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Records of *Versuriga anadyomene* and *Cassiopea andromeda* (Scyphozoa, Rhizostomeae) in the coastal waters of Vietnam

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Abstract
Scyphozoans are currently causing great concern because of their blooms in the marine environment. During the field surveys in Cat Ba and Hon Me islands in 2019 and Thuy Trieu lagoon in June 2020, we found rhizostome jellyfish that had rarely recorded in Vietnamese waters. These specimens had the following morphological characters: Hemispherical umbrella with reticular grooves; eight large semicircular velar lappets alternating with narrow lappets in each octant; laterally flattened mouth-arms with numerous flat, membranous branches bearing many clubs and intermediate filaments; non-anastomosed broad perradial canals and anastomosed narrow interradial canals. The morphological characters of these rhizostome jellyfish were consistent with descriptions of *Versuriga anadyomene*. In addition, the morphology of some of other jellyfish bloomed in a marine lake was consistent with those of *Cassiopea andromeda* with a broad, shallow, aboral concavity; about 19 rhopalia; 4 square lappets per paramere; oral arms round in cross section, about 1.5 times as long as bell radius; 4–6 alternate branches, bifurcated distally; 1–2 appendages stemming from the central point of the disk, plus one at the base of each pair of oral arms, plus one at distal bifurcation of each oral arm or lacking; coloration yellow-brown with white or pale spots and streaks, size of the letter different with others (bigger), ocelli not observed. This paper reported the occurrence of rare scyphozoans, *Versurigia anadyomene* and *Cassiopea andromeda* in Vietnamese waters.

Keywords: Scyphozoa, jellyfish, lagoon, marine lake.

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INTRODUCTION

The class Scyphozoa often referred to as the "true jellyfish" includes approximately 200 accepted species worldwide [1–4]. The earliest records of Scyphozoa in Vietnamese seas were made by Kramp (1961, 1962) [2, 5], followed by Omori and Nakano (2001); Nishikawa et al., (2008, 2009); Thu N. T. et al., (2009); Thu P. T. et al., (2009) [6–10].

Only 26 species of Scyphozoa, belonging to 9 families, have been recorded in Vietnamese waters. Recently, these scyphozoans have caused great concern and considered as fisheries resources which can be utilized as a food source mainly in Asia [6, 7, 10]. For example, approximately 800–1,600 tons of the processed edible jellyfish *Rhopilema hispidum* per year were sold for food in Vietnam [7, 8].

In this paper, two species of scyphozoan jellyfish collected during the field survey were described.

MATERIALS AND METHODS

Only one jellyfish specimen was collected with a hand net in Hon Me island (Thanh Hoa province) in May 2019. Ten specimens were collected with a plastic bag during snorkeling in Cat Ba island (Hai Phong) in June and November 2019, and three specimens were collected in Thuy Trieu lagoon (Khanh Hoa province) in June 2020. Jellyfish specimens were fixed with a 10% formalin-seawater (borax buffered). Underwater photographs of the medusae were taken using an Olympus TG-4 digital camera with underwater housing.

