SUPPLEMENTARY MATERIAL

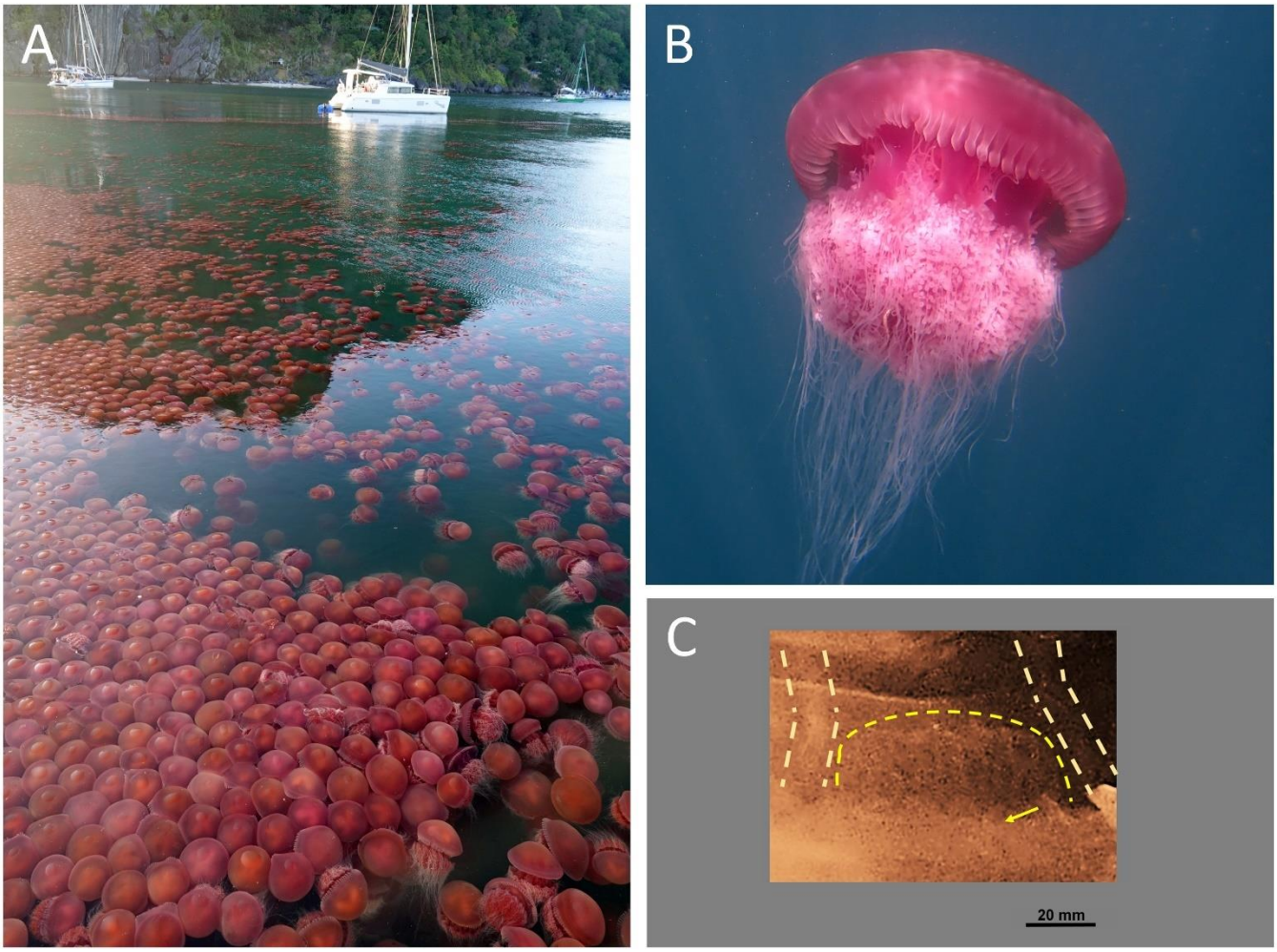
Journal of the Marine Biological Association of the United Kingdom
Research Article

