

## Note

**First record of association between *Tamoya haplonema* (Cnidaria: Cubozoa) and stromateid fish, with a review on interactions between fish and cubozoan jellyfishes**JONATHAN W. LAWLEY<sup>1,\*</sup> & EDSON FARIA JÚNIOR<sup>2</sup><sup>1</sup>Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, São Paulo, SP 05508–090, Brazil<sup>2</sup>Instituto Brasileiro de Biodiversidade, Rio de Janeiro, RJ 20031–205, Brazil

Received 11 October 2017; Accepted 18 December 2017 Responsible Editor: Jun Nishikawa

**Abstract:** Jellyfish-fish interactions have long been reported, most of these related to medusae as ichthyoplankton predators. Conversely, associations are much less documented, most involving scyphozoan jellyfishes in comparison to cubozoans. We report for the first time the association between the cubozoan *Tamoya haplonema* and stromateid fish, along with a review of all published cubomedusae-fish interactions. Four individuals of *Peprilus* cf. *crenulatus*, were observed swimming around the tentacles and subumbrellar cavity of an individual of *T. haplonema* during a SCUBA dive on the southern coast of Brazil. This behavior has been noted before, in which fish roam around the tentacles, avoiding them, and may move inside the subumbrellar cavity if threatened. In the review of cubomedusae-fish interactions, over 20 reports involve predation on fish whilst only 6 involve associations, which is much less than the over 80 associations described for scyphomedusae. This emphasizes the scarcity of reports on associations compared to predation, as well as of interactions of fishes with cubozoans if compared to scyphozoans. This could be due to host preference or even the large spatial and temporal variability in the occurrence of the former. Furthermore, even though there are no indications of species-specific interactions, reports of associations with cubozoans only involve fish species from the families Carangidae and Stromateidae, which produce pelagic young that have the highest potential for these associations. Future studies may address the possibility of size relationships in jellyfish-fish associations, as well as potential host preferences by the fish consorts.

**Key words:** association, interaction, follower, jellyfish, plankton

Jellyfish and fish have been reported to interact in a variety of ways, such as predation on medusae by fish, competition for zooplankton as a food resource, predation on fish by medusae, parasite transmission to fish, as well as in association (Mansueti 1963, Ates 1988, Arai 1988, Thiel 1970, 1978, Purcell & Arai 2001, Arai 2005). Most of the data for jellyfish-fish interactions exist on medusae as ichthyoplankton predators (Purcell & Arai 2001). However, interest has grown on the continuously increasing reports of fish preying on medusae. This is due to the possibility of medusivorous fish playing a significant role in controlling jellyfish blooms by feeding on jellyfish adults or even on their eggs and planulae (see Arai 2005 for a review and Miyajima-Taga et al. 2016, 2017 for recently reported examples). These blooms have become a major concern for the regulation of fish stocks mainly because jellyfish, as voracious zooplankton feeders (Purcell 2003), may prey on fish larvae and compete with zooplanktivorous fish for food (Möller 1984, Purcell & Arai 2001, Brodeur et al. 2008).

Associations, herein defined as situations in which different species occur together (see Duffy 2008 for a more detailed definition and examples), are much less documented and studied compared to other interactions, and their importance for both jellyfish and fish consorts is still poorly known (Mansueti 1963, Purcell & Arai 2001). These associations are almost exclusively temporary (except for *Nomeus grovonii* (Gmelin, 1789) and the siphonophore *Physalia physalis* (Linnaeus, 1758)) and result from extrinsic chance factors, such as fish in search of food supplies as well as thigmotactic and negative phototropic responses (Mansueti 1963, Kingsford 1993). As chance factors play a major role, it is reasonable that there are no reported cases of species-specific or obligatory associations (Purcell & Arai 2001). Therefore, even though the term symbiosis has been used to describe some of these associations (Mansueti 1963), their casual, facultative and temporal nature, in most reported cases, seems to fall out of the degree of intimacy that defines symbiosis in the continuum of ecological associations (Duffy 2008). Most cases of jellyfish-fish associations appear to be commensal, in which jellyfish are passive hosts and fish are active opportunists (Mansueti 1963). However, other types of associa-

