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Author for correspondence:
Mohamed Nejib Daly Yahia,
E-mail: nejibdaly@qu.edu.qa

First jellyfish records for Qatar and further notes on Scyphomedusae species from the Arabian Gulf (Cnidaria, Scyphozoa)

Mohamed Nejib Daly Yahia[1], Pedro Range[2], Bruno Welter Giraldes[2] and André C. Morandini[3,4]

[1]Environmental Sciences Program, Department of Biological and Environmental Sciences, College of Arts and Sciences, Qatar University, PO Box 2713, Doha, Qatar; [2]Environmental Science Center, Qatar University, PO Box 2713, Doha, Qatar; [3]Departamento de Zoologia, Instituto Biociências, Universidade de São Paulo, Rua do Matão, trav. 14, n. 101, Cidade Universitária, São Paulo, SP, 05508-090, Brazil and [4]Centro de Biologia Marinha, Universidade de São Paulo, Av. Manoel Hipólito do Rego, km 131.5, São Sebastião, SP, 11612-109, Brazil

Abstract

This study focused on a jellyfish monitoring and sampling programme along the eastern Qatar seawaters and reports the first jellyfish records for the Qatar pelagic ecosystem and the occurrence of three scyphozoans: the semaeostome *Chrysaora* cf. *caliparea* and the rhizostomes *Marivagia stellata* and *Catostylus perezi*, considered as first records of Scyphomedusae for Qatar. Jellyfish monitoring, underwater photography and sample collection were carried out along an inshore-offshore transect composed of five stations along the eastern coast of Qatar. Jellyfish material examined, systematic description, general distribution and sting risk of the three species are provided. The discussion section highlights the blooming capabilities of *Chrysaora* cf. *caliparea* and *Catostylus perezi*, while *Marivagia stellata* seems scarcer, being spotted for the first time since we started our jellyfish investigation programme in August 2018.

Introduction

Scyphozoan jellyfishes are known as top predators in pelagic ecosystems, playing a significant trophic role in marine food webs and serving as food for several marine organisms (Arai, 2005; Gueroun *et al.*, 2020). Meanwhile, they have a negative impact on many human activities such as tourism, fishing and aquaculture (Purcell *et al.*, 2007). Jellyfish blooms result from a variety of natural hydroclimatic factors (Goy *et al.*, 1989; Lynam *et al.*, 2004; Gatt *et al.*, 2018) and anthropogenic activities including overfishing and exploitation of living resources, eutrophication, coastal constructions and marinas, maritime transport (ballast waters) combined with environmental and climatic changes (Molinero *et al.*, 2005; Attrill *et al.*, 2007; Purcell *et al.*, 2007; Daly Yahia *et al.*, 2010; Brotz & Pauly, 2012; Boero, 2013; Roux *et al.*, 2013; Canepa *et al.*, 2014). In addition, jellyfish blooms may cause severe economic consequences on finfish aquaculture causing farmed fish envenomation with related skin and gill disorders (leading to fish mortalities), or clogging fish cages and inflicting severe stings to aquaculture operators (Bosch-Belmar *et al.*, 2016, 2017; Ensibi *et al.*, 2017).

The Arabian Gulf is an extremely sensitive marine system providing goods and services through unique ecosystems such as coral reefs, mangroves, seagrass meadows and a rich pelagic neritic system supporting an important fishery industry (Sheppard *et al.*, 2010; Sheppard, 2016).

The Scyphomedusae fauna of the Arabian/Persian Gulf is poor if compared with the rich Indian Ocean nearby (Rao, 1931; Stiasny, 1937; Nair, 1951; Tahera & Kazmi, 2006; Muhammed & Sultana, 2007; Daryanabard & Dawson, 2008; Gul & Morandini, 2013, 2015; Gul *et al.*, 2014, 2015*a*, 2015*b*, 2015*c*; Pourjomeh *et al.*, 2018; Riyas *et al.*, 2019; Gul, 2020; Mondal & Asha Devi, 2020). The number of species reported and confirmed specifically from the Arabian/Persian Gulf area is only seven: *Cassiopea andromeda* (Forskål, 1775), *Catostylus perezi* Ranson, 1945, *Chrysaora* sp., *Crambionella orsini* (Vanhöffen, 1888), *Cyanea nozakii* Kishinouye, 1891, *Pelagia noctiluca* (Forskål, 1775) and *Sanderia malayensis* Goette, 1886 (Ranson, 1945; Kramp, 1956; Daryanabard & Dawson, 2008; Nabipour *et al.*, 2015; Pourjomeh *et al.*, 2018). Another recent paper (Baniasadi *et al.*, 2019) contains further reports that cannot be completely confirmed either due to absence of museum specimens for checking or due to poor quality of the images in the paper.

Several cases of dangerous jellyfish stings have been registered by Qatar authorities, for example the Hamad Medical Corporation (El Khatib & Al Basti, 2000), but to our knowledge there are no formal records of Scyphomedusae for the country. Unfortunately, the sting reported by El Khatib & Al Basti (2000) did not present any indication of the jellyfish responsible for the case.