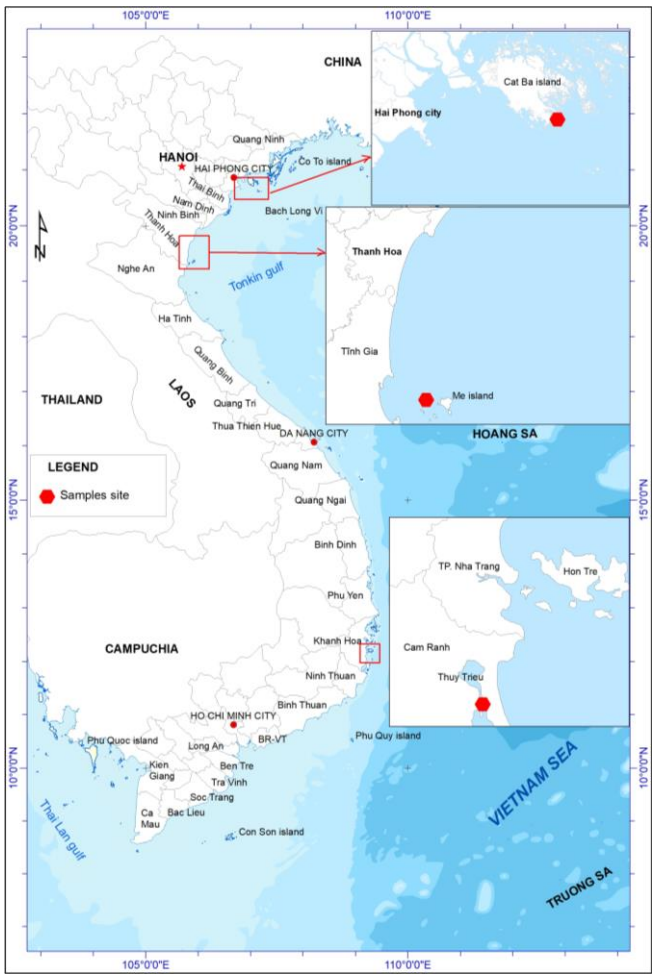

Figure 1. Location of the samplings

The fixed specimens were brought to the laboratory, and the size of jellyfish, structures of oral-arms and canals were observed under transmitted light microscope, Nikon SZM 745T. The morphological characters were examined according to the previous literatures by Mayer (1910); Kramp (1961, 1962) and Gershwin (2010) [1, 2, 5, 11, 12]. Blue ink were injected into canals to visualize the canal and other structures, if it was neccesary. Temperature and salinity at the sampling locations were measured by a thermometer (YSI Model 55) and a refractometer (Master Refractometer, Atago, Japan) respectively.

Locality: The specimens were collected in the following sites along the coastline of Vietnam.

Trat Sao marine lake - Cat Ba island (Hai Phong): 20°46'29"N - 107°04'26"E;

Tung Gau marine lake - Cat Ba island (Hai Phong): 20°47'55"N - 107°03'53"E;

Co Do marine lake, Cat Ba island (Hai Phong): 20°46'02"N - 107°03'01"E;

Hon Me island (Thanh Hoa province): 19°20'43.62"N - 105°54'17.21"E;

Thuy Trieu lagoon (Khanh Hoa province): 12°4'49.27"N - 109°10'43.18"E.

RESULTS

Cassiopea andromeda

Systematics

Class Scyphozoa Goette, 1887;

Order Rhizostomeae Cuvier, 1800;

Family Cassiopeidae Tilesius, 1831;

Genus *Cassiopea* Péron & Lesueur, 1810;

***Cassiopea andromeda* (Forskål, 1775) - figures 1–3**

Morphological characters

Bell is yellow-brown with white or pale spots and streaks; arms are also brownish with extended frilly tentacles. Usually lying upward on the bottom.

Width to 12 cm (how many individuals examined?). Disc flat, with eight short mouth-arms (figures 2A, 2C), each with four (or six) side-branches supporting many filaments and clubs (figures 2B, 2D), marginal lappet short and blunt (figure 1E, figure 3). Usually inverted and staying still on bottom but can swim.

In our observation, the mass occurrence of this jellyfish (bloom) was mainly observed at depths of 0.5–1.5 m, on a muddy-sand bottom in the marine lake of Cat Ba island. Moreover, their aggregations included about more than 10 individuals m^{-2} with different sizes, but they typically ranged between 6–15 cm in bell diameter. It seems that the upside-down jellyfish prefer warm, shallow and sheltered waters with mud or sand in the lake. Underwater photographs of the bloom were shown in figure 4.