\*Corresponding author: Jonathan W. Lawley; E-mail, jwlawley@ib.usp.br

tions have been observed, such as mutualistic, with fish eating jellyfish parasites; and parasitic, with fish eating parts of the jellyfish hosts without destroying them, as well as stealing some of the jellyfish's food (Mansueti 1963, Thiel 1970). In that sense, the terminologies should not be rigidly applied, as they only represent a snapshot in the time frame that species are co-occurring. Furthermore, at least 80 species pairs in association have been previously reported, most of them with scyphomedusae (Purcell & Arai 2001). Conversely, very few cubomedusae-fish associations have been described, some of them almost 90 years ago (Beebe 1928), even though there are approximately 50 described species in this class (Bentlage et al. 2010).

Cubozoan jellyfishes, with unique features such as complex eyes (Coates 2003) and powerful venom (Brinkman & Burnell 2009), have drawn much attention from the scientific community and the public. Studies that observe interactions involving these jellyfish, such as predation, indicate that prey items vary usually from planktonic crustaceans to fish, with preference for fish commonly related to larger or more mature individuals, in which more potent venom is developed (Kingsford & Mooney 2014). Nevertheless, knowledge of the biology and ecology of cubozoans is still scarce compared to scyphozoans, potentially due to the large spatial and temporal variability in their abundances (Kingsford & Mooney 2014). This variability might also reflect a sampling bias towards scyphozoan-fish associations, as well as less chance of encounters between fish and cubozoans. Also, there might be a preference by fish for scyphozoan hosts, as cubomedusae have more potent venom and are commonly reported as post-larval fish predators (Purcell & Arai 2001). These are all likely reasons for the very few reports of associations between cubomedusae and fishes. Beebe (1928), in his book regarding an expedition in Haiti, records for the first time these associations. In a tentatively identified 4.5 kg *Chiropsalmus quadrumanus* (Müller, 1859) medusa, he found more than 300 juvenile bumpers and one harvestfish, as well as up to 12 juvenile bumpers following *Tamoya haplonema* Müller, 1859 medusae. Regarding the latter jellyfish, he also noticed that about one in every four medusae were in an association with fish and that there was a positive relationship between size of the jellyfish and that of guest fishes, which was further discussed in Mansueti (1963), although it is still poorly corroborated. More recently, Kondo et al. (2014) record in a summary table two new cubomedusae-fish associations, though the source of these reports is still unpublished. In this study, we report for the first time an association between the cubomedusa *Tamoya haplonema* and stromateid fish *Peprilus* cf. *crenulatus* Cuvier, 1829, offering an overview of reported cubomedusae-fish interactions.

