



A Study on Nematocyst Types of *Chrysaora hyoscella* and *Anemonia sulcata* in the Southwest of Türkiye

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ABSTRACT

Cnidaria species possess specialized organelles called “nematocysts” used for defense and hunting. Different types of nematocysts are thought to have different functions and venom contents in prey capture. In this study, the nematocyst types of *Chrysaora hyoscella* and *Anemonia sulcata* sampled from the Muğla coastline were examined. Thirty different species of nematocysts have been identified. *C. hyoscella* individuals which were sampled 2012, only O-isorhiza, holotrichous a-isorhiza, holotrichous A-isorhiza, and heterotrichous microbasic eurytele were found. In *Chrysaora hyoscella* which sampled in 2024, O-isorhiza, holotrichous a-isorhiza, holotrichous A-isorhiza, heterotrichous microbasic eurytele, mastigophore, and spirocyst type nematocysts were detected. Microbasic p-mastigophore and spirocyst nematocyst types were found in *Anemonia sulcata* individuals. Interestingly, the mastigophores and spirocysts observed in *C. hyoscella* samples, albeit in small numbers, show that these nematocyst types can also be found in scyphozoans.

Introduction

Jellyfish, belonging to the Scyphozoa class of the Cnidaria phylum, are generally represented by a small number of species in coastal waters, but under suitable environmental conditions, they can reach high seasonal densities and biomass values, becoming dominant zooplankton organisms. They are of great ecological importance due to their significant consumption of zooplankton, their wide distribution, and their complex life cycles. In addition, they cause economic and social consequences such as clogging the cooling water systems of industrial facilities and ships, harming fishing activities, and negatively impacting recreational coastal use (Pitt and Purcell, 2009). The significant increase observed in the populations of venomous jellyfish in the oceans over the last thirty years has led to a substantial decrease in fish stocks in the Gulf of Mexico, the Sea of Japan, and the Mediterranean, resulting in a negative impact on the tourism sector (Cengiz, 2019).

Most gelatinous organisms belonging to the phylum Cnidaria live in marine environments, while only a few species are found in freshwater. Their life cycles exhibit two distinct life forms, referred to as polymorphism. These forms are the polyp and medusa stages. The polyp form, which lives attached to a surface, is immobile. Mature polyps reproduce asexually to form ephyra larvae. These free-swimming larvae complete their development and transform into medusae. Medusae, in turn, reproduce sexually to produce planula larvae. After swimming in the water column for a certain period, planula larvae attach to a suitable surface and form new polyp individuals (Boero et al., 2005).

Cnidaria species possess specialized organelles called “nematocysts” used for defense and hunting (Wiebring et al., 2010). The nematocyst, formed by the Golgi apparatus, consists of a protein capsule, a venom with a burning property, and a tightly coiled thread. When the nematocyst is contacted by mechanical or chemical stimuli, the thread penetrates the tissue at a speed of 2 meters per second and an acceleration of 40,000 g in 3 milliseconds. The thread reverses itself from the inside out and is launched at the prey. This event is one of the fastest-developing events in nature (Holstein and Tardent, 1984).

Nematocysts deliver venom by enveloping their prey, piercing it like a harpoon, or attaching to it. Different types of nematocysts are thought to have different functions and venom contents in prey capture (Peach and Pitt, 2005). Studies show that soft-bodied prey (fish eggs, etc.) are neutralized by nematocysts that are launched like a harpoon. Hard-bodied organisms (crustaceans), on the other hand, are hunted with nematocysts that have an adhesive or enveloping function (Purcell and Mills, 1988; Carrette et al., 2002; Peach and Pitt, 2005). Nematocyst toxins cause itching, redness, pain, burning, blistering, involuntary muscle contractions, cytotoxic, cardiovascular, neurotoxic effects, and even death in humans (Theoharides, 1983; Mariottini and Pane, 2010). The potential effect of Cnidaria venoms depends on the structure of the toxin, but also varies depending on the amount of venom injected, the size of the contact area and the duration of contact, the general health status and age of the victim (Jouiaei et al., 2015).