Since 2012, various national and regional newspapers have warned swimmers and tourists about the presence of venomous jellyfish between May and October (Ponce de Leon, 2012;

Ramesh, 2016; Bakshi, 2016; Qatar Tribune, 2018). The Arabian Gulf does not escape the global trend of increasing jellyfish as a result of global changes and during the period 2011 and 2016 the problem of jellyfish proliferations and blooms was part of the Qatar National Development Strategy and the Qatar National Vision 2030 (Qatar National Development Strategy 2011–2016, 2011).

Due to increasing concerns about jellyfish stings and also several anecdotal bloom events reported in local newspapers, in this study we report the occurrence of three Scyphomedusae to contribute to the improvement of the knowledge of scyphozoans from the Arabian Gulf and Qatar. The semaeostome *Chrysaora* cf. *caliparea* and the rhizostomes *Marivagia stellata* and *Catostylus perezi* are considered the first records of Scyphomedusae for Qatar.

Materials and methods

Scyphozoan jellyfish were sampled during three RV 'Janan' campaigns organized in August 2019, October 2019 and March 2020 in the east Exclusive Economic Zone (EEZ) of Qatar in the central Arabian Gulf. The sampling was carried out along an inshore-offshore transect composed of five stations (J1–J5, Figure 1). Two sampling techniques were used: horizontal towing using a WP2 zooplankton net (0.7 m mouth diameter, 200 µm mesh size, sub-surface) and visual underwater observations. Coastal prospections were also performed in May and June 2019 along Al-Dhakhira, Lusail, Doha Bay, Al-Wakra and Sealine beaches respectively in the north-eastern, east and south-eastern coast of Qatar (Figure 1).

All jellyfish samples were collected by net or by hand and preserved in 4% buffered formaldehyde solution. Some specimens were photographed *in situ* or maintained in aquaria to be photographed alive.

Biometric measurements were taken using a stainless steel ruler and given in cm with an accuracy of 0.1 cm.

Identifications were made according to Kramp (1961), Daly *et al.* (2007), Morandini & Marques (2010), Castellani & Edwards (2017), and Jarms & Morandini (2019). As there are no zoological collections in Qatar, the specimens are housed in the laboratory of the first author.

Results

Systematics of Chrysaora *cf.* caliparea

Class SCYPHOZOA Goette, 1887
Subclass DISCOMEDUSAE Haeckel, 1880
Order SEMAEOSTOMEAE L. Agassiz, 1862
Family PELAGIIDAE Gegenbaur, 1856
Genus *Chrysaora* Péron & Lesueur, 1810
Chrysaora cf. *caliparea* (Reynaud, 1830)
Figures 2–4

Material examined

Two specimens photographed on 6 August 2019 in station J4 and 30 specimens sampled on 12 October 2019 in station J2 preserved in 4% formaldehyde solution (bell diameter 2.0–8.2 cm).

Description

Live and preserved Scyphomedusae 2.0–8.2 cm in diameter shows a hemispherical umbrella (Figure 2 and 3) with marginal lappets rounded, 4 per octant, without canals (Figure 4). Adult specimens