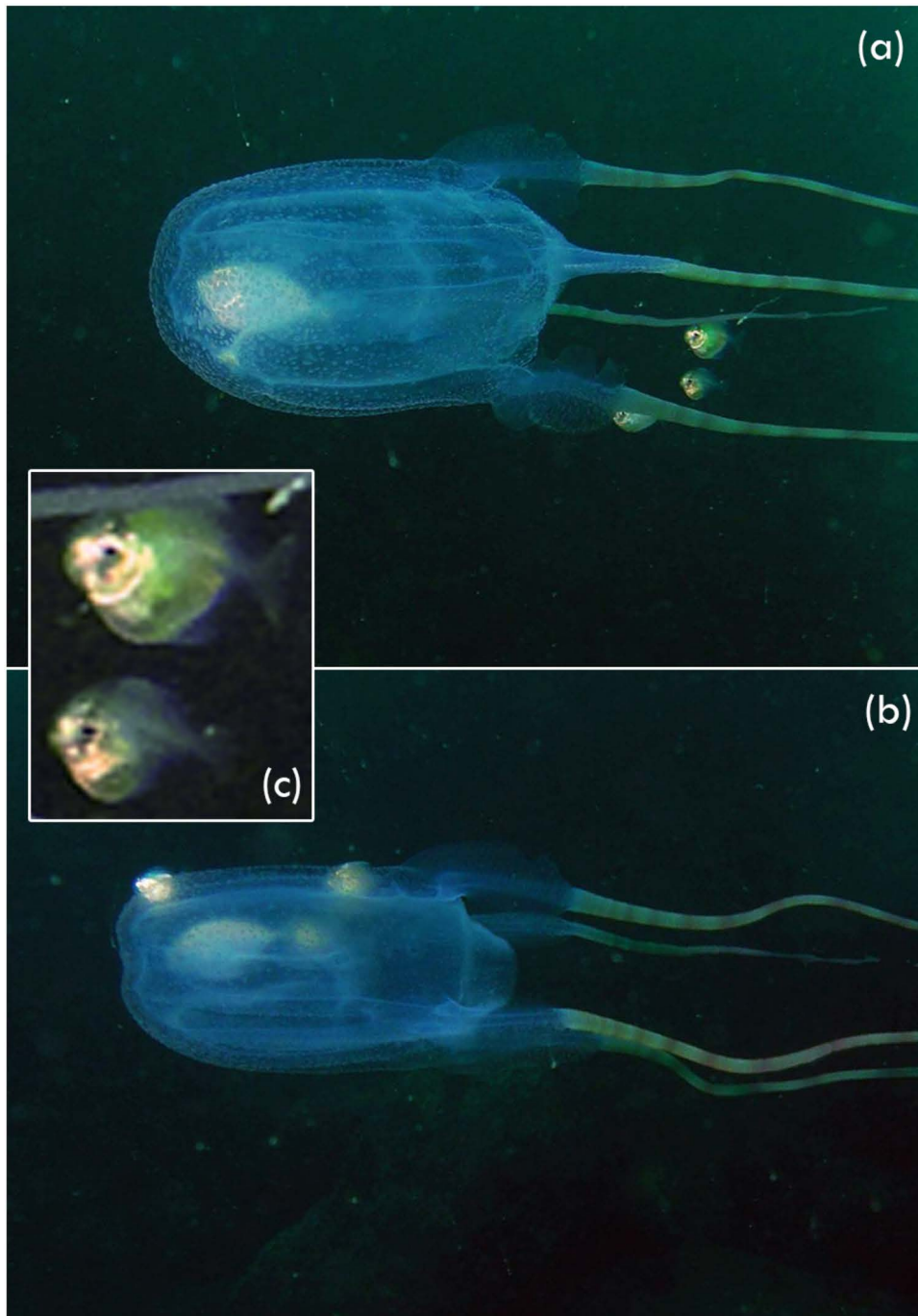
We recorded the association between an individual of *Tamoya haplonema* and four stromateid fish while SCUBA diving near Ilha dos Lobos, Laguna, on the south coast of Santa Catarina, Brazil (28°26'45"S, 48°42'38"W) (Fig. 1). We observed the association at a depth of 8 m, in the late afternoon (around 16:00) of June 14<sup>th</sup>, 2013, for about 5 to 10 minutes. The fish

ranged in size from approximately 3 to 5 cm (from tip of the snout to the posterior end of the caudal fin), and bell height of the medusa measured approximately 15 cm. One of the stromateids was moving inside the subumbrellar cavity of the medusa, while the others were swimming around the tentacles and moved to the other side of the jellyfish from the side we were approaching as if attempting to hide (Fig. 1). Nevertheless, the fish did not stop following the medusa during our observations. Other interactions, such as predation on fish and fish eating parts of the medusa or stealing the medusa's food, were not noticed. Furthermore, in an attempt to improve knowledge on medusae-fish interactions, we undertook a literature review on interactions that involved cubozoan jellyfishes, and the results are summarized in Table 1.

In order to identify the jellyfish as *T. haplonema*, we used the identification key provided in Morandini et al. (2005), which indicates that this is the only cubozoan with four pedalia and one tentacle per pedalia reported for Brazilian waters. *T. haplonema* is likely distributed throughout Central and South America's Atlantic coast, from the Caribbean Sea in the north, south to Uruguay (Leoni et al. 2016; S. N. Stampar, pers. comm.). The associated fish were identified within the family Stromateidae mainly based on general morphology, the laterally compressed body, absence of pelvic fins and the arched lateral line (Fischer et al. 2011). Fish species in this family are present in coastal marine habitats off the Americas, western Africa and Indo-Pacific (Nelson 1994). In Brazil, only two genera of stromateid fish occur (Figueiredo & Menezes 2000), *Peprilus* and *Stromateus*, the former being more likely the genus of the fish we observed, due to a more circular body, opposed to the more elongate form of *Stromateus* (Nakamura et al. 1986, Figueiredo & Menezes 2000, Haedrich 2003). Within *Peprilus* there are two species that occur on the Atlantic coast of South America, *Peprilus xanthurus* (Quoy & Gaimard, 1825) and *P. crenulatus*. We identified the observed specimens as *P. cf. crenulatus*, based on the shorter anal fin, with a shape and size similar to the dorsal fin, compared to the longer anal fin present in *P. xanthurus* (Marceniuk et al. 2016).

