

# ***Sphaeronectes pagesi* sp. nov., a new species of sphaeronectid calycophoran siphonophore from Japan, with the first record of *S. fragilis* Carré, 1968 from the North Pacific Ocean and observations on related species**

DHUGAL J. LINDSAY<sup>1,\*</sup>, MARY GROSSMANN<sup>1</sup> & RYO MINEMIZU<sup>2</sup>

<sup>1</sup> Marine Biology and Ecology Research Program, Extremobiosphere Research Center, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) 2–15 Natushima, Yokosuka, 237–0061, Japan

<sup>2</sup> Ryo Minemizu Photo Office 224–1–101 Yawata, Shimizu, Suntou, Shizuoka, 411–0906, Japan

Received 24 December 2010; Accepted 27 January 2011

**Abstract:** A new species of calycophoran siphonophore, *Sphaeronectes pagesi* sp. nov., is described from material collected in Sagami Bay, Japan. The taxonomic affinities of the other *Sphaeronectes* species known from Japanese waters are discussed. For *S. fragilis*, which is reported for the first time from the North Pacific, and *S. koellikeri* new photographs of the living animals and line drawings are provided.

**Key words:** calycophoran, new species, Sagami Bay, siphonophore, *Sphaeronectes*, Suruga Bay.

## **Introduction**

The Sphaeronectidae Huxley, 1859 is an enigmatic family of calycophoran siphonophores that exhibit paedomorphy, in that each colony retains its larval nectophore in the adult state and develops no definitive nectophores (Totton 1954). The family has recently been reviewed by Pugh (2009), who recognised a single genus, *Sphaeronectes*, containing nine species. To date four members of the genus have been reported from Japanese waters; namely *S. koellikeri*, Huxley, 1859 [as *S. gracilis*] (Kitamura et al. 2003), *S. irregularis* (Claus, 1873) by Kitamura et al. (2003) [but see below], *S. japonica* (Stepanjants, 1967), and *Sphaeronectes* sp. (Yoshida 1896). No new records of *S. japonica* have been published since its original description, and Pugh (2009) has suggested that it might be a junior synonym of *S. brevituncata* (Chun, 1888). Recently three specimens of a *Sphaeronectes* species that closely resembles that reported and sketched by Yoshida (1896) have been collected. The morphological characters of these specimens suggest that it is a new species, which is described herein, together with notes on other *Sphaeronectes* species recently found in Japanese waters.

## **Results**

### **Family Sphaeronectidae Huxley, 1859**

Monotypic for the genus *Sphaeronectes* Huxley, 1859.

Diagnosis: With a single, rounded nectophore, the retained larval nectophore. No definitive nectophores developed. Bracts with a simple phyllocyst, resembling the somatocyst of the nectophore, with no other bracteal canals.

### **Genus *Sphaeronectes* Huxley, 1859**

With the characters of the family.  
Type species: *Sphaeronectes koellikeri* Huxley, 1859.

### ***Sphaeronectes pagesi* sp. nov.**

Diagnosis: Relatively small nectophore resembling a rounded cone. Nectosac extending to 70% the height of the nectophore. Radial canals with single curve, extending to 80% of nectosac height. Hydroecium on proximal side only, with apex lying nearly on a level with the junction of the radial canals and the base of the somatocyst; hydroecial opening on lower side of nectophore, extending from 14 to 50% height of latter. Pedicular canal virtual, on lower side of nectophore, with somatocyst arising from it at 50% nectophore height; somatocyst only 14% height of nectophore, an inverted pear-shape with apex just short of nectosac