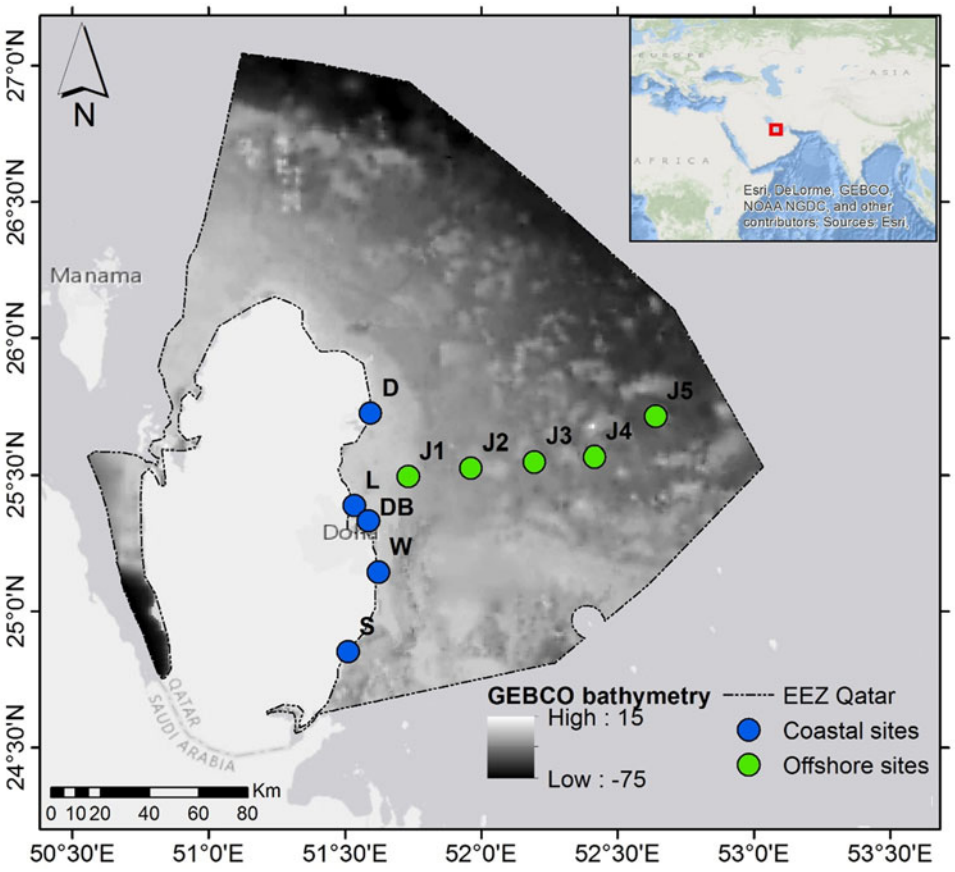

Fig. 1. Sampling stations during RV 'Janan' campaigns in August 2019, October 2019 and in March 2020 in the East Exclusive Economic Zone of Qatar (J1–J5 stations). Coastal zone stations at Al-Dhakhira (D), Lusail (L), Doha Bay (DB), Al-Wakrah (W) and Sealine (S) are also represented on the map. The green and blue dots indicate respectively the sampling stations offshore and inshore; the broken black lines delimit the marine Exclusive Economic Zone (EEZ) of Qatar.

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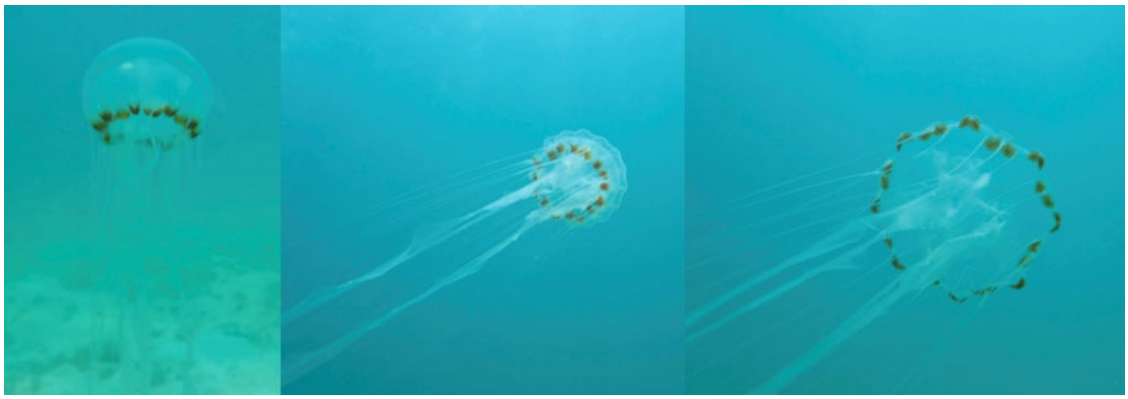

Fig. 2. Live specimen of *Chrysaora* cf. *caliparea* photographed on Qatar's coral reefs. Size of specimen ~10 cm in diameter.

with 24 tentacles (3 tentacles per octant), primary tentacle centrally sided by two secondary tentacles (Figure 4) – in one of the specimens we found a single octant with 4 tentacles. Adult exumbrella surface is finely granulated with a milky-white colouration with small brown spots and a radial pattern of 16 brownish triangles (Figure 3). Tentacles are rounded and longer in length to the oral arms reaching 1.5–2 m in extension (Figure 2). Subumbrella bears a central circular mouth followed by a central circular stomach. The mouth forms an oral tube extended by 4 long festooned arms. Arrangement of the gonadal tissue within the gastrovascular cavity shows inverted W-shaped gonads (Figure 4).

Systematics remarks and distribution

The jellyfish genus *Chrysaora* is known to occur in several parts of the world (Morandini & Marques, 2010; Jarms & Morandini, 2019). Identifying species of the genus *Chrysaora* is not an easy task, although several advances have been made with a revision of the genus (Morandini & Marques, 2010). In recent years, some new species were described, increasing the diversity in