As reported by Beebe (1928) on the association with *T. haplonema*, fish roam around the tentacles avoiding it and, when feeling threatened, may move inside the subumbrellar cavity of the medusa, as we also observed (Fig. 1). Mansueti (1963) suggests this could be considered a form of inquilinism. This reinforces the idea that, even though in most cases, or most of the time, the associations between medusae and fish are considered commensal, this should not be interpreted so strictly (Mansueti 1963). Also, the possibility of mutualistic and parasitic associations, as well as predatory interactions, cannot be discounted, even though they were not observed. Furthermore, although *T. haplonema* is a rare medusa in the area, it is not unprecedented to observe it at the beginning of June (Nogueira Júnior et al. 2010). Nevertheless, only one medusa was observed and it was associated with the stromateids (Fig. 1).

For cubomedusae-fish associations, there have been a total



**Fig. 1.** Association between *Tamoya haplonema* and four stromateid fish, identified as *Peprilus* cf. *crenulatus*, around Ilha dos Lobos, Laguna, Santa Catarina, Brazil. One of the stromateids was moving inside the subumbrellar cavity of the jellyfish (a), while the others were swimming near the tentacles (a) and moved to the opposite side of the jellyfish as we approached (b). Inset (c) shows magnified image of two of the stromateids for more detail.

of 6 species-pairs reported, including this study, although the two reports cited in Kondo et al. (2014) refer to an unpublished source and there are no images or other details on these associations (Table 1). Compared to scyphomedusae-fish associations, for which there are more than 80 species pairs reported (Purcell & Arai 2001), associations with cubozoans are rarely documented. As mentioned before, this could be related

to the large spatial and temporal variability of occurrence of these medusae (Kingsford & Mooney 2014), which may result in a sampling bias or lead to a scarcity of cubomedusae-fish encounters. It could also be due to potential host preference for scyphomedusae by fish. Additionally, none of the associations in Cubozoa have been proven species-specific or even obligatory, made evident by Beebe (1928) when reporting