Integrating molecular and morphological evidence revives the blubber jellyfish, *Catostylus purpurus* (Scyphozoa: Rhizostomeae; Catostylidae) of the Indo-Pacific (Philippines)

Authors:
Sheldon Rey Boco[1,2,*], Christine Gloria Grace Capidos[1,3], André C. Morandini[4], G. William M. Harrison[5,6], Piet A. J. Bakker[5], Dennis Talacay[1], Allen G. Collins[7], Joseph Comendador[8], Sue Muller Hacking[1,9], Karen van Dorp[5], Dino Angelo Ramos[10], Paul John Geraldino[3]

Affiliations:
[1]Philippine Jellyfish Stings Project, Tacloban City, the Philippines and Brisbane, Queensland, Australia
[2]Griffith School of Environment and Science, Gold Cost Campus, Griffith University, Gold Coast, QLD 4222, Australia
[3]Department of Biology, University of San Carlos, Talamban, Cebu City, 6000, The Philippines
[4]Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, São Paulo, Brazil; and Centro de Biologia Marinha, Universidade de São Paulo, Rodovia Manoel Hypólito do Rego, São Sebastião, Brazil
[5]Naturalis Biodiversity Center, Leiden, The Netherlands
[6]University of Amsterdam, Amsterdam, The Netherlands
[7]National Systematics Laboratory, NOAA's National Marine Fisheries Service; Smithsonian National Museum of Natural History, Washington, DC, United States of America
[8]National Museum of Natural History of the National Museum of the Philippines, Taft Ave., 33 Ermita, Manila 1000, The Philippines
[9]Marine Animal Surveys, Seattle, Washington 98177, United States of America
[10]Departamento de Estratigrafía y Paleontología, Universidad de Granada, Granada, Spain

*Corresponding author's details:
Sheldon Rey Boco, PhD
E-mail: raey_boco@yahoo.com
Phone: +61 452 419 914



Supplementary Fig. 1. Medusae and bloom of the tomato jellyfish *Crambione mastigophora* Maas, 1903 observed *in situ* on April 2020 near Corong Corong beach (11°10'05.2"N, 119°23'30.5"E) in El Nido, Palawan. (**A**) Aggregates of the tomato jellyfish, (**B**) mature medusa *in situ,* (**C**) arrangement of gastrovascular canal system (broken lines for emphasis) of this live tomato jellyfish with dome-shaped intracircular anastomoses that do not connect to their radial canals; a lappet = arrow.

Table S1. Records of occurrences of the blubber jellyfish *Catostylus townsendi.*

Locality	Observation date	Latitude	Longitude	Source
Beibu Gulf, China	None	21°26'31.6"N	108°04'25.6"E	This study[A]
Phuket, Thailand	17 Jan 2002	7°57'59.6"N	98°23'27.0"E	Aungtonya & Chanachon (2012)
Chao Lao, Thailand	4 October 2014**	12°32'52.4"N	101°55'24.3"E	This study; S. Charrunchon obs.
Phang-nga, Thailand	2014-2015	8°48'50.0"N	98°15'36.2"E	This study[B]
Phang-nga, Thailand	2014-2015	8°19'16.5"N	98°15'51.7"E	This study[B]
Trat province, Thailand	None**	11°59'32.9"N	102°46'11.6"E	Punnarak *et al.*, (2023); K. Chanachon obs.
Sabah, Malaysia	30 Sept 1909	4°14'20.0"N	117°53'12.0"E	Mayer (1915); USNM 28721-2
Pantai Melawi, Malaysia	June 2008-Oct 2010	5°59'59.23"N	102°25'36.20"E	Rizman-Idid *et al.*, (2016)
Selangor, Malaysia	June 2013	3°10'23.6"N	101°11'26.1"E	Gómez Daglio & Dawson, (2017)
Changi, Singapore	26 April 2005	1°22'41.4"N	104°00'16.2"E	Tan (2019)
Lazarus Island, Singapore	16 March 2016	1°13'28.6"N	103°51'04.5"E	Tan (2019)
Jakarta, Indonesia	None	6°06'03.2"S	106°47'00.4"E	Stiasny (1925)
Surabaya, Indonesia	Sept-Oct 2010	7°16'07.7"S	112°51'03.1"E	Gómez Daglio *et al.*, (2022)
Roxas, Palawan, Philippines	None**	10°19'19.8"N	119°22'45.6"E	Heeger (1998)
Roxas, Palawan, Philippines	28 March 1994	10°19'46.3"N	119°21'34.4"E	NHMUK 1997.841-847
Narra, Palawan, Philippines	8 June 2018**	9°21'33.2"N	118°31'58.4"E	This study; A. Galindez obs.
Narra, Palawan, Philippines	4 February 2019**	9°12'47.4"N	118°22'36.1"E	This study; P. Dimalaluan obs.
Rizal, Palawan, Philippines	1 April 2023**	9°01'18.4"N	117°37'29.6"E	This study; A. Schilde obs.