\* Corresponding author: Dhugal J. Lindsay, E-mail: dhugal@jamstec.go.jp

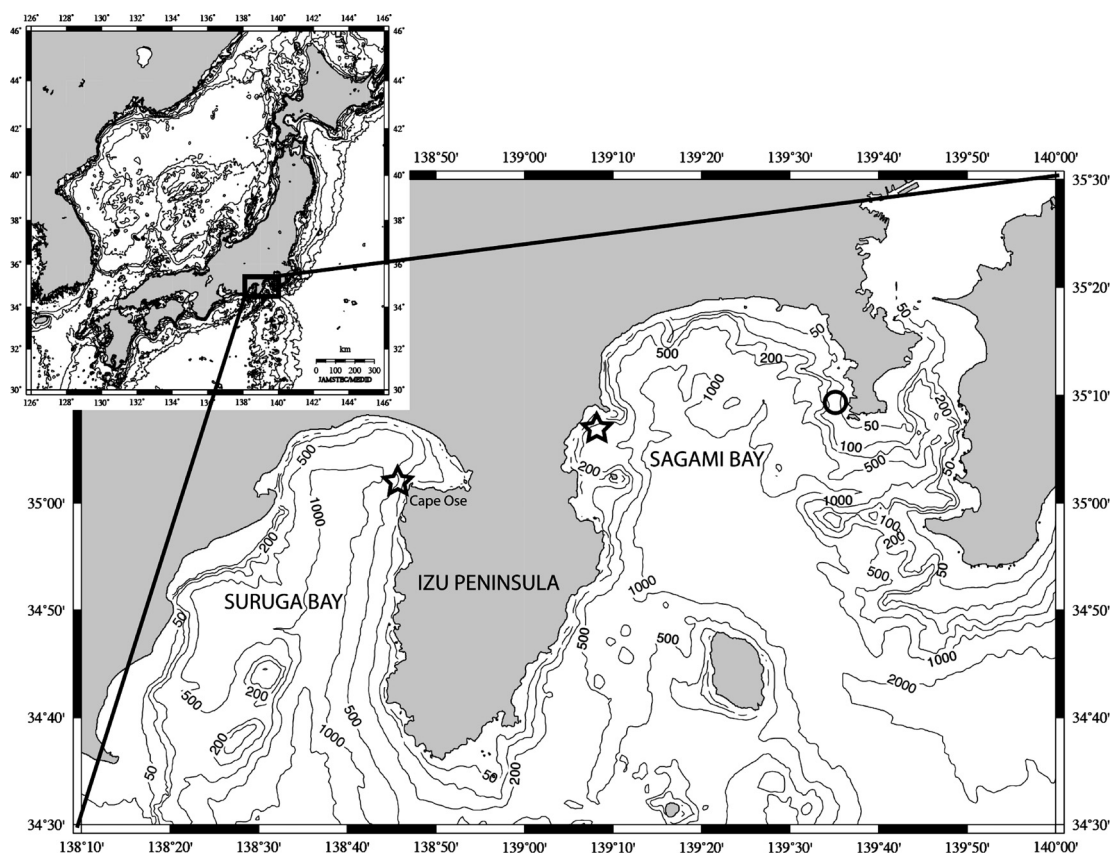


Fig. 1. Map showing the collection sites for the present specimens (\*) and for the animal of Yoshida (1896) (o).

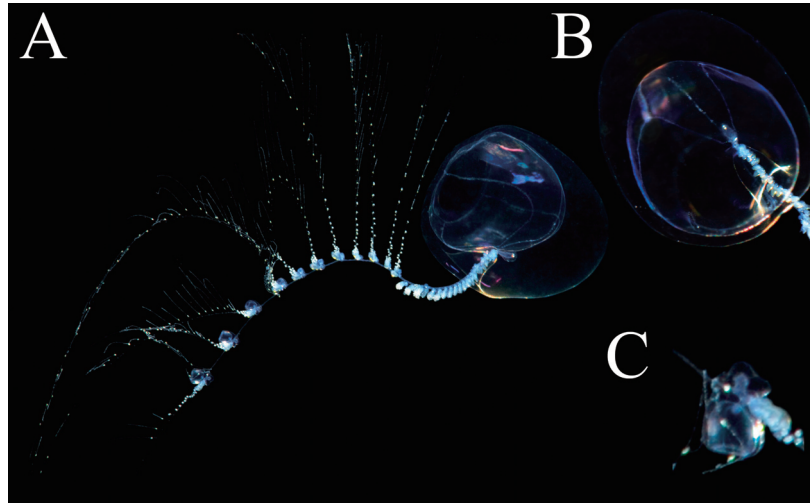
apex.