**Table 1.** Summary table of reported interactions between cubomedusae and fish.

Type of interaction	Cubomedusae species	Fish species	Notes on interaction	Locality	Source
Associations	<i>Chironex yamaguchii</i> Lewis & Bentlage, 2009	<i>Gnathanodon speciosus</i> (Forsskål, 1775)		Okinawa, Japan	Okada et al. unpublished (as in Kondo et al. 2014)
	<i>Chiroscalmus quadrumanus</i> (Müller, 1859)?	<i>Chloroscombrus chrysurus</i> (Linnaeus, 1766); <i>Peprilus paru</i> (Linnaeus, 1758)	303 bumpers and one harvest-fish	Port-au-Prince, Haiti	Beebe 1928
	<i>Morbakka virulenta</i> (Kishinouye, 1910)	<i>Trachurus japonicus</i> (Temminck & Schlegel, 1844)		Seto Inland Sea, Japan	Okada et al. unpublished (as in Kondo et al. 2014)
	<i>Tamoya haplonema</i> Müller, 1859	<i>Chloroscombrus chrysurus</i> (Linnaeus, 1766)	Up to 12 fish following a medusa. Some of the fish were preyed upon	Port-au-Prince, Haiti	Beebe 1928
Predation on fish	<i>Alatina alata</i> (Reynaud, 1830)	Stromateidae (identified as <i>Peprilus</i> cf. <i>crenulatus</i> Cuvier, 1829)		Ilha dos Lobos, Lagunas, Santa Catarina, Brazil	This study
	<i>Alatina alata</i> (Reynaud, 1830)	Unidentified	Medusae fed bits of fresh fish in aquarium conditions (as in Arneson & Cutress, 1976)	Puerto Rico, USA	Arneson & Cutress 1976; R. N. Larson, pers. comm. (as in Lewis Ames & Macrander 2016)
	<i>Carukia barnesi</i> Southcott, 1967	<i>Amphiprion</i> sp.	Potential prey species in natural habitat, fed in aquarium conditions	Double Island, Australia (in aquarium conditions)	Underwood & Seymour 2007
	<i>Carybdea brevipedalia</i> Kishinouye, 1981 (as <i>Carybdea rastonii</i> ; see Straehler-Pohl et al. 2017)	Unidentified	Diet shifts to fish with increasing medusae size	Double Island, Australia	Underwood & Seymour 2007
	<i>Carybdea brevipedalia</i> Kishinouye, 1981 (as <i>Carybdea rastonii</i> ; see Straehler-Pohl et al. 2017)	<i>Acanthochronis</i> sp.	Larval/Juvenile fish	Double Island, Australia (in aquarium conditions)	Courtney et al. 2015
	<i>Carybdea confusa</i> Straehler-Pohl, Matsumoto & Acevedo, 2017 (as <i>Carybdea marsupialis</i> ; see Straehler-Pohl et al. 2017)	Unidentified	Young or small fishes	Shizuoka, Japan	Ishida 1936
	<i>Carybdea confusa</i> Straehler-Pohl, Matsumoto & Acevedo, 2017 (as <i>Carybdea marsupialis</i> ; see Straehler-Pohl et al. 2017)	Unidentified	Often eats relatively large fish	Japan	Uchida 1929
	<i>Carybdea rastonii</i> Haacke, 1886	<i>Engraulis japonicus</i> Temminck & Schlegel, 1846 (as <i>Engraulis japonica</i> )	Diet shifts to fish with increasing medusae size	Eastern Taiwan	Lai 2010
	<i>Carybdea rastonii</i> Haacke, 1886	Unidentified	Fish hatchlings	Santa Barbara, California, USA	Martin 2004
	<i>Carybdea rastonii</i> Haacke, 1886	Unidentified	Several larval fish	Southern California, USA	Matsumoto 1995
	<i>Carybdea rastonii</i> Haacke, 1886	<i>Kestratherina brevirostris</i> Pavlov, Ivanoff, Last & Crowley, 1988; <i>Gambusia affinis</i> (Baird & Girard, 1853)	Fish were fed in plankton kreisel	Yorke Peninsula and Adelaide, Australia (in aquarium conditions)	Matsumoto 1995
	<i>Carybdea rastonii</i> Haacke, 1886	Unidentified	Fish present in one of the 23 medusae collected	Yorke Peninsula and Adelaide, Australia	Matsumoto 1995
	<i>Carybdea xaymacana</i> Conant, 1897 (as <i>Carybdea marsupialis</i> ; see Straehler-Pohl et al. 2017)	<i>Jenkinsia</i> sp.	Fish represented 85% of total prey biomass	La Parguera, Puerto Rico, USA	Larson 1976
<i>Carybdea marsupialis</i> ; see Straehler-Pohl et al. 2017)	Unidentified	Small fish were most frequently observed	Port Antonio, Jamaica	Berger 1900	