Text in bold are new records of the species.
Obs. = observation/s

** = bloom present during observation.

[A]Verified and re-analysed data from He *et al.,* (2014) with mention of an unidentified species of *Catostylus.*

[B] Verified and re-analysed data from Liu *et al.,* (2016) with description of an unidentified species of *Catostylus.*

NHMUK = Natural History Museum of the United Kingdom and specimen accession code
USNM = specimen accession code for Smithsonian National Museum of Natural History in the United States of America

Sources:

Aungtonya C and Chanachon K (2012) *Species and distribution of venomous jellyfish in coastal areas of Phuket Province* (Technical Paper No. 1). Phuket Marine Biological Center, Thailand.

Gómez Daglio L and Dawson MN (2017) Species richness of jellyfishes (Scyphozoa: Discomedusae) in the Tropical Eastern Pacific: missed taxa, molecules, and morphology match in a biodiversity hotspot. *Invertebrate Systematics* 31 (5), 635-663.

Gómez Daglio L, Hayati R, Coleman T, Han YM, Muzaki F, Aunurohim and Saptarini D (2022) Species composition of Discomedusae jellyfish (Scyphozoa) in the coastal waters of Eastern Surabaya, East Java. *Marine Biodiversity* 52 (2), 23.

Heeger T (1998) *Quallen. Gefährliche Schönheiten.* Wissenschaftliche Verlagsgesellschaft mbH, Stuttgart, Germany.

He JR, Zheng LM, Lin YS, Zhang WJ and Cao WQ (2014) *DNA Barcoding Medusozoa of China Seas*. Department of Marine Biological Science and Technology, College of Ocean and Earth Sciences, Xiamen University, China.

Liu R, J Xiao, X Zhang and C Aungtonya (2016) Genetic analysis of common venomous Cubozoa and Scyphozoa in Thailand waters (in Chinese). *Haiyang Xuebao* 38(6): 51–61.

Mayer AG (1915) VII. Medusae of the Philippines and of Torres Straits –Report upon the Scyphomedusae collected by the United States Fisheries Bureau steamer "Albatross" in the Philippine Islands and Malay Archipelago, 1907–1910, and upon Medusae collected by the Expedition of the Carnegie Institution of Washington to Torres Straits, Australia in 1913. *Papers of the Department of Marine Biology, Carnegie Institution of Washington, USA* 8, 157–202.

Punnarak P, Sopon A, Panichpol A and Bunpent T (2023) Diversity and Distribution of Jellyfish Polyps Along Coastal Areas of Chonburi and Rayong Provinces, Thailand. *Tropical Natural History* 23, 6-18.

Rizman-Idid M, Farrah-Azwa AB and Chong VC (2016) Preliminary taxonomic survey and molecular documentation of jellyfish species (Cnidaria: Scyphozoa and Cubozoa) in Malaysia. *Zoological Studies* 55.

Stiasny G (1925) Zur Entwicklung und Phylogenie der Catostylidae. Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam. *Afdeeling Natuurkunde*. Tweede sectie (d. 24), no. 2.

Tan R (2019) Fat-armed jellyfish (*Catostylus* sp.). Wildfactsheets. Retrieved from http://www.wildsingapore.com/wildfacts/cnidaria/others/jellyfish/catostylus.htm

Table S2. Systematics of the Catostylidae species *Acromitoides stiphropterus*.