Biology: The color due to commensal microalgae within, usually lying upward on the bottom and often mistaken as sea anemones; the host of crustacean *Hyperia galba* [13]; typically found in shallow lagoons, intertidal sand or mudflats and around mangroves [14]; also among seagrass beds [15]. Members of the class Scyphozoa are gonochoric. Life cycle: Egg is laid by the adult medusa which later develops into a free-living planula, then to a scyphistoma, to a strobila and lastly to a free-living young medusa [16].

Habitat: *Cassiopea* is typically found in shallow lagoons, intertidal sand or mudflats, and around mangroves [14]. They feed on drifting zooplankton [reference]. Individuals also harbor photosynthetic dinoflagellates that provide food for the jellyfish [reference]. The zooxanthellae live in the tissues on the bell surface of the jellyfish and the jellyfish sits on the bottom upside-down to provide sunlight for the symbiotic algae [14, 17].

Distribution: Trat Sao marine lake - Cat Ba Island (Hai Phong) 20°46'29"N - 107°04'26"E; Tung Gau marine lake - Cat Ba island (Hai Phong) 20°47'55"N - 107°03'53"E; Co Do marine lake - Cat Ba island (Hai Phong) 20°46'02"N - 107°03'01"E; Thuy Trieu lagoon (Khanh Hoa province) 12°4'49.27"N - 109°10'43.18"E.

Impact: *Cassiopea andromeda* is a nuisance and venomous species and its nematocysts may cause welts, rashes, itching, vomiting, and skeletal pains depending on the person's sensitivity to the nematocyst toxin [14].

Remark: According to Kramp (1962), a single individual of this species was collected

in the Bay of Nha Trang in 1959 by Dr. Knudsen. However, detailed description of this specimen was not carried out. This is probably the second record for a member of the Cassiopeidae from Vietnam subtropical waters. *Cassiopea* was reported to increase its spatial distribution by invading, for example, Hawaiian and Mediterranean waters [18, 19]. As invasive species are a principal threat to biodiversity and responsible for enormous economic, and especially jellyfish are known for their direct negative effect on human enterprises [20], alterations in distribution and abundance of *Cassiopea* sp. require monitoring. This suggests that anthropogenic introductions of *Cassiopea* are associated with the same mechanisms as other marine invertebrate invasions, namely hull-fouling, ballast-water release, intentional or unintentional direct release [21] and similar ecological constraints [22]. Like other introduced scyphozoans, *Cassiopea* is capable of colonizing large nearshore areas and producing problematic blooms [23]. Coastal eutrophication, habitat disturbance, and mangrove filling have been identified as leading causes in large-scale increases of *Cassiopea xamachana* in the Bojorquez Lagoon, Mexico [24]. Kramp (1970) proposed that *Cassiopea* is an evolutionarily ancient genus that originated in the Indo-Pacific and dispersed from the south of Africa into the Atlantic [25].