Table 1. Continued

Type of interaction	Cubomedusae species	Fish species	Notes on interaction	Locality	Source
Predation on fish	<i>Chironex fleckeri</i> Southcott, 1956	<i>Ambassis</i> sp.; <i>Caranx</i> sp.; <i>Leiognathus</i> sp.; <i>Mugil cephalus</i> Linnaeus, 1758 <i>Pomacentrus moluccensis</i> Bleeker, 1853	Fish are present in collected locations but were fed in plankton kreisel Fish are absent in collected locations and were fed in plankton kreisel	Townsville, Queensland, Australia (in aquarium conditions) Townsville, Queensland, Australia (in aquarium conditions)	Hammer et al. 1995 Hammer et al. 1995
		Unidentified	Diet shifts to fish with increasing medusae size	Darwin, Australia	Carrette et al. 2002
		Unidentified	Small fish	Australia	Barnes 1966
	<i>Chiropsalmus quadrumanus</i> (Müller, 1859)	Unidentified			Larson, unpublished (as in Larson 1976)
	<i>Chiropsella bronzie</i> Gershwin, 2006 (as <i>Chiropsalmus quadrigatus</i> ; see Gershwin, 2006)	Unidentified	Fish present in less than 5% of medusae collected	Paraná, Brazil	Nogueira Júnior & Haddad 2008
	<i>Malo filipina</i> Bentlage & Lewis, 2012	Rabbitfish	Small fish	Australia	Barnes 1966
	<i>Tamoya haplonema</i> Müller, 1859	Unidentified		Aurora, Philippines	S. Tuason, pers. comm. (as in Lewis Ames & Macrander 2016)
Predation on medusae	<i>Chironex fleckeri</i> Southcott, 1956	Small tailor; Bream; Small Spanish Mackerel; Queenfish; Toadfish; Parrotfish	Only fish (Teleostei) were present in the gastrovascular cavity of collected medusae	Paraná, Brazil Australia	Nogueira Júnior & Haddad 2008 Kinsey 1986

juvenile *Chloroscombrus chrysurus* (Linnaeus, 1766) living independently as well as associated with both *Chiropsalmus quadrumanus* and *T. haplonema*, all in the same locality (Table 1). This follows the overall trend that associations between jellyfish and fish are facultative and non-specific (Mansueti 1963, Purcell & Arai 2001).

Predation on fishes by cubomedusae is an interaction much more documented than associations (Table 1), following yet another trend explored in Purcell & Arai (2001). There are over 20 reports, although most of them do not identify the species of fish involved, and many others are records of feeding in aquarium conditions, so these may not apply in the natural environment (Table 1). Only one of the records from these interactions occurring in the natural environment identifies the fish species, and it is related to reasonably small fish, which can be preyed on by the cubomedusae (Table 1). For the fish species reported in association with cubozoans, all fall into the families Carangidae or Stromateidae, as in the case of this study (Table 1). These families are amongst the most commonly reported to have fish in association with jellyfish, and are among the many families that produce pelagic young, which have the potential for this association. Moreover, there have been no cases reported for in the literature that regard other possible interactions, such as parasite transmission to fish or even competition involving cubomedusae. Future studies may address questions such as the possibility of a relationship between size of jellyfish and of its fish guests, as well as potential host preferences by the fish consorts regarding scyphomedusae, cubomedusae, and even floating objects.

### Acknowledgements

We are grateful to Alfredo Carvalho Filho and Murilo Pastana for their help with fish identification and to Gisele Tiseo, Edgar Mora and André Morandini, for their assistance with the literature review and comments on manuscript preparation. We are also grateful to Rebecca Helm and Allen Collins for their suggestions and insights regarding the manuscript. This study was supported by the Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC 4302/2010-8).