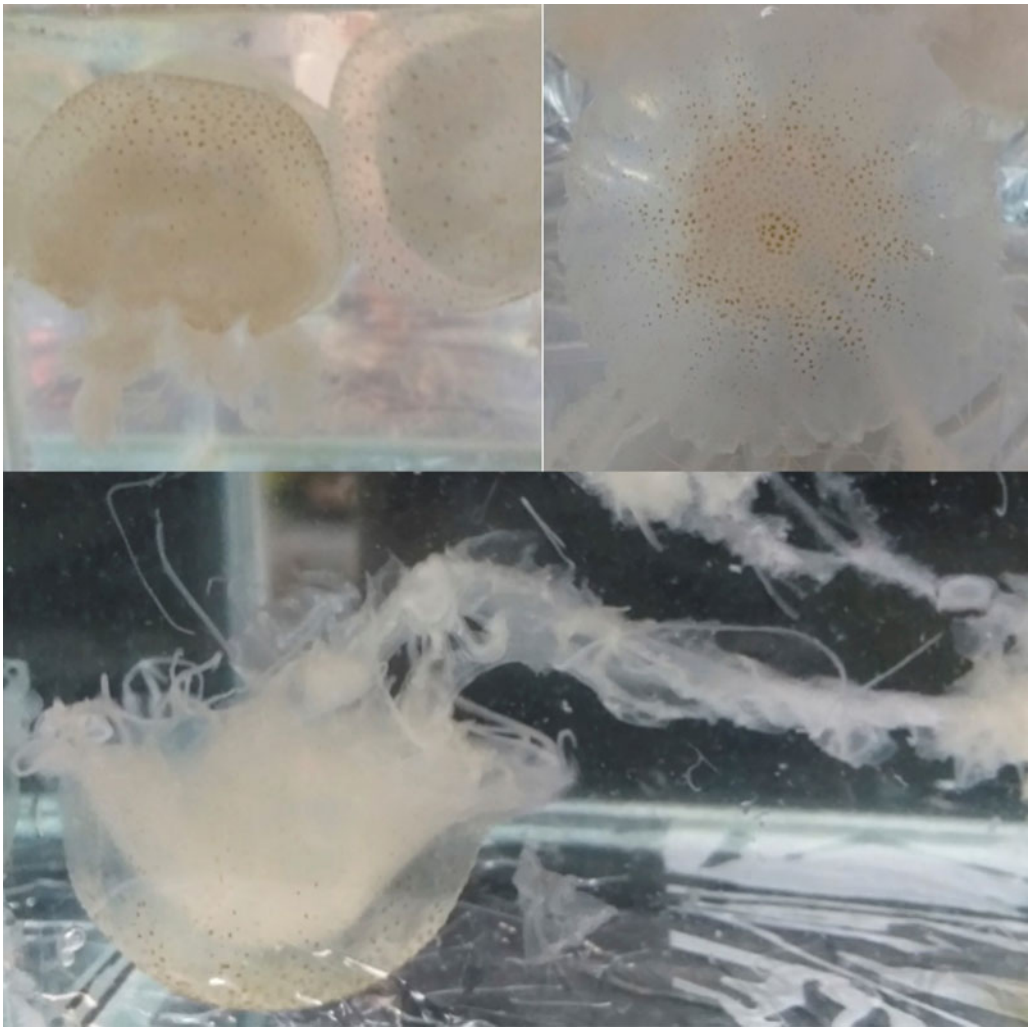

Fig. 3. Live specimen of *Chrysaora* cf. *caliparea* photographed in aquaria showing the long oral arms and the small brown spots associated with a radial pattern of 16 brownish triangles. Size of specimen ~10 cm in diameter.

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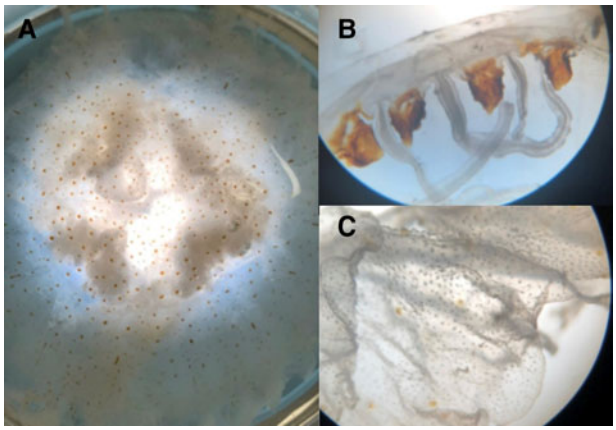

Fig. 4. Preserved specimen of *Chrysaora* cf. *caliparea*. (A) exumbrellar view showing the inverted W-shaped gonads; (B) partial lateral view showing 4 somewhat rounded marginal lappets and 3 tentacles per octant; (C) exumbrellar view near rhopalium showing finely granulated surface.

some areas (Bayha *et al.*, 2017; Mutlu *et al.*, 2020; Ras *et al.*, 2020). But little progress in pelagiids identification (especially the genera *Chrysaora* and *Pelagia*) was made in the Indian Ocean and related areas (e.g. Arabian Sea, Red Sea, Bay of Bengal, Andaman Sea). Although there are reports of such jellyfishes in those areas (Kanagaraj *et al.*, 2011; Gul & Morandini, 2013), the precise identifications still lack further confirmation based on morphological and molecular comparisons. Here we followed a conservative approach and identified our specimens as *Chrysaora* cf. *caliparea* because of similar morphological features and geographic proximity to the putative occurrence of this species (Jarms & Morandini, 2019). Thus, this is the first record of the species for the Arabian Gulf and Qatar. Pourjomeh *et al.* (2018) mentioned blooms of *Chrysaora* in the Arabian Gulf, but the authors did not identify the species at that time. We are aware that Baniasadi *et al.* (2019) reported specimens of the genus *Chrysaora* for the Iranian coast (Khuzestan and Hormozgan); the identifications are slightly confusing, but the names reported are *Chrysaora hysoscella*, *Chrysaora* sp. 1, *Chrysaora* sp. 2 and *Chrysaora* sp. 3. For sure *C. hysoscella* is a wrong identification, because this species is restricted to Mediterranean and NE Atlantic waters (Russell, 1970; Morandini & Marques, 2010). Possibly the authors misinterpreted the distinct colour patterns and different numbers of tentacles as single taxonomic units. We emphasize that only a thorough approach including detailed morphology and combining different molecular markers will help us to understand the true diversity of the genus *Chrysaora* in the Arabian Gulf waters and the world.