Taxonomic details
Systematics:
Class SCYPHOZOA Goette, 1887
Subclass DISCOMEDUSAE Haeckel, 1880
Order RHIZOSTOMEAE Cuvier, 1800
Family CATOSTYLIDAE Claus, 1883
Genus *Acromitoides* Stiasny, 1921
Acromitoides stiphropterus Stiasny, 1921, *species inquirenda*
Taxonomic record:
Crambessa stiphroptera – Schultze (1897): 159, *sp. nov.* description, Plate 15: figures 4, 5: oral arm, 5a: oral arm pillar cross-section; Schultze (1898): 454, mention.
Catostylus stiphropterus – Mayer (1910): 666, 670-671, brief description.
Acromitoides stiphropterus – Stiasny (1921): 136-137, new species description; Kramp (1961): 368, list of species records, brief description; Thiel, (1976): 425, 430, 437, mentions; Kitamura & Omori (2010): 114, brief remarks; Jarms & Morandini (2019, 2023): 556-557, species description.
Type specimen:
None.
Type locality:
Near Ternate in North Maluku, Indonesia (around 0°51'35.8"N, 127°20'56.5"E).

Table S2. *Continuation*

Etymology:

Acromitoides genus consists of the genus name *Acromitus* and the Greek "-oides" which means "looking like or similar to" (Stiasny 1921; Jarms & Morandini, 2019; 2023). The epithet *stiphropterus* likely came from the Greek words "stiphros" and "pteron," meaning strong and wing (or feather), respectively (Jarms & Morandini, 2019; 2023), although Stiasny (1921), Mayer (1910) and Schultze (1897, with the *stiphroptera* epithet) did not discuss the etymology of this species.

Description:

The bell is flat and rounded, measuring 100 mm in width, and features a smooth exumbrella surface devoid of the protuberances observed in Catostylidae jellyfish like *C. mosaicus.* Brown spots on the exumbrella that fade at the bell margin. Bell contains 8 marginal rhopalia (sensory organs). The rhopaliar lappets are slender with sharp points. Each octant of the bell houses at least 5 larger cleft velar lappets, measuring approximately 10 mm in length and 6 mm in width at their bases. The arm-disk has a diameter of about 38 mm, slightly narrower than the bell-radius. The 4 arm-disc columns are almost as wide as the 4 narrow subgenital ostia. The lower arm is 5 times longer than the upper arm, with the combined length of both arms being slightly shorter than the bell's radius. No mention about a subgenital papilla. The stomach's square central section measures 2 cm per side. Coronal muscles with abrasion but somewhat intact. Oral arms typical of Catostylidae (Supplementary Figure 2A-B). Gastrovascular system containing 16 radial canals connected to an extracircular anastomoses and a ring canal (Supplementary Figure 2C). Intracircular anastomoses, that arise from the ring canal, are connected only to inter-rhopaliar canals.

Distribution:

Known from the type locality only (Indonesia).

Table S2. *Continuation*

Remarks:

Acromitoides stiphropterus Stiasny as *species inquirenda* here, was previously categorized as *Catostylus stiphropterus* (Mayer, 1910). Kitamura & Omori (2010) and Stiasny (1921) noted stark similarities of this species to a *Catostylus* sp., but Kitamura & Omori (2010) doubted the systematics of *A. stiphropterus* and argued the species is nearly identical to *A. purpurus*. *A. stiphropterus* appears as parts of *Catostylus townsendi* by having brown spots that do not reach the bell margin, the absence of filaments on a smooth exumbrella, and shape and features of oral arms typical of Catostylidae (see also *C townsendi* image in Figure 1E and 5F, main text). Historically, Mayer (1910) formed *C. stiphropterus* following Schultze (1897)'s description of *Crambessa stiphroptera* during the synonymy of *Crambessa* into several genera (e.g., *Catostylus*). Then, Stiasny (1921) established *Acromitoides stiphropterus* as a new species using Schultze (1897) and Mayer (1910)'s description of this jellyfish knowing that the original description for this species (as *C. stiphroptera*) was made from only one, damaged specimen. This description does not show whether a subgenital papilla on the medusa was present or not. Stiasny (1921) argued that the jellyfish needed a new binomen due to Schultze (1897)'s account stating a gastrovascular canal system with intracircular anastomoses that connect only to inter-rhopaliar canals, contrary to the canal system of *Catostylus* spp. jellyfish. However, due to the absence of a type specimen, incomplete morphological description resulting from specimen damage, the absence of details on potential presence of subgenital papilla/e and a potentially malformed gastric canal system, our study retains the *species inquirenda* status of *A. stiphropterus.*