**Material examined:** Photographs of a specimen caught by RM while SCUBA diving on 31 January 2006 at 35°01.27'N, 138°47.16'E at 1m depth (water temperature 15°C) in Suruga Bay, Japan, off the coast of Cape Ose (see Fig. 1) that, unfortunately, was not preserved. Two further specimens collected in a 330µm mesh plankton net (mouth diameter 50 cm) deployed from the R/V *Natsushima* during PICASSO Cruise 1 on 26 February 2007 in the surface waters (0–5 m) of Sagami Bay to the north of Hatsushima Island (35°07.00'N, 139°08.69'E), just south of the Manazuru peninsula (Fig. 1). One of these, the holotype, was preserved in 5% buffered formalin-seawater solution, while the paratype was fixed in 99.5% ethanol, for forthcoming genetic analyses. The holotype has been deposited at the Showa Memorial Institute, National Museum of Nature and Science, Tokyo, under registration number NSMT-Co 1535, and the paratype is deposited in the JAMSTEC biological sample collection under registration number PICASSO-20070226SP1.

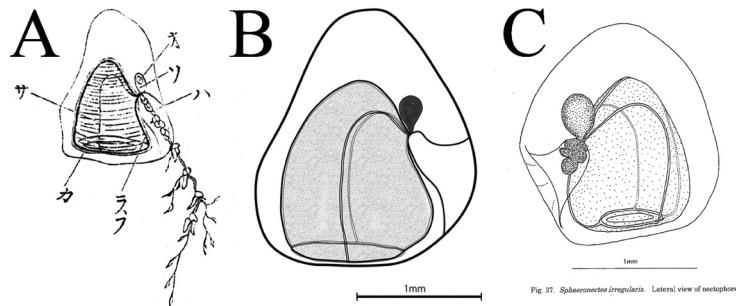
**Description:** Photographs of the specimen collected in Suruga Bay are shown in Fig. 2. Fig. 3 shows an illustration, in lateral view, of the type specimen of *Sphaeronectes pagesi* (Fig. 3B), together with reproductions of the figures from Yoshida (1896, p. 170), of *Sphaeronectes* sp. sampled off Misaki in Sagami Bay (Fig. 3A) and Kitamura (1997,

fig. 37), as *S. irregularis* (Fig. 3C). The holotype specimen consisted of a single nectophore with a small anterior portion of the siphosome. The nectophore had the appearance of a rounded cone and measured 1.8 mm in width and 2.1 mm in height. The nectosac, 1.2 mm in width, occupied about two-thirds of the width of the nectophore and was 1.5 mm in height. The radial canals arose on the proximal side of the nectosac at about 60% the height of the latter above the ostium. At this point the angle between the lateral and upper canals was close to 30°. Initially the lateral radial canals formed a single loop, extending to about 80% of the height of the nectosac, before curving toward the base of the nectophore and running directly, in the mid-lateral line of the nectosac, to the ostial ring canal. Hydroecium opened from 14 to 50% height of the nectophore; its apex lying nearly on a level with the junction of the radial canals and the base of the somatocyst; thus forming an opening that occupied 45% of the height of the nectophore on its proximal side. The depth of the hydroecium was about 40% of the nectophore's width. Pedicular canal virtual. The somatocyst, in line with the proximal side of the nectosac, had no pedicle and formed a vertical, pyriform structure, with the globular side facing anteriorly. It measured 0.16 mm at its widest, and 0.36 mm in height.

The siphosomal stem arose in the upper distal part of the hydroecium, but in the holotype specimen, only its anterior



**Fig. 2.** Photographs of the specimen of *Sphaeronectes pagesi* sp. nov. collected in Suruga Bay. A, lateral view with extended siphosome; B, close-up of nectophore in proximal view; C, close-up of a stem group with sexual products visible in the gonophore.