Nematocysts are mostly found in high concentrations in the tentacles, mouth arms and umbrella margins (Figure 2). Each nematocyst is used only once, and ruptured nematocysts are destroyed by adjacent cells (Mariscall, 1974). Studies by Endean and Rifkin (1975) and Burnett et al. (1986) indicated that different nematocyst types have different morphologies and different venom contents. Moriottini and Pane (2010) and Helmholtz et al. (2011) demonstrated that various venom components have different effects on organisms, identifying these effects as paralytic, neurotoxic, cytotoxic, hemolytic, dermatotoxic, and lytic. Sutton and Burnett (1969) distinguished at least ten different nematocyst types in *Chrysaora quinquecirrha*. Heeger and Möller (1987) provided information about the prey-catching properties of nematocysts in *A. aurita*. In addition, studies have been conducted on the nematocyst morphologies of *Cyanea capillata* (Östman, 1991), *C. lamarekii* (Östman and Hydman, 1997, Östman, 1991), *Pelagia noctiluca* (Avian et al., 1991; Marino et al., 2007; Marino et al., 2008), *Rhopilema nomadica* (Avian et al., 1995), *Catostylus mosaicus* and *Phyllophiza punctata* (Peach and Pitt, 2005).

Sixteen Scyphozoa species are distributed in Turkey (Mutlu and Biçer, 2021; Cengiz and Killi, 2021; İşinibilir et al., 2022; Çınar et al., 2024) and eighteen of them are alien (Çınar et al. 2024). There are very few studies on the nema-

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tocyst morphology of these species. Gülşahin (2016a; 2016b) investigated the nematocyst types of *Cassiopea andromeda* and *Chrysaora hysoscella*. Cengiz and Killi (2021) revealed the nematocyst types and morphologies of *Cotylorhiza tuberculata*, *Phyllorhiza punctata*, and *Chrysaora hysoscella*, and the relationship between bell diameters and nematocyst numbers. Killi et al. (2020) investigated the nematocyst types of *Aurelia aurita* and *Veella veella*. In the study conducted by Cengiz (2019), different nematocyst types and morphologies were found in individuals of *Aurelia aurita* sampled from different regions. Therefore, it is necessary to reveal these differences with current studies. In this study, the nematocyst types of *Chrysaora hysoscella* and *Anemonia sulcata* sampled from the Muğla coastline were examined.

Material and Methods

Anemonia sulcata individuals were collected from the intertidal zone along the Milas, Ören coastline. Five *C. hysoscella* specimens were obtained in March and April 2012 from Güllük Bay, Muğla Province, Turkey. Then one *Chrysaora hysoscella* individual was collected from the Güllük Bay, using a hand net from a boat in 2024. The specimens were brought to the Marine Biology Laboratory of the Faculty of Fisheries at Muğla Sıtkı Koçman University, where the tentacles and mouthparts were separated and stored at -18°C. Frozen samples were kept on +4°C and then stirred by homogeniser. Samples were centrifuged for five minutes on 5000 rpm. Squash preparation method was used to identify discharged and undischarged nematocysts and samples were observed on light microscope. A hundred nematocysts of per individual were selected randomly, identified and measured. Measurements of discharged and undischarged nematocyst capsules were made with using ocular micro meter at x100 objective and photographed.

Results and Discussion

Approximately, thirty different types of nematocysts have been identified (Carlgren, 1940, 1945; Cutress, 1955; Werner, 1965; Mariscal, 1974; Bauillon et al., 1986; Östman, 1983, 1997; Rifkin, 1996; Östman and Hyman, 1997), while the nomenclature of nematocysts was first made by Weil (1934). Characteristics such as thread length, the presence or absence of a shaft, the presence or absence of spiny threads, or the extension of spiny bands along the thread, the arrangement, length, and shortness of the spinies are used in the identification of nematocysts (Östman, 2000).

Isorhiza are types of nematocysts in which the spindle fiber is located in the central region within the capsule (Figure 1). The spindle fiber can be spiny (trichous) or unspiny (atrachous) (Östman, 2000). A-isorhiza is distinguished by its drop-shaped capsule and tightly packed thread inside at the distal end. The thread within the capsule appears A-shaped, hence its name. Significantly smaller than other nematocyst types, a-isorhiza has an oval capsule with regularly and horizontally packed tubules (Figure 1). The diameter of the thread varies along the length of the nematocyst.

O-isorhiza is characterized by its spherical capsule and irregularly distributed thread inside. The thread has spiral rows. The Eurytele type nematocyst is distinguished from other nematocysts by a significantly widened basal tube and a shaft at the end of an inverted thread inside (Figure 2, 3). The shaft in the unruptured capsule is clearly visible as a rod (Östman and Hyman 1997). The shaft is widened distally.