Sting ability

Many species of the genus *Chrysaora* are reported to cause stings (Burnett, 1991; Williamson *et al.*, 1996; Marques *et al.*, 2014; Haddad *et al.*, 2018), but most of them are not serious. On the other hand, the most harmful species of the family Pelagiidae (*Pelagia noctiluca*) can cause important problems (Mariottini *et al.*, 2008). *Chrysaora* cf. *caliparea* caused burning sensations as soon as the skin is in contact with tentacles – a similar sensation compared with *Pelagia noctiluca* from the Mediterranean Sea (Range, pers. observ.).

Systematics of Marivagia stellata

Class SCYPHOZOA Goette, 1887
Subclass DISCOMEDUSAE Haeckel, 1880
Order RHIZOSTOMEAE Cuvier, 1800
Family CEPHEIDAE Agassiz, 1862
Genus *Marivagia* Galil & Gershwin, 2010
Marivagia stellata Galil & Gershwin, 2010
Figures 5–8

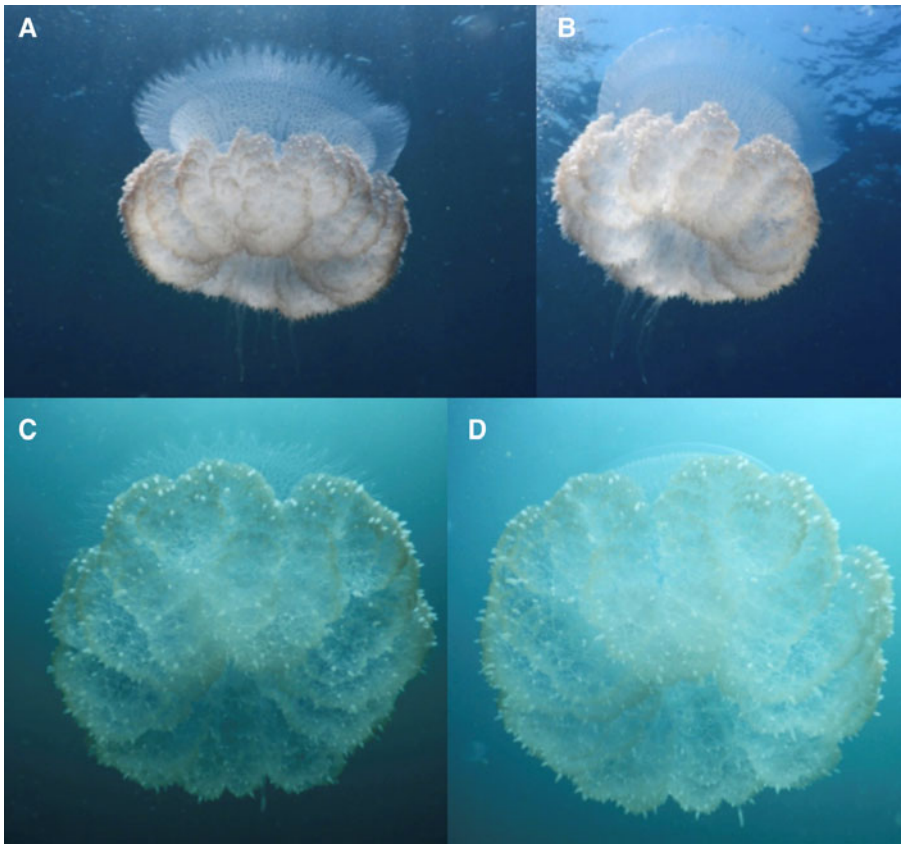

Fig. 5. Live specimen of *Marivagia stellata* photographed *in situ*. (A, B) subumbrellar view, showing general aspects of oral arms, lappets and gastrovascular canals; (C, D) subumbrellar view, highlighting the oral arms arrangement. Specimen ~20 cm in umbrella diameter.