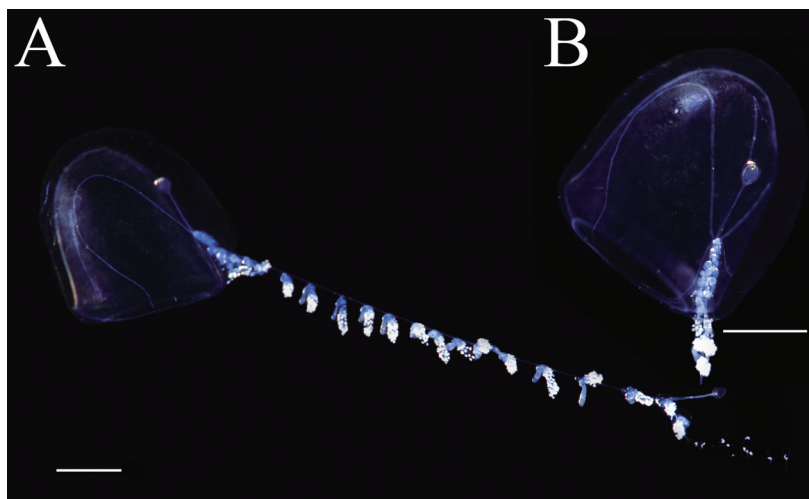
**Fig. 3.** A, copy of the line drawing of a *Sphaeronectes* species from Yoshida (1896, p. 170, fig. 1); B, line drawing of the holotype of *S. pagesi* sp. nov. in lateral view; C, copy of the line drawing of the same species (as *S. irregularis*) in Kitamura (1997, fig. 37).

part remained, and no useful information on the structure of the cormidia was obtainable. From the photographs of the specimen sampled in Suruga Bay (Fig. 2C), evidently the same species but not part of the type material, it appeared that the most mature cormidial bract was approximately half the height of the gonophore, though this may not apply to the free-living eudoxid. The cormidial bract had the approximate shape of a wide-brimmed hat, being twice as wide as high and with a distinct ‘brim’. The phyllocyst was thick, approximately 20% of the bracteal width, and had a slightly distended distal portion.

**Comments:** The nectophore of *Sphaeronectes pagesi* is most similar to that of *S. irregularis* and *S. brevituncata* (probably *S. japonica*) but, as the comparative table of morphological characters in Pugh (2009) shows, the nectophore is slightly smaller. By the form of the somatocyst and/or the arrangement of the lateral radial canals, *S. pagesi* cannot be mistaken for the other two *Sphaeronectes* species with small nectophores, namely *S. gamulini* Carré, 1966 and *S. bougisi* Carré, 1968. It is distinguished from *S. irregularis* by the fact that the radial canals arise, from the virtual

pedicular canal, at 3/5th the height of the nectosac, compared with 2/5th in *S. irregularis*; and the relative sizes of the somatocyst, which in *S. pagesi* extends apically beyond the anterior loop of the lateral radial canals, and hydroecium, which is open for almost half the height of the nectophore. *Sphaeronectes pagesi* can be distinguished from *S. brevituncata* by its somatocyst, which is shorter and has an inverted pear-shape, rather than being cylindrical and pyriform. The shape of the most mature cormidial bract resembles that of no sphaeronectid described to date.

**Distribution:** At present, *Sphaeronectes pagesi* sp. nov. is known only from Suruga Bay and Sagami Bay, Japan. However, Kitamura (1997) figured a specimen (see Fig. 3C) that he identified as *S. irregularis*, but which can clearly be referred to the present species. It was collected in Sagami Bay sometime between 1996 and 1997 but the exact date and place of collection cannot be traced (Kitamura, pers comm). Kitamura et al. (2003) reported collecting six further specimens of what they called *S. irregularis* in the Kii Channel, south of Osaka Bay, between 33°43.0'N and 34°07.4'N and at a latitude of 134°57.33'E, between 13–16



**Fig. 4.** Photographs of the specimen of *Sphaeronectes fragilis*. A, lateral view with extended siphosome, and B, close-up of nectophore. Scale bars 1 mm.