### References

- Arai MN (1988) Interactions of fish and pelagic coelenterates. *Can J Zool* 66: 1913–1927.
- Arai MN (2005) Predation on pelagic coelenterates: a review. *J Mar Biol Assoc UK* 85: 523–536.
- Arneson AC, Cutress CE (1976) Life history of *Carybdea alata* Reynaud, 1830 (Cubomedusae). In: *Coelenterate Ecology and Behavior* (ed Mackie GO). Plenum, New York, pp. 227–236.
- Ates RML (1988) Medusivorous fishes, a review. *Zool Meded* 62: 29–42.
- Barnes (1966) Studies on three venomous Cubomedusae. In: *The Cnidaria and their evolution* (ed Rees, WJ). *Symp Zool Soc Lond*, 16: 305–332.
- Beebe W (1928) *Beneath tropic seas*, 1st edn. G. P. Putnam's Sons, New York, 234 pp.
- Bentlage B, Cartwright P, Yanagihara AA, Lewis C, Richards GS, Collins AG (2010) Evolution of box jellyfish (Cnidaria: Cubozoa), a group of highly toxic invertebrates. *Proc R Soc B Biol Sci* 277: 493–501.
- Berger EW (1900) *Physiology and histology of the Cubomedusae, including Dr. F. S. Conant's notes on the physiology*. *Mem Biol Lab Johns Hopkins Univ* 4: 1–84.
- Brinkman DL, Burnell JN (2009) Biochemical and molecular characterization of cubozoan protein toxins. *Toxicon* 54: 1162–1173.
- Brodeur RD, Suchman CL, Reese DC, Miller TW, Daly EA (2008) Spatial overlap and trophic interactions between pelagic fish and large jellyfish in the northern California Current. *Mar Biol* 154: 649–659.
- Carrette T, Alderslade P, Seymour J (2002) Nematocyst ratio and prey in two Australian cubomedusans, *Chironex fleckeri* and *Chiropsalmus* sp. *Toxicon* 40: 1547–1551.
- Coates MM (2003) Visual ecology and functional morphology of Cubozoa (Cnidaria). *Integr Comp Biol* 43: 542–8.
- Courtney R, Sachlikidis N, Jones R, Seymour J (2015) Prey capture ecology of the cubozoan *Carukia barnesi*. *PLoS ONE* 10: e0124256.
- Duffy JE (2008) General Ecology: Association. In: *Encyclopedia of Ecology* (eds Jorgensen SE, Fath B). Elsevier, Oxford, pp. 269–272.
- Figueiredo JL, Menezes NA (2000) *Manual de peixes marinhos do Sudeste do Brasil VI Teleostei (5)*. Museu de Zoologia da USP, São Paulo, 116 pp.
- Fischer LG, Pereira LED, Vieira JP (2011) *Peixes Estuarinos e Costeiros*, 2nd edn. Rio Grande, 131 pp.
- Haedrich RL (2003) Stromateidae. In: *The living marine resources of the Western Central Atlantic Volume 3: Bony fishes part 2 (Opistognathidae to Molidae), sea turtles and marine mammals* (ed Carpenter KE). FAO, Rome, pp. 1879–1884.
- Hammer WM, Jones MS, Hamner PP (1995) Swimming, feeding, circulation and vision in Australian Box Jellyfish *Chironex fleckeri* (Cnidaria: Cubozoa). *Mar Freshwater Res* 46: 985–990.
- Ishida J (1936) Note on the digestion of *Charybdea rastonii*. *Annot Zool Japan* 15: 449–452.
- Kingsford MJ (1993) Biotic and abiotic structure in the pelagic environment: Importance to small fishes. *Bull Mar Sci*, 53: 393–415.
- Kingsford MJ, Mooney CJ (2014) The ecology of box jellyfishes (Cubozoa). In: *Jellyfish Blooms* (eds Pitt KA, Lucas CH). Springer Netherlands, Dordrecht, pp. 267–302.
- Kinsey (1986) *Barnes on box jellyfish*. James Cook University of North Queensland, Townsville.
- Kondo Y, Ohtsuka S, Nishikawa J, Metillo E, Pagliawan H, Sawamoto S, Moriya M, Nishida S, Urata M (2014) Associations of fish juveniles with rhizostome jellyfishes in the Philippines, with taxonomic remarks on a commercially harvested species in Carigara Bay, Leyte Island. *Plankton Benthos Res* 9: 51–56.
- Lai C (2010) Ecological study of the box jellyfish, *Carybdea rastonii* (Cnidaria: Cubozoa), in the coastal waters of eastern Taiwan. National Sun-Yat-sen University, Taiwan, 88 pp.
- Larson (1976) Cubomedusae: feeding—functional morphology, behaviour and phylogenetic position. In: *Coelenterate Ecology and Behavior* (ed Mackie GO). Plenum, New York, pp. 237–245.
- Leoni V, González S, Ortega L, Scarabino F, Siquier GF, Dutra A, Rubio L, Abreu M, Serra W, Campi AGA, Stampar SN, Morandini AC (2016) *Tamoya haplonema* (Cnidaria: Cubozoa) from Uruguayan and adjacent waters: oceanographic context of new and historical findings. *Mar Biodivers Rec* 9: 92.
- Lewis Ames C, Macrander J (2016) Evidence for an alternative mechanism of toxin production in the Box Jellyfish *Alatina alata*. *Integr Comp Biol* 56: 973–988.
- Mansueti R (1963) Symbiotic behavior between small fishes and jellyfishes, with new data on that between the stromateid, *Peprilus alepidotus*, and the scyphomedusa, *Chrysaora quinquecirrha*. *Copeia* 1: 40–80.
- Marceniuk AP, Caires R, Siccha-Ramirez R, Oliveira C (2016) Review of the harvestfishes, genus *Peprilus* (Perciformes: Stromateidae), of the Atlantic coast of South America. *Zootaxa* 4098: 311–332.
- Martin VJ (2004) Photoreceptors of cubozoan jellyfish. In: *Coelenterate*