Spirocysts have a thin capsule wall, and the thread is strongly coiled. In unejected spirocysts, the thread is arranged in accordion-like folds (Östman, 2000). The stem or spines are indistinguishable.

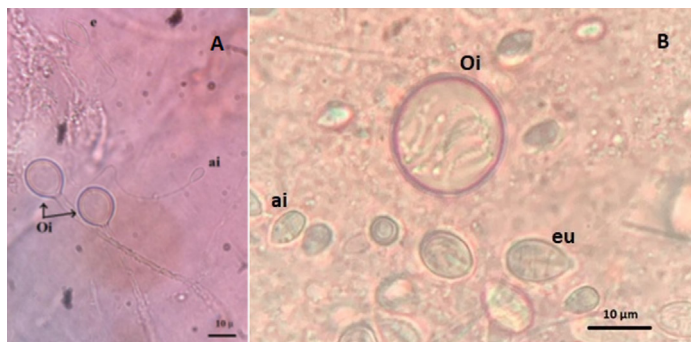


Figure 1 A) Discharged O-isorhizas (Oi) and a-isorhiza (ai), B) undischarged O-isorhiza (Oi), eurytele (eu), a-isorhiza (ai) (Photographs: Nurçin KİLLİ)

Spirocysts, like nematocysts, rotate outwards during ejaculation. Instead of spines, hollow tubules are found within the thread (Mariscal et al. 1977), and it secretes an adhesive substance (Östman, 2000). Spirocysts exhibit adhesive properties while serving both prey capture and substrate attachment. This property allows, for example, the symbiotic sea anemone *Calliactis* to adhere to shells (Mariscal, 1972; McFarlane and Shelton, 1975).

Microbasic p-mastigophores are characterized by their inverted shafts with a V-shaped notch at the end (Carlgren, 1940). b-mastigophores lack this V-shaped notch. Therefore, the shafts of p-mastigophores are wider than those of b-mastigophores. The large, narrow, elongated nematocyst capsule is also specific for the sea anemones (Östman, 2000).

Chrysaora hysoscella (Linnaeus, 1767) (Compass jellyfish)

Chrysaora hysoscella is distributed along the Atlantic Ocean and the Mediterranean coasts. In Turkey, it is found along the Marmara, Aegean, and Mediterranean coasts. The umbrella-shaped structure has 16 yellow-brown bands extending from the apex to the edge. Four long oral arms extend around the mouth, and 24 tentacles extend from the edge of the umbrella-shaped structure. *C. hysoscella* individuals which were sampled 2012, only O-isorhiza, holotrichous a-isorhiza, holotrichous A-isorhiza, and heterotrichous microbasic eurytele were found (Gülşahin, 2016). a-isorhizas and O-isorhizas were the most frequently seen in the samples and O-isorhizas had up to 18 µm in length and width. Maximum length-width of euryteles were 9-7 µm in this species (Figure 3). Length and width range of the undischarged A-isorhizas was found 13-11 and 8-6.5 micrometers, respectively. Cengiz and Killi (2021) identified five nematocyst types which were a-isorhiza, A-isorhiza, O-isorhiza, eurytele and polyspiras in *C. hysoscella*. The maximum length-to-width ratio of the euryteles was 10-6 µm, while the length and width of unexploded O-isorhizas could reach up to 20 µm. Also, the mean length and width of A-isorhiza were 6-4.5 µm, respectively. In this study, the length of unexploded O-isorhizas was found to be between 17-20 µm. Eurytele lengths varied between 7-14 µm. A-isorhizas had lengths between 5-7 µm, and a-isorhizas between 3-5 µm. The lengths of mastigophores and spirocysts varied between 70-100 µm. This shows that different nematocyst types can be prominent in number in different individuals.