June 1997, as well as 12 individuals between 17–23 June 1998 at various locations within Sagami Bay from the mouth of Tokyo Bay (35°11.91'N, 139°44.62'E) to the semi-oceanic waters just north of Oshima Island (34°50.21'N, 139°20.00'E). Unfortunately, these specimens could not be located (Kitamura, pers comm) so it has not been possible to verify the specific identity. These are the only records for *S. irregularis* in Japanese waters and, probably, the entire North Pacific as Pugh (2009) has cast doubt on the record off California given by Margulis & Vereshchaka (1994). Nonetheless, *S. irregularis* has been recorded several times from off the Pacific coast of South America (e.g. Palma & Apablaza 2004), and Margulis (1992) gave several records for specimens at latitudes exceeding 40°S, although Pugh (2009) believed that more than one species was involved. However, in none of these papers were illustrations provided. Thus, although it is possible that Kitamura's *Sphaeronectes* specimens might be referable to *S. irregularis*, or possibly *S. brevitruncata*, the present authors consider it highly likely that they actually belong to *S. pagesi*; thereby extending its distributional range at least to south of Osaka Bay.

**Etymology:** Named in honour of the senior author's good friend Francesc Pagès, who tragically passed away on 5 May 2007, and whose great enthusiasm for siphonophores and taxonomy rubbed off on him during his short stay in Barcelona in late 2005–early 2006.

#### ***Sphaeronectes fragilis* Carré, 1968**

On 18 March 2007, a specimen of a *Sphaeronectes* species was observed at 1m depth (water temperature 15°C) in the surface waters of Suruga Bay, Japan, off the coast of Cape Ose (35°01.28'N, 138°47.15'E) on the west side of the Izu Peninsula (Fig. 1) by RM while SCUBA diving. The specimen was collected and photographed in a land labora-

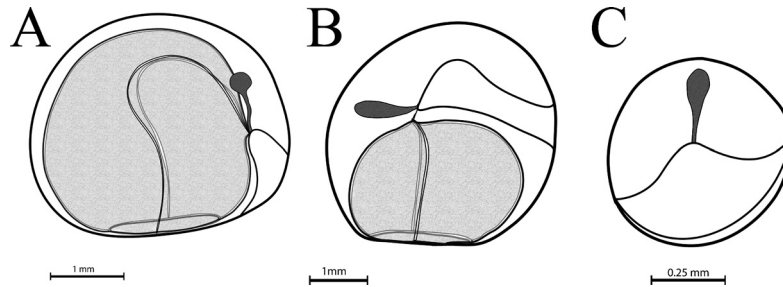
tory (Fig. 4A, B), before being preserved in 5% buffered formalin-seawater. The looped radial canals, large nectosac in relation to the size of the nectophore (>9/10), and the vertical somatocyst, arising from the lower side of the nectosac, with a long peduncle and globular terminal thickening, serve to identify this individual as *S. fragilis*. The nectophore was 3.5 mm in width and 2.9 mm in height.

The original description of *Sphaeronectes fragilis* was based on a score of specimens caught at the entrance to the bay of Villefranche-sur-Mer in the western Mediterranean Sea (Carré 1968b). Since then it has been reported from other parts of the Mediterranean Sea, and quite recently Bouillon et al. (2004) supposed it to be an endemic Mediterranean species. However, *S. fragilis* had already been reported from the other side of the world, off the coast of Chile from as far north as the Bay of Mejillones at 23°S (Palma & Apablaza 2004), in Valparaíso Bay (Palma & Rosales 1995), and as far south as the Magellan fjords (Pagès & Orejas 1999, Palma & Aravena 2001, Palma & Silva 2004), as well as from several other southern Chilean inlets in between (Palma & Rosales 1997). Unfortunately, none of these reports included sketches or photographs to allow morphological comparisons to be made. Nonetheless, this is the first record of *S. fragilis* in the northern Pacific Ocean and the first record outside the Mediterranean Sea to include photographs and a sketch of the animal (Fig. 5A).