Sources:

Kitamura M and Omori M (2010) Synopsis of edible jellyfishes collected from Southeast Asia, with notes on jellyfish fisheries. *Plankton and Benthos Research* 5 (3), 106-118.

Kramp PL (1961) Synopsis of the medusae of the world. *Journal of the Marine Biological Association of the United Kingdom* 40, 1–569.

Jarms G and Morandini AC (2019) *World Atlas of Jellyfish*. Dölling und Galitz Verlag, 816p.

Jarms G and Morandini AC (Eds.) (2023) *World Atlas of Jellyfish* (Digital edition). Dölling und Galitz Verlag.

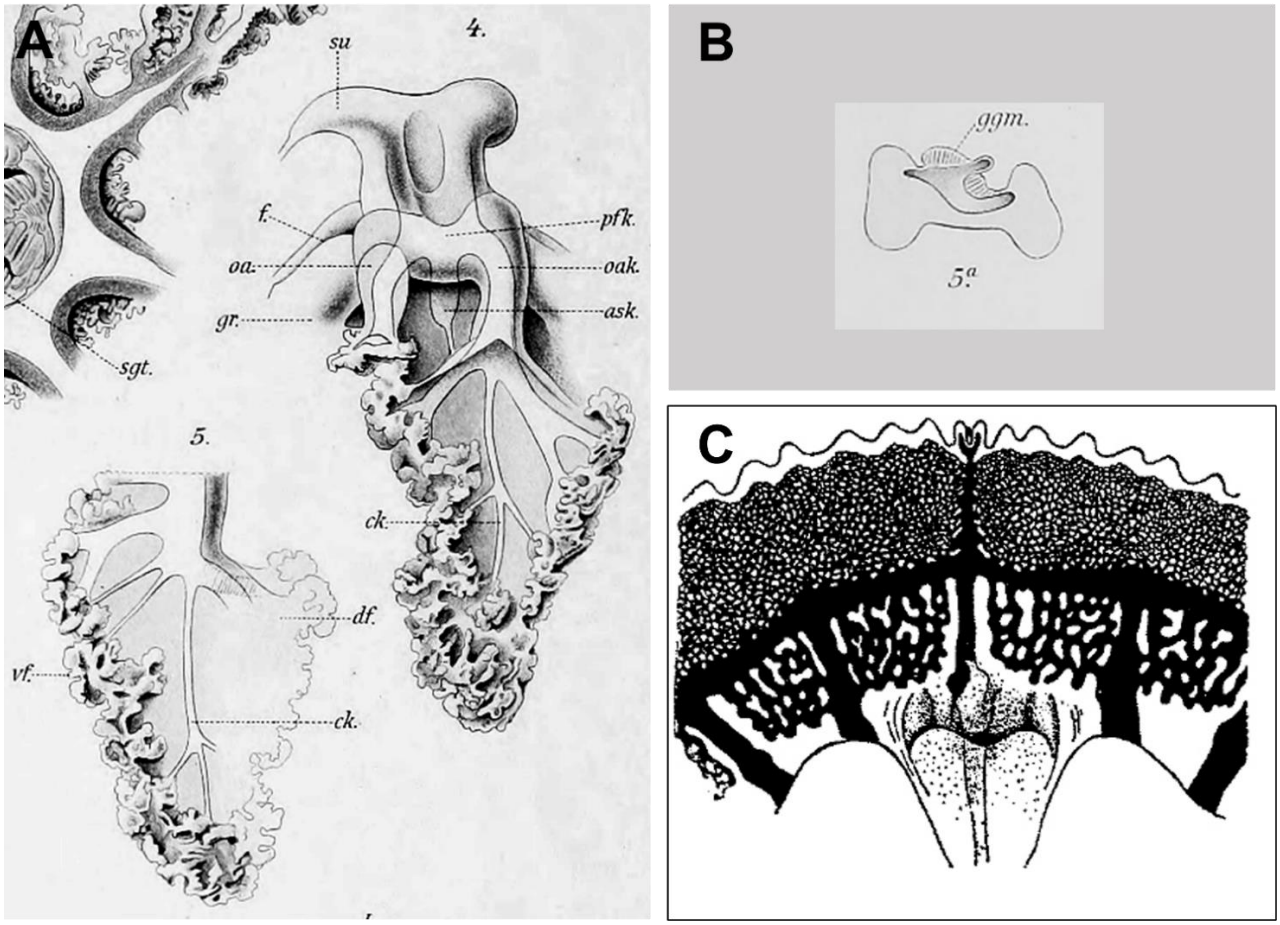
Mayer AG (1910) *Medusae of the World. Scyphomedusae*, Vol. 3, 499–735, Washington, DC, USA.