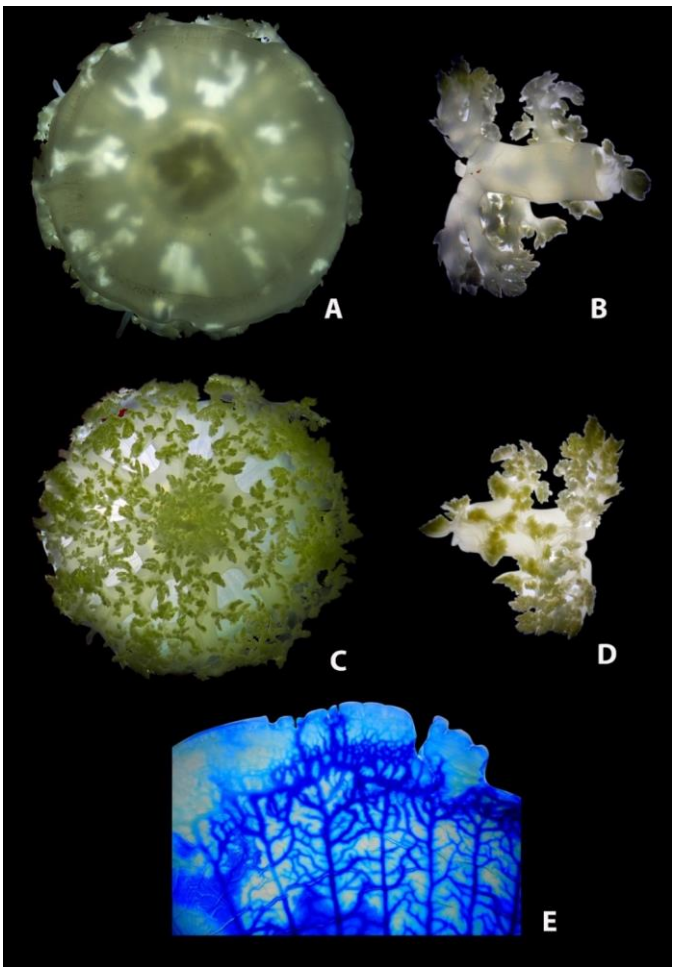

Figure 2. Cassiopea andromeda (Forsskål, 1775): A. Exumbrellar view of preserved specimen; B. Oral arms (lateral view); C. Subumbrellar view of preserved specimen; D. Oral arms from subumbrellar side; E. Ring canals and rhopalia (blue-ink injected)

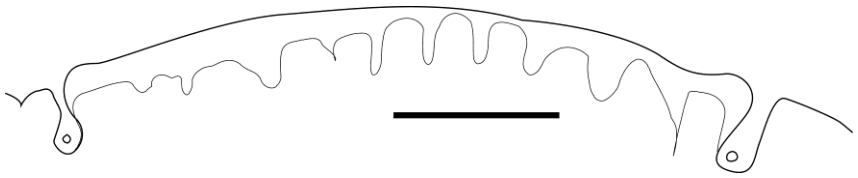

Figure 3. Valar lappets of *Cassiopea andromeda* (Forsskål, 1775), scale = 5 mm

Figure 4. Bloom of *Cassiopea andromeda* (Forsskål, 1775) in the marine lake Trat Sao in June 2019 [*Photo* taken by Tran Manh Ha]

Versuriga anadyomene

Systematics

Class Scyphozoa Goette, 1887;
Order Rhizostomeae Cuvier, 1800;
Family Versurigidae Kramp, 1961;
Genus *Versuriga* Kramp, 1961;

***Versuriga anadyomene* (Maas, 1903) - figure 4**

Morphological characters

Only one individuals examined. Figure 5 shows the morphological characters of the collected specimens. These specimens had a hemispherical umbrella, bell is hemispherical, but flat, up to 600 mm in diameter, with reticular grooves on the exumbrella surface, comprised of adjacent pointy shapes, larger and taller near the center, becoming shorter and more radially orientated toward the margin (figures 5A, 5B). The margin of the umbrella bore eight large semicircular velar lappets, alternating with narrow rhopaliar lappets in each octant (figure 5G). Oral arms were flattened laterally, with numerous flat, membranous branches bearing many clubs and intermediate filaments (figures 5E, 5F). There were 8 subumbrellar muscle fields, roughly triangular, completely divided at the perradii and interradii, with many fine circular bands and subumbrella canal structures, including non-anastomosed broad perradial canals and anastomosed narrow interradial canals.

Colour: Mesoglea translucent whitish, with exumbrellar pinky to purple reticulations near the center, fading to brown near the margin; subumbrellar muscles brown; oral arms whitish with brown mouthlets (figure 5A, 5B).

Biology: Host of a copepod *Paramacrochiron tridentatum* sp. nov. identified by Ohtsuka et al., (2020) [26].

Distribution. Hon Me island (Thanh Hoa province): 19°20’43.62”N - 105°54’17.21”E.

Impact: The *Versuriga anadyomene* has tough and rigid tissue and thus can be utilized to produce processed products [27], Further studies on the population and stock resources are needed to assess the possibility of exploiting edible products from this jellyfish.

