy – Integrative systematics of the genera *Gymnangium* Hincks, 1874 and *Taxella* Allman, 1874 (Hydrozoa, Aglaopheniidae). *PLOS One*. <http://doi.org/10.1371/journal.pone.0174244>
- Stechow E. 1919. Neue Ergebnisse auf dem Gebiete der Hydroidenforschung. *Münchener medizinischer Wochenschrift* 1919(30): 1-37.
- Stechow E. 1921. Neue Genera und Species von Hydrozoen und anderen Evertibraten. *Archiv für Naturgeschichte* (A)87(3): 248-265.
- Stechow E. 1923. Zur Kenntnis des Hydroidenfauna des Mittelmeeres, Amerikas und anderer Gebiete. II. Teil. *Zoologische Jahrbücher* 47(1): 29-270.
- Teissier G. 1922. Observations des médusoides libres et des

- planulas de *Sertularia operculata* L. *Bulletin de la Société Zoologique de France* 47: 357-361.
- Watson J.E. 2000. Hydroids (Hydrozoa: Leptothecata) from the Beagle Gulf and Darwin Harbour, northern Australia. *The Beagle, Records of the Museum and Art Galleries of the Northern Territory* 16: 1-82.
- Watson J.E. 2011. New species, new records and redescription of thecate hydroids (Cnidaria: Hydrozoa: Leptothecata) from Southern Australia. *Zootaxa* 3122: 1-36.