Schultze LS (1897) Rhizostomen von Ternate. *Abhandlungen herausgegeben von der Seckenbergischen naturforschenden Gesellschaft.* 24 (2), 153-165.

Schultze LS (1898) Rhizostomen von Ambon. *Denkschriften der Medicinisch Naturwissenschaftlichen Gesellschaftzu Jena* 8, 443–466.

Stiasny G (1921) Studien über Rhizostomeen mit besonderer Berücksichtigung der Fauna des Malayischen Archipels nebst eine Revision des Systems. *Capita Zoologica* 1 (2), 1-179.

Thiel ME (1976) Wirbellose meerestiere als parasiten, kommensalen oder symbionten in oder an Scyphomedusen. *Helgoland Marine Research* 28 (3), 417-446.

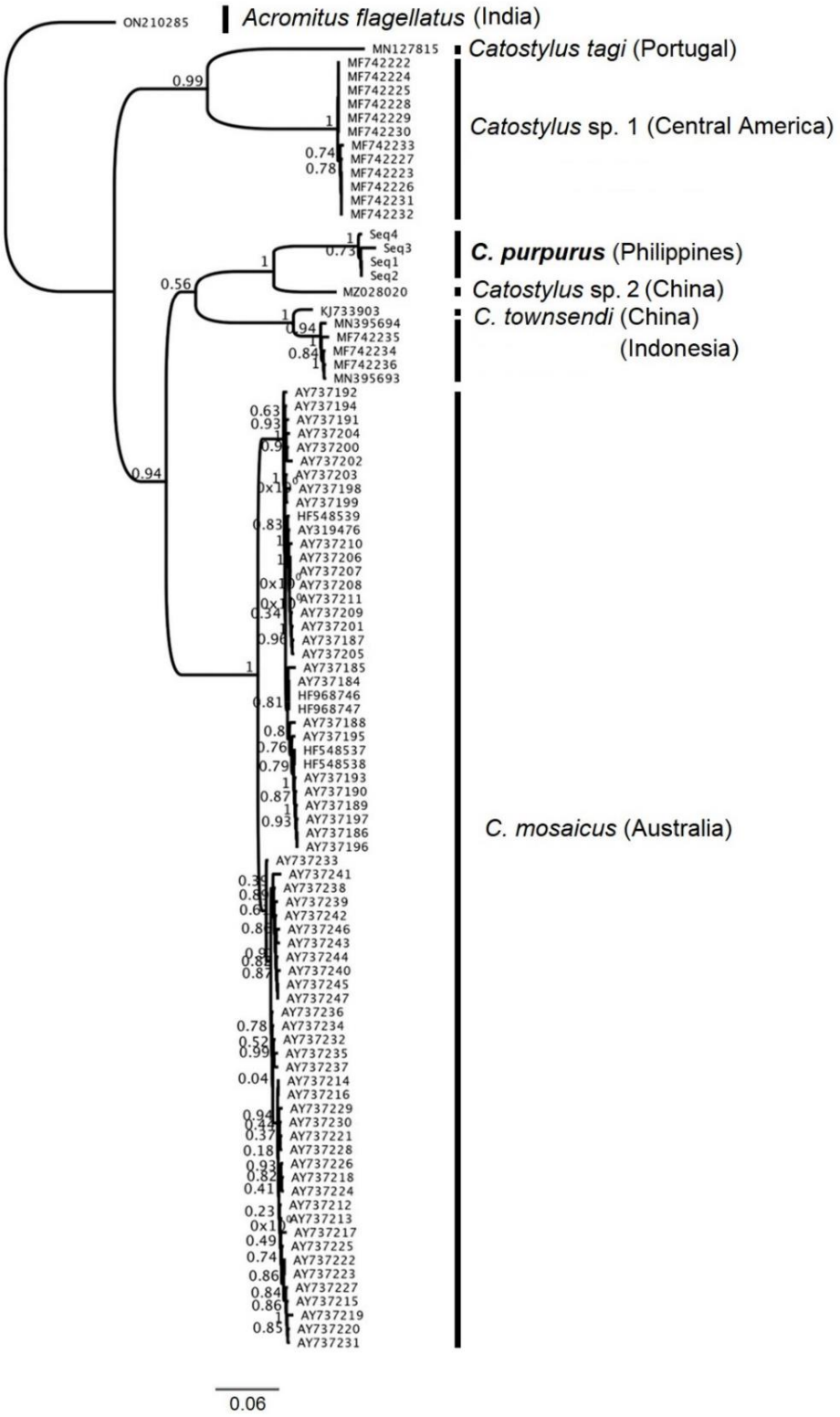


Supplementary Fig. 2. Parts of the medusa of *Acromitoides stiphropterus.* **(A)** Schultze (1897)'s sketch of arm disc and oral arm (4), canals in the oral arm (5) and, **(B)** gastric pillar with gastrogenital membrane (*ggm*; 5a) of this jellyfish, (**C**) Thiel (1978)'s sketch depicting the gastric canals of genus *Acromitoides* in Schultze (1897)'s account. Original labels in A-B from Schultze (1897): *f.* furrow separating the upper part of the arm disc from the gall ring (*gr.*), *oa.* upper arm in cross section, *ck.* central canal, *pfk.* pillar channel, *oak.* upper arm canal, *ask.* horizontal arm disc channel; in image 5: *vf.* ventral wing, *df.* dorsal wing, *ck.* central canal.