Remarks. Our observation probably the second record of this species in Vietnam. Uncommon species, but occurred in the Beibu Gulf, China [27] and Java Sea [28].

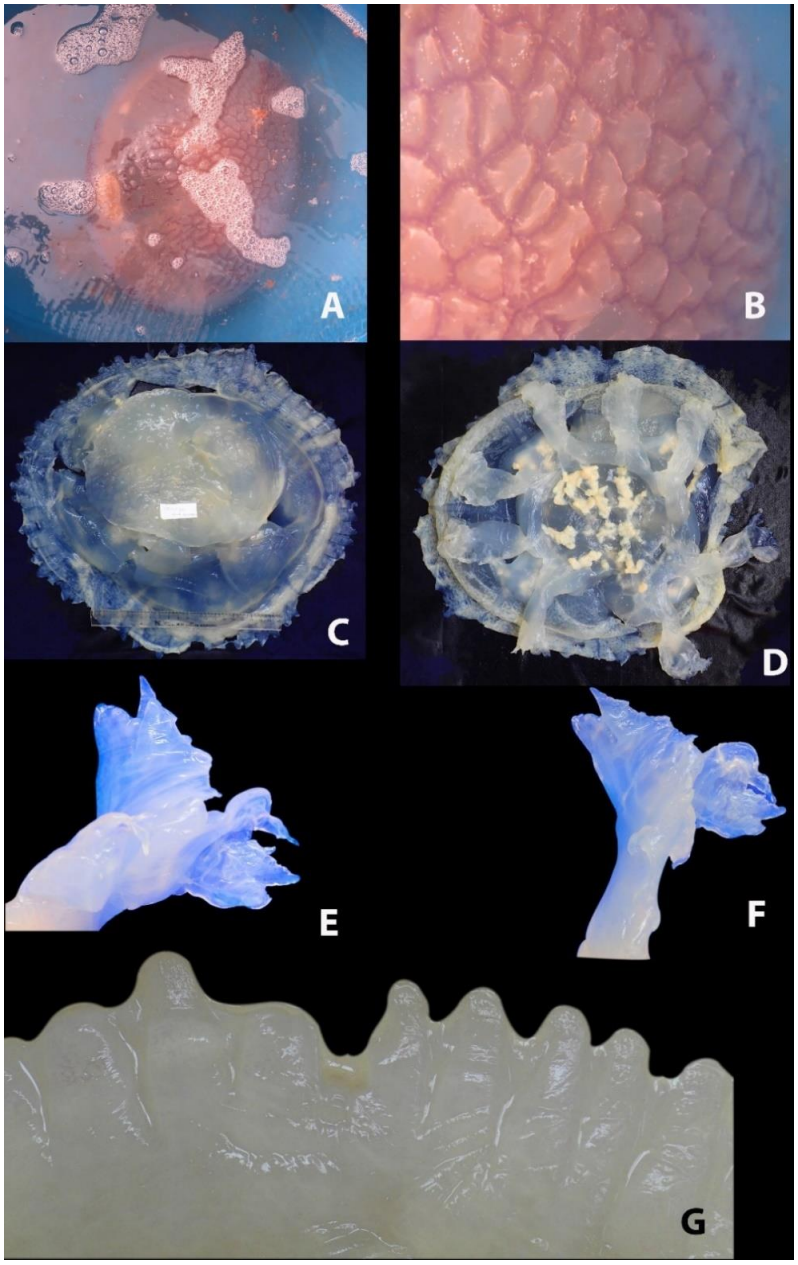

Figure 5. Versuriga anadyomene (Maas, 1903): A. Live photo; B: Papilae of exumbrellar surface; C. Exumbrella of preserved specimen (blue-ink stained); D. Subumbrellar view of preserved specimen (blue-ink stained); E. Exumbrellar view of oral arm; F. Subumbrellar view of oral arm; G. Umbrellar margin showing lappets and a rhopalium

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