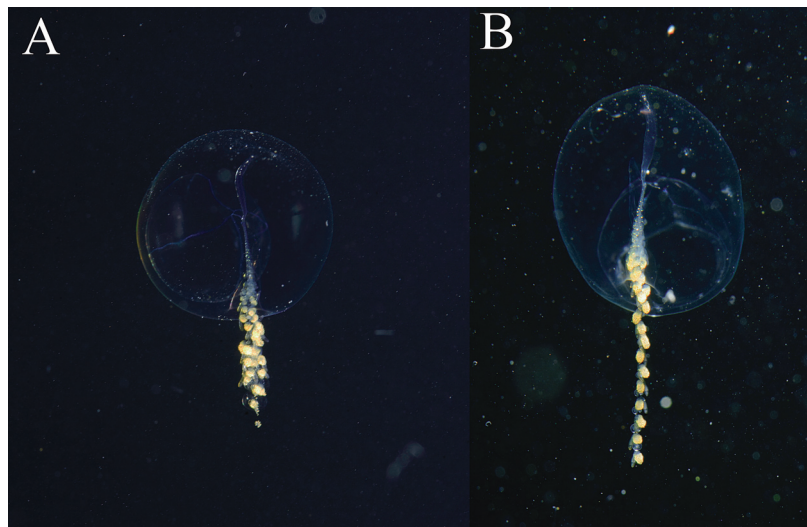
#### ***Sphaeronectes koellikeri* Huxley, 1859**

*Sphaeronectes koellikeri* has been reported in the western North Pacific not only from coastal waters such as in the Kii Channel, south of Osaka Bay, and semi-oceanic waters at the mouth of Sagami Bay (Kitamura et al. 2003), but also from the Sea of Japan, Taiwan Straits, off Hong Kong and in the South China Sea (e.g. Zhang 2005). Using the same





**Fig. 5.** A, line drawing of nectophore of *Sphaeronectes fragilis* from Suruga Bay in lateral view; line drawing of B, nectophore and C, bract of *Sphaeronectes koellikeri* from Suruga Bay in lateral view.



**Fig. 6.** Photographs of a *Sphaeronectes koellikeri*. A, dorsolateral view of retained larval nectophore, and B, close-up of same with partially extended siphosome.

techniques as described above for *S. fragilis*, RM observed *in situ*, captured and photographed (Fig. 6A, B) a specimen of *S. koellikeri* at 1m depth (water temperature 15°C) on 9 January 2006 in the surface waters of Suruga Bay, Japan, off the coast of Cape Ose (35°01.27'N, 138°47.15'E) on the west side of the Izu Peninsula (Fig. 1). Three other individuals were collected on 12 October 2007 at the same depth and location and one of these is figured here (Fig. 5B, C). One of these specimens was host to 6 hyperiid amphipods of the Infraorder Physocephalata, which embedded within the hydroecial tube and in the mesoglea between it and the apex of the nectophore. In contrast to the other two species considered herein, the course of the lateral radial canals in *S. koellikeri* is mostly straight, curving only slightly towards the lower face of the nectophore, the internal pedicular canal is long and clearly visible, and the well-developed, fusiform somatocyst is positioned to the anterior of the nectosac and oriented parallel to the plane of the ostial opening. The apical mesoglea is very thick and the hydroecium is deep and tubular. Yellow pigmentation to the tentilla was very evident, while it had been only slightly evident in *S. fragilis* and *S. pagesi*. Carré (1968a) reported that

the number of cormidia was 30–50 for *S. koellikeri* and in the twenties for *S. fragilis*, while the values for the present individuals were, respectively, 25–30 (Fig. 6A, B) and approximately 20 (Fig. 4A). For *S. pagesi* at least 28 cormidia were present in the photographed specimen (Fig. 2). Cormidia are, of course, easily broken off and the numbers presented here are intended purely to provide data that can be related to estimates of possible predation pressure and the like.