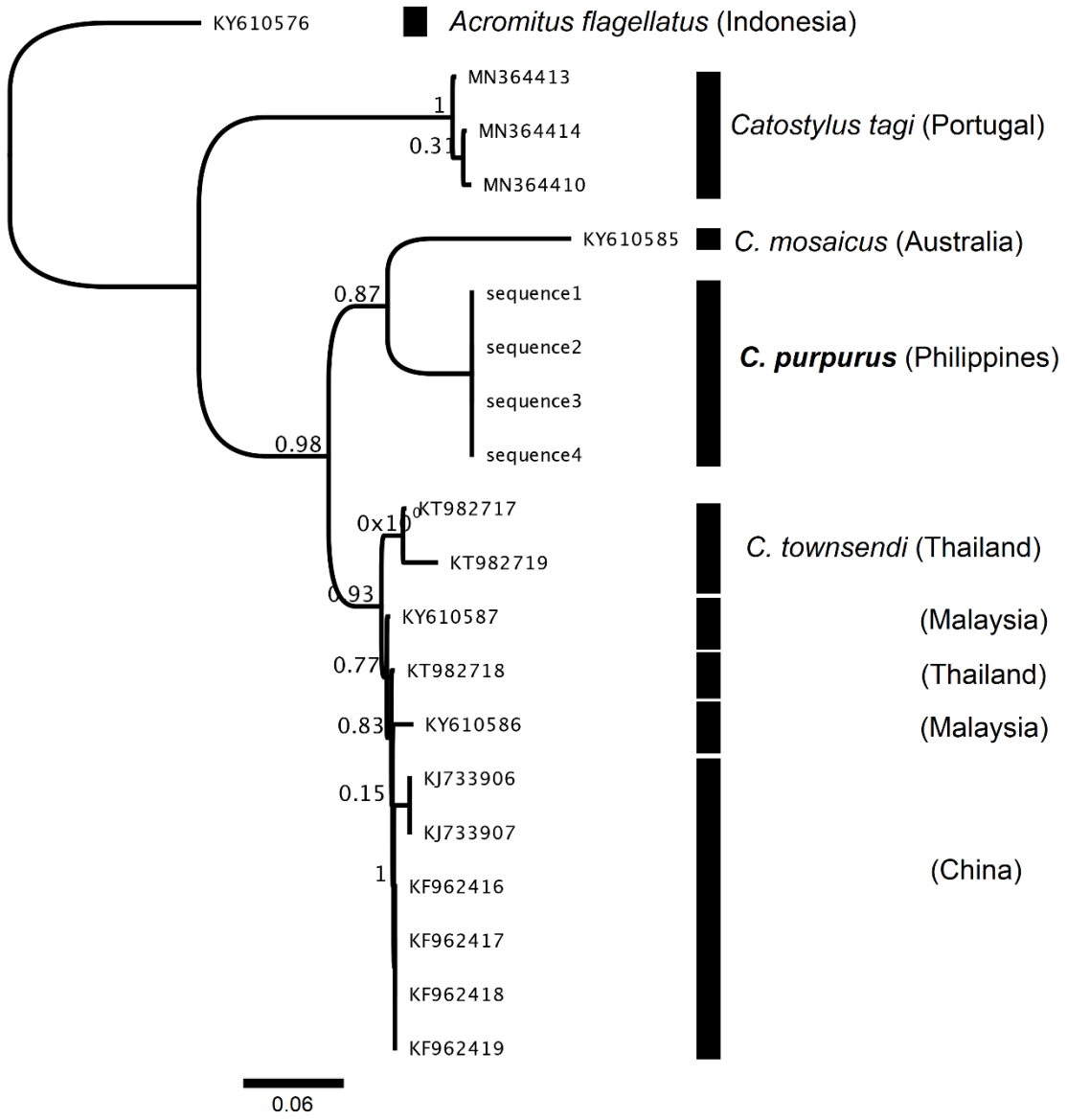
Paper cited:

Schultze LS (1897) Rhizostomen von Ternate. *Abhandlungen herausgegeben von der Seckenbergischen naturforschenden Gesellschaft* 24 (2), 153-165.

Thiel ME (1978) Die postephyrale Entwicklung des Gastrovascularsystems der Rhizostomida nebst Ergänzungen und Berichtigungen zu den Stiasnyschen Typen dieser Entwicklung, zugleich ein Zeugnis für das Haeckelsche biogenetische Grundgesetz. *Zeitschrift für zoologische Systematik und Evolutionsforschung* 16 (3), 145–168.



Supplementary Fig. 3. This phylogenetic tree is based on a Maximum Likelihood analysis, using FastTree implemented in Geneious Prime 2024, of **cytochrome oxidase I** sequences from the blubber jellyfish, *Catostylus* spp., sourced from GenBank. It includes new nucleotides from *C. purpurus* (in bold) obtained in this study and *Catostylus* sp. 1 (Gómez Daglio and Dawson, 2017) and sp. 2 (Chong *et al.,* 2022). FastTree support values at the nodes range from 0 to 1 (or 0% to 100%). The codes at the branch tips are from GenBank, and adjacent to these are line bars separating species, species names and geographic locations of the sequences. *Acromitus flagellatus* is the outgroup. Sources: Gómez Daglio and Dawson (2017) https://doi.org/10.1071/IS16055; Chong *et al.,* (2022) http://doi.org/10.11978/2021071.



Supplementary Fig. 4. This phylogenetic tree is based on a Maximum Likelihood analysis, using FastTree implemented in Geneious Prime 2024, of **16S** sequences from the blubber jellyfish, *Catostylus* spp., sourced from GenBank. It includes new nuceotides from *C. purpurus* (in bold) obtained in this study. FastTree support values at the nodes range from 0 to 1 (or 0% to 100%). The codes at the branch tips are from GenBank, and adjacent to these are line bars separating species, species names and geographic locations of the sequences. *Acromitus flagellatus* is the outgroup.