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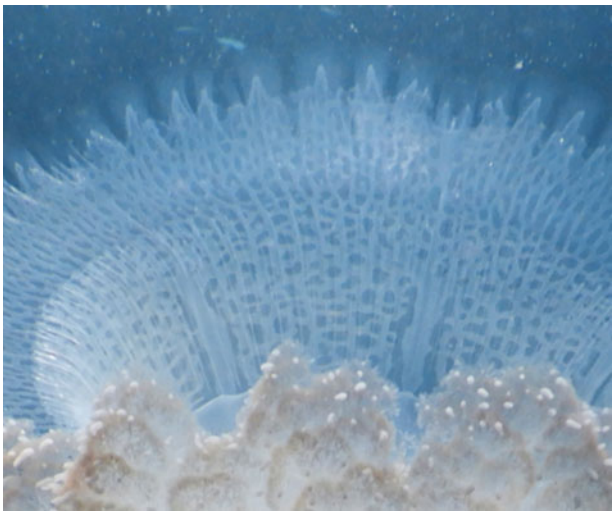

Fig. 6. Umbrella margin (subumbrellar view) of *Marivagia stellata* showing the marginal lappets, the rhopalia and the rhopaliar lappets, and also part of the gastrovascular system. Specimen ~20 cm in umbrella diameter.

Material examined

Three specimens photographed on 7 March 2020 in station J5, east of Halul Island and not collected (bell diameter 15–20 cm).

Description

Exumbrella with a low central dome, small warts and ridges (not seen in images). Specimens varying from 15–20 cm in bell diameter. Umbrella margin with 7–8 oblong-shaped, round velar lappets per octant (Figure 5). Rhopalia are associated with 2 smaller rhopaliar lappets (Figures 5 and 6). Oral arms are short and bear mouth openings with numerous tiny, pointed white short appendages (spindle-shaped) (Figures 5, 7 and 8); in the middle of the oral arms there are some longer appendages (Figures 7 and 8). Canal system is composed of 8 main radial canals (all of them reaching the rhopalia); they start to anastomose around the medial part (Figure 6); the number of secondary radial canals cannot be stated accurately due to image angles; anastomosing canals enter the marginal lappets. Colour in life is bright blue with a more milky-white colouration of the arms.

Fig. 7. Subumbrellar view of *Marivagia stellata* showing the cauliflower structure of oral arms with longer appendages at the central part. Specimen ~20 cm in umbrella diameter.

Fig. 8. Subumbrellar view of *Marivagia stellata* showing a more detailed part of the oral arms highlighting the numerous tiny, pointed short white appendages all over the arms and the longer appendages at the centre. Specimen ~20 cm in umbrella diameter.

Systematics remarks and distribution

The monotypic rhizostome jellyfish genus *Marivagia* was recently described (Galil *et al.*, 2010). Although described for the Mediterranean coast of Israel, the species *Marivagia stellata* was considered alien to that region based on the argument that the region was well studied and that a 'large native littoral species' would not be overlooked (Galil *et al.*, 2010). In fact, the reasoning of the original authors seems justified based on the finding of *M. stellata* in several other places, mostly in the Indian Ocean (Galil *et al.*, 2013; Gul *et al.*, 2014; Karunarathne & de Croos, 2020) and a few reports also in the Mediterranean (Mamish *et al.*, 2016; Bitar & Badreddine, 2019).

Similar to the genus *Chrysaora*, Baniasadi *et al.* (2019) reported specimens of *Marivagia stellata* for the Iran coast (Khuzestan and Hormozgan), thus this is the first record for Qatar.

Although the original description (Galil *et al.*, 2010) mentions that appendages were absent on the oral arms and oral disc of the species, several images from specimens collected elsewhere do show such features, as already mentioned in Karunarathne & de Croos (2020). In our observations, the specimens indeed do present small appendages (spindle-shaped) all over the arms surfaces and also longer filament-like appendages at the centre of the oral disc between the arms. Perhaps the observations of the original authors (Galil *et al.*, 2010) did not include such features because the animals were not mature enough or they were slightly damaged. In some rhizostome species (e.g. *Cotylorhiza tuberculata* and *Phyllorhiza punctata*) the presence of filament-like appendages at the centre of the oral disc is a clear sexual dimorphism character present in females (e.g. Kikinger, 1992) and is an important indication that such species brood their planula larvae.

Further studies combining different molecular markers will allow us to comprehend the geographic origin of the genus *Marivagia*.

Systematics of Catostylus perezi

Class SCYPHOZOA Goette, 1887
Subclass DISCOMEDUSAE Haeckel, 1880
Order RHIZOSTOMEAE Cuvier, 1800
Family CATOSTYLIDAE Claus, 1883