## Discussion

With this description of *Sphaeronectes pagesi* the total number of described species of *Sphaeronectes* reaches ten, although at least two further species await description; one mentioned by Pagès & Kurbjeweit (1994) and Pagès & Schnack-Schiel (1996), and another identified by the senior author. The phylogenetic position of the family Sphaeronectidae within the Sub-Order Calycophorae has, over the years, been the subject of much discussion (see Pugh 2009 & Mapstone 2009). For instance, Leloup (1954) considered it to be an offshoot from the Family Prayidae, while Totton

(1965) thought it to be descended from precursors of the family Abylidae.

The overall morphology of the nectophore, the retained larval one, of *Sphaeronectes* species has some affinities, such as the form of the hydroecium in some, with the anterior nectophore of clausophyids such as *Kephyes ovata* (Kerferstein & Ehlers 1860) and, indeed, it has been supposed that the anterior nectophores of most clausophyids may be the retained larval nectophore (Totton 1965 [see p. 19]; Pugh 2006), but their development also remains unstudied. Even so, the bracts of *Sphaeronectes* species have only a phyllocyst and no other bracteal canals, which might suggest an affinity with the Diphyidae, rather than the Clausophyidae, whose bracts, where known, include two hydroecial canals.

As Pugh (2009) has already pointed out, molecular phylogenetic data should be useful in determining the taxonomic position of the family Sphaeronectidae. The preliminary molecular analysis of Dunn et al. (2005) found that, in a maximum likelihood analysis of siphonophore 16S and 18S ribosomal DNA sequences, *S. koellikeri* (as *S. gracilis*) was positioned between the Diphyidae and Clausophyidae within the diphyomorph subclade, and did not group with the prayomorphs. Unfortunately, although *Kephyes ovata* (as *Clausophyes ovata*) was included, certain key species, such as one belonging to the genus *Clausophyes*, *Dimophyes arctica*, or members of the prayid subfamily Amphicaryoninae, were not included in the analyses. Furthermore, several novel clausophyids still await formal descriptions (pers obs) and as the molecular data for more species and more genes become available, then the position of the Sphaeronectidae within the Calyphorae will become clearer, and should greatly advance our knowledge of evolution within this highly diverse group.

### Acknowledgements

The senior author would like to express his gratitude to Dr. Phil Pugh for sharing his knowledge on siphonophores and continuing to foster the enthusiasm instilled in the senior author by Francesc Pagès during a sabbatical stay at the Institut de Ciències del Mar (CSIC) in Barcelona, as well as to the Japan Society for the Promotion of Science for funding the sabbatical. This manuscript was greatly improved thanks to the constructive comments of the two reviewers, Drs. Gill Mapstone and Phil Pugh. Thanks are also due to Dr. Aska Yamaki for help with the intricacies of Adobe Illustrator and to the captain and crew of the R/V *Natsushima* (JAMSTEC) for logistical support. Maps were kindly prepared by Mr. Mamoru Sano (Nippon Marine Enterprises, LTD) based on data from the Geographical Information Network of Alaska and the JODC-Expert Grid data for Geography –500 m. This study is a contribution from the Census of Marine Zooplankton (CMarZ), an ocean realm field project of the Census of Marine Life (CoML), and was done under the auspices of the Japan National

Regional Implementation Committee (Japan NRIC of CoML).