- ate Biology 2003: Trends in Research on Cnidaria and Ctenophora (eds Fautin DG, Westfall JA, Cartwright P, Daly M, Wyttenbach CR). Springer Netherlands, Dordrecht, pp. 135–144.
- Matsumoto GI (1995) Observations on the anatomy and behaviour of the cubozoan *Carybdea rastonii* Haacke. *Mar Fresh Behav Physiol* 26: 139–148.
- Miyajima-Taga Y, Masuda R, Yamashita Y (2016) Larvae of the thread-sail filefish *Stephanolepis cirrhifer* feed on eggs and planulae of the jellyfish *Aurelia* sp. under laboratory conditions. *Plankt Benthos Res* 11: 96–99.
- Miyajima-Taga Y, Masuda R, Yamashita Y (2017) Feeding capability of black scraper *Thamnaconus modestus* on giant jellyfish *Nemopilema nomurai* evaluated through field observations and tank experiments. *Environ Biol Fishes* 100: 1237–1249.
- Möller H (1984) Reduction of a larval herring population by jellyfish predator. *Science* 224: 621–622.
- Morandini AC, Ascher D, Stampar SN, Ferreira JF V. (2005) Cubozoa e Scyphozoa (Cnidaria: Medusozoa) de águas costeiras do Brasil. *Iheringia* 95: 281–294.
- Nakamura I, Inada T, Takeda M, Hatanaka H (1986) Important fishes trawled off Patagonia. Japan Marine Fishery Resource Research Center, Tokyo, 369 pp.
- Nelson JS (1994) *Fishes of the world*, 3rd edn. New York, John Wiley and Sons, 600 pp.
- Nogueira Júnior M, Haddad MA (2008) The diet of cubomedusae (Cnidaria, Cubozoa) in southern Brazil. *Braz J Oceanogr* 56: 157–164.
- Nogueira Júnior M, Nagata RM, Haddad MA (2010) Seasonal variation of macromedusae (Cnidaria) at North Bay, Florianópolis, southern Brazil. *Zoologia* 27: 377–386.
- Purcell JE, Arai MN (2001) Interactions of pelagic cnidarians and ctenophores with fish: a review. *Hydrobiologia* 451: 27–44.
- Purcell J (2003) Predation on zooplankton by large jellyfish, *Aurelia labiata*, *Cyanea capillata* and *Aequorea aequorea*, in Prince William Sound, Alaska. *Mar Ecol Prog Ser* 246: 137–152.
- Straehler-Pohl I, Matsumoto GI, Acevedo MJ (2017) Recognition of the Californian population as a new species—*Carybdea confusa* n. sp. (Cnidaria, Cubozoa, Carybdeida). *Plankton Benthos Res* 12: 129–138.
- Thiel ME (1970) Das Zusammenleben von Jung- und Kleinfischen mit Rhizostomeen (Scyphomedusae). *Ber Dtsch Wiss Komm Meeresforsch* 21: 444–473.
- Thiel ME (1978) Das Zusammenleben von Jung- und Kleinfischen mit Semaestomen (Scyphomedusae). *Mitt Hamb Zool Mus Inst* 75: 19–47.
- Uchida T (1929) Studies on Stauromedusae and Cubomedusae, with special reference to their metamorphosis. *Jap J Zool* 2: 103–193.
- Underwood AH, Seymour JE (2007) Venom ontogeny, diet and morphology in *Carukia barnesi*, a species of Australian box jellyfish that causes Irukandji syndrome. *Toxicon* 49: 1073–1082.