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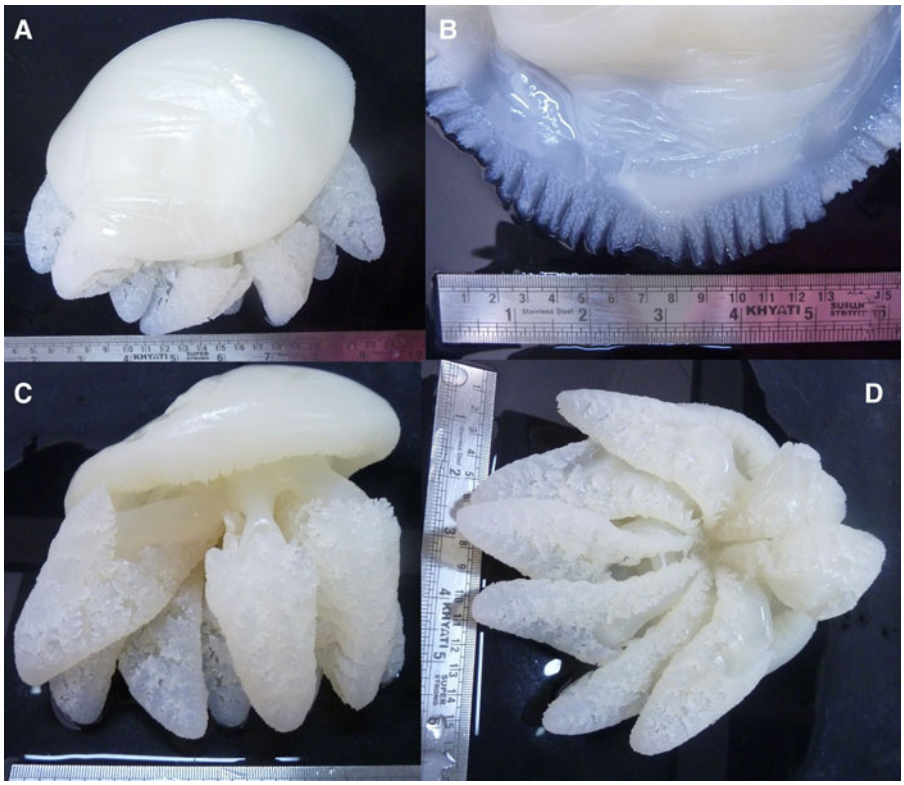

Fig. 9. Preserved specimen of *Catostylus perezi*. (A) general view of the specimen from exumbrellar side; (B) detailed view of exumbrella margin, highlighting the marginal lappets; (C) general view in lateral position, showing shape of oral arms (note absence of appendages); (D) subumbrellar (oral) view highlighting the oral arms arrangement.

Genus *Catostylus* Agassiz, 1862
Catostylus perezi Ranson, 1945
Figures 9 and 10

Material examined

Three specimens collected on 26 May 2019 at Sealine coastal station (bell diameter 13–17.5 cm).

Description

Hemispherical umbrella with central part smooth (Figures 9A and 10). Specimens varying from 13–17.5 cm in bell diameter. Umbrella margin with 10–12 oblong-shaped, somewhat pointed velar lappets per octant (Figure 9B) – some of the larger lappets divided into two; characteristically all lappets bearing numerous small elevated pointed warts on the exumbrella. Rhopalia sided by two smaller rhopaliar lappets. Oral arms are compact and short (~bell diameter in length), conical, three-winged and devoid of any kind of appendages (Figures 9C, D and 10). Wide subgenital ostia, without any structure in the aperture (Figure 10). Subumbrellar musculature continuous over the canal system (not interrupted). Gastrovascular system typical of the genus with 16 radial canals (8 rhopaliar and 8 interrhopaliar) communicating with a ring canal (located ~1/3 from bell margin), and a wide network of anastomosing canals communicating with all parts. Gonads forming a Maltese cross, but not fully developed. Live and preserved specimens white-cream in colour.

Fig. 10. Live specimen of *Catostylus perezi* photographed *in situ*, inside view. Note complete absence of appendages. Specimen ~15 cm in bell diameter.

Systematics remarks and distribution

The Scyphomedusae genus *Catostylus* is widely distributed in the Indian and Pacific Oceans (Kramp, 1970), and with a single species reported for Atlantic waters, *Catostylus tagi* Haeckel, 1869 (Kramp, 1961). The species *Catostylus perezi* is endemic to the NW Indian Ocean, mostly the Arabian Sea and Arabian-Persian Gulf (Ranson, 1945; Gul & Morandini, 2013; Riyas *et al.*, 2019). In Pakistani coastal waters the species is fished together with *Rhopilema hispidum* (Vanhöffen, 1888) and exported (Gul *et al.*, 2015*a*). The record of *Catostylus* sp. (or *C. tagi*) published by Pourjomeh *et al.* (2018) is surely *C. perezi* due to the peculiar feature mentioned below.

The morphological features observed in our specimens agree with the descriptions available for the species. It is a quite peculiar jellyfish with a unique character among the members of the genus *Catostylus* – the numerous small pointed warts at the exumbrellar surface of the velar lappets (Ranson, 1945).