### References

- Bouillon J, Medel MD, Pagès F, Gili JM, Boero F, Gravili C (2004) Fauna of the Mediterranean Hydrozoa. *Sci Mar* 68 (Supl. 2): 5–438.
- Carré C (1968a) Contribution à l'étude du genre *Sphaeronectes* Huxley 1859. *Vie Milieu* 19: 85–94.
- Carré C (1968b) *Sphaeronectes fragilis* n. sp., une nouvelle espèce de siphonophore calyphore méditerranéen. *B I Oceanogr Monaco* 67: (1385), 9 pp.
- Dunn CW, Pugh PR, Haddock SHD (2005) Molecular Phylogenetics of the Siphonophora (Cnidaria), with implications for the evolution of functional specialization. *Syst Biol* 54: 916–935.
- Kitamura M (1997) Taxonomic study and seasonal occurrence of jellyfish in Sagami Bay. M.Sc. thesis, Tokyo University of Fisheries. 87 pp, 4 tables, 47 figures.
- Kitamura M, Tanaka Y, Ishimaru T (2003) Coarse scale distributions and community structure of hydromedusae related to water mass structures in two locations of Japanese waters in early Summer. *Plankton Biol Ecol* 50: 43–54.
- Leloup E (1954) A propos des Siphonophores. Volume jubilaire Victor van Straelen 2: 643–699.
- Mapstone, GM (2009) Siphonophora (Cnidaria, Hydrozoa) of Canadian Pacific waters. NRC Research Press, Ottawa, Ontario, Canada. 302 pp. including 65 figs.
- Margulis RYa (1992) Siphonophora from the Indian Sector of the Antarctic. pp. 125–134 in “*The Antarctic*”. The Committee Reports No. 30. Nauka, Moscow.
- Margulis RYa, Vereshchaka AL (1994) Siphonophores from the northern part of the Pacific Ocean. *Trudy Inst Okeanolog* 131: 76–89.
- Pagès F, Kurbjeweit F (1994) Vertical distribution and abundance of macroplanktonic medusae and siphonophores from the Weddell Sea, Antarctica. *Polar Biol* 14: 243–251.
- Pagès F, Orejas C (1999) Medusae, siphonophores and ctenophores of the Magellan region. *Sci Mar* 63 (Supl. 1): 51–57.
- Pagès F, Schnack-Schiel SB (1996) Distribution patterns of the mesozooplankton, principally siphonophores and medusae, in the vicinity of the Antarctic Slope Front (eastern Weddell Sea). *J Mar Sys* 9: 231–248.
- Palma S, Apablaza P (2004) Abundancia estacional y distribución vertical del zooplancton gelatinoso carnívoro en una área de surgencia en el norte del Sistema de la Corriente de Humboldt. *Investig Mar, Valparaíso* 32: 49–70.
- Palma S, Aravena G (2001) Distribución de Quetognatos, Eufáusidos y Sifonóforos en la región Magallánica. *Cienc Tecnol Mar* 24: 47–59.
- Palma SG, Rosales SG (1995) Composición, distribución y abundancia estacional del macroplankton de la bahía de Valparaíso. *Investig Mar, Valparaíso* 23: 49–66.
- Palma SG, Rosales SG (1997) Sifonóforos epipelágicos de los canales australes Chilenos (41°30'–46°40'S). *Cienc Tecnol Mar* 20: 125–145.
- Palma S, Silva N (2004) Distribution of siphonophores, chaetog-

- naths, euphausiids and oceanographic conditions in the fjords and channels of southern Chile. *Deep-Sea Res II* 51: 513–535.
- Pugh, PR (2006) Reclassification of the clausophyid siphonophore *Clausophyes ovata* into the genus *Kephyes* gen. nov. *J Mar Biol Assoc UK* 86: 997–1004.
- Pugh, PR (2009) A review of the family Sphaeronectidae (Class Hydrozoa, Order Siphonophora), with the description of three new species. *Zootaxa* 2147: 1–48.
- Stepanjants SD (1967) Siphonophores of the seas of the USSR and the north western part of the Pacific Ocean. *Opred Faune SSSR* 96: 1–216.
- Totton AK (1954) Siphonophora of the Indian Ocean together with systematic and biological notes on related specimens from other oceans. *Disc Rep* 27: 1–162.
- Totton AK (1965) A Synopsis of the Siphonophora. British Museum (Natural History), London, 230 pp., 153 figs, 40 pls.
- Yoshida S (1896) Some calyconectae from Misaki, Japan. *Zool Mag* 8: 169–172. (in Japanese)
- Zhang J (2005) Pelagic Siphonophora in China Seas. China Ocean Press, Beijing. 151 pp.