Discussion

The Arabian/Persian Gulf and Qatar Pelagic Ecosystem is an extremely sensitive marine ecosystem characterized by high temperature and high salinities. Sea surface temperature (SST) ranged typically from 19–33°C in offshore waters (Rakib *et al.*, 2021) with fluctuations between 20–22°C in winter to 25–35°C in spring in the coastal zone (Rivers *et al.*, 2019). During the summer period in August and September, SST in the coastal environment of

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Doha Bay (DB station) can reach 35–36°C (Daly Yahia, pers. observ.). Salinity in Qatar's open offshore seawaters is always higher than 39 and can reach 40.9 (Sheppard *et al.*, 2010; Al-Ansari *et al.*, 2015). In coastal zones, values of 50 are regularly registered along the eastern coast of Qatar in summer and autumn (Daly Yahia, pers. observ.) and in some embayments such as the Gulf of Salwah salinities reach 70 (Sheppard *et al.*, 2010). Qatar Pelagic Ecosystem is also known to be oligotrophic with low nutrients and chlorophyll *a* concentrations (Quigg *et al.*, 2013; Wei *et al.*, 2016; Liu *et al.*, 2022). Nevertheless, the rapid economic and coastal development of the Arabian Gulf region and Qatar has led to excessive dredging, outfall discharge and organic pollution (Sheppard *et al.*, 2010; ROPME, 2013). Al-Ansari *et al.* (2015) and Al-Naimi *et al.* (2017) observations and measurements have shown that *in situ* averaged chlorophyll *a* values are less than 0.5 mg m^{-3} from March to October and range in average between 0.5–1.2 mg m^{-3} from November to February in Qatar offshore seawaters. Recent investigations in Doha Bay and Lusail (DB and L stations) recorded higher values of chlorophyll *a* at the end of the long summer period in September reaching respectively 3.02 mg m^{-3} and 2.81 mg m^{-3} (Daly Yahia, pers. observ.), highlighting a recent and drastic shift from oligotrophic to eutrophic conditions at least in the coastal environment.

Although there are some laboratory experiments with higher salinity effects on bioenergetics of scyphozoan ephyrae (Båmstedt *et al.*, 1999) and also on polyps growth and reproduction (Dong *et al.*, 2015), most of the studies focused on reduced salinity effects on polyps or medusae (e.g. Holst & Jarms, 2010; Feng *et al.*, 2018; Dong *et al.*, 2019). Nevertheless, such higher values of salinity as found at the coast of Qatar have rarely been tested on scyphistomae or medusae by very few scientists, such as Prieto *et al.* (2010) on *Cotylorhiza tuberculata* showing that the process of polyp formation is not affected by salinity within the range 20–53, while polyp survival rate dropped from 91% to 68% only when experimental salinity increased in one step from 20 to 35. Therefore, high plasticity of certain species in tolerating diel or seasonal variation of salinity (e.g. *Cassiopea*, Morandini *et al.*, 2017; Thé *et al.*, 2020) might reveal undocumented survival ability to withstand extreme environmental factors.

In this extreme and oligotrophic offshore environment scyphozoan jellyfishes seems to find excellent trophic conditions and some populations such as *Chrysaora* cf. *caliparea* seem to be well adapted, as we have spotted several individuals since October 2018 in different coastal zones such as The Pearl and Lusail and more recently a huge bloom in October 2019 at stations J2, J3 and J4. The species are aggregating every year during spring and summer, and in certain cases reach high densities in near-shore areas probably due to a combination of drifting and advection processes. Some dive clubs cancelled dives during such periods (Range, pers. observ.).

Marivagia stellata seems to be scarcer as it is the first time we spotted this species during our investigations on jellyfish since August 2018. Nevertheless this rhizostome medusa, like several species of this order, seems to feed on the rich microplankton growing in the Arabian/Persian Gulf and Qatar coastal waters using its numerous mouth openings: recent investigations on plankton diversity and abundance in the coastal environment of Doha Bay have shown that relatively high densities of microplankton (72,730 ind. $m^{-3} \pm 40{,}290$ in October 2019) and small copepods such as the cyclopoids *Oithona* spp (2638 ind. $m^{-3} \pm 821$ in October 2019), have been registered confirming the shift from oligotrophic to eutrophic coastal conditions (Daly Yahia, pers. observ.).

Recently, and more specifically in spring and summer 2020, important outbreaks of *Catostylus perezi* have been recorded by citizens and divers between Bahrain and Qatar coastal waters and densities estimated between 50–100 ind. m^{-3} over thousands of m^2 (Daly Yahia, pers. observ.). This rhizostome medusa, like other species belonging to the same order, such as *Rhizostoma octopus*, seems to be able to maintain blooms in relatively coastal shallow waters by feeding on the rich microplankton and swimming against currents (current-oriented swimming), the increasing chance of bloom survival and concentration as described by Fosette *et al.* (2015).

Knowing the biodiversity of a certain area/region – in this case the Scyphomedusae fauna – is the first step towards a better understanding of the relation of such animals with their environment. Further research might focus on studying the ecology of key jellyfish species and provide baseline data to verify pattern of occurrence and seasonality intra- and interannually. With those investigations, we will be able to comprehend blooms phenomena and explore the ecosystem services those gracious gelatinous animals can provide.

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Author contributions. M.N. Daly Yahia: conceptualization (lead), investigation (lead), methodology (lead), writing – original draft (lead), writing – review and editing (equal), data curation (lead); P. Range: resources (equal), writing – review and editing (equal): B. Welter Giraldes: resources (equal), writing – review and editing (equal); A.C. Morandini: resources (equal), writing – review and editing (equal).

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Conflict of interest. The authors declare that they do not have a conflict of interest.

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