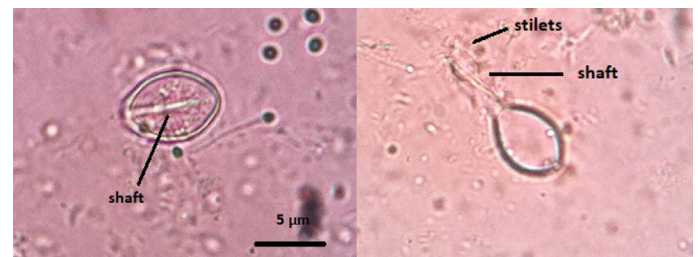


Figure 2 Undischarged and discharged eurytele in *C. hysoscella* (Photograph: Sibel CENGİZ)

In *Chrysaora hysoscella* which sampled in 2024, O-isorhiza, holotrichous a-isorhiza, holotrichous A-isorhiza, heterotrichous microbasic eurytele, mastigophore, and spirocyst type nematocysts were detected. According to Cutress (1955), mastigophores and amastigophores are not found in Scyphozoa. According to Östman (2000), spirocysts are present only in the Anthozoa. However, the mastigophores and spirocysts observed in *C. hysoscella* samples, albeit in small numbers, show that these nematocyst types can also be found in scyphozoans (Figure 4). Although we might think that spirocysts somehow adhere to *C. hysoscella* due to their adhesive properties, the spirocysts we observed were undischarged. Radwan et al. (2000) found O-isorhizas, small and large euryteles in *Chrysaora achlyos*. Calder (1977) detected a-isorhizas, A-isorhizas, anisorhizas, and euryteles in the ephyra stage of *Chrysaora quinquecirrha*, and a-isorhizas and euryteles in its polyps.

Nematocysts also vary in size among individuals (Carlgren, 1940, 1945; Schmidt, 1974; Östman and Hyman, 1997), and some are larger in larger animals (Östman and Hyman, 1997). The sizes of nematocysts also differ in specific organs and parts of organs. The same type of nematocyst can appear in several different size classes in the same organ or in different organs of the same animal (Östman, 2000). This study also demonstrated that different types of nematocysts can be found in different individuals and that their sizes also vary. Our measurements revealed that the microbasic mastigophores in *C. hysoscella* ranged in size from 55-80 µm, while the spirocysts ranged from 65-105 µm.

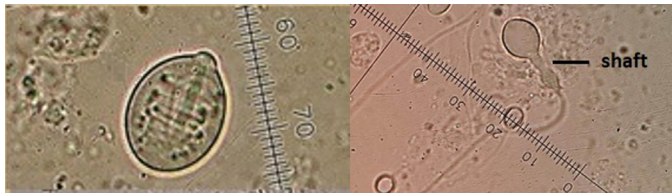


Figure 3 Undischarged and discharged eurytele nematocysts in *C. hysoscella*. (Photograph: Sibel CENGİZ).



Figure 4 Microbasic mastigophore and spirocysts in *C. hysoscella* (Photograph: Nurçin KİLLİ).

Anemonia sulcata (Pennant, 1777) (Mediterranean sea anemone)

One of the most common *Cnidaria* species of the Mediterranean coast is *Anemonia sulcata*. *A. sulcata* forms a light-dependent symbiotic relationship with photosynthetic dinoflagellate microalgae (zooxanthellae) belonging to the genus *Symbiodinium* (Stien, 2020). Microbasic p-mastigophore and spirocyst nematocyst types were found in *Anemonia sulcata* individuals (Figure 5, 6). The common actiniaria nematocysts are the p-mastigophores and the amastigophores (Östman, 2000). England (1991) distinguished microbasic mastigophores in *A. sulcata*. Godknecht and Tardent (1988) and Thomason (1991) detected two types of nematocysts in *A. sulcata*: spirocysts and microbasic mastigophores. Godknecht and Tardent (1988) measured the capsule length of microbasic mastigophores as approximately 35 µm and the thread length as 490 µm. In our study, the capsule length was found to reach 110 µm (Figure 4). The lengths of ruptured microbasic mastigophores decreased to 48 µm. Spirocyst lengths were measured to be between 20 µm and 36 µm.



Figure 5 Undischarged microbasic mastigophore (Please note that V-shaped shaft) (Photograph: Nurçin KİLLİ).



Figure 6 Spirocyst (Photograph: Nurçin KİLLİ) observations on cnidarian envenomation syndromes.

Conclusion

Nematocyst discharge, one of the fastest-growing events in the world, while potentially painful and detrimental to humans, represent defense and predation for *Cnidaria* species. Indeed, we often forget that we are merely guests in the oceans, while complaining about the true owners of these seas. Unless we properly utilize the world's resources, the negative changes and unsustainability of our oceans are inevitable. The biggest reason for the increase in *Cnidaria* species populations over the last thirty years is the human factor. Uncontrolled overfishing leads to the decline and even extinction of top predator species, and the subsequent replacement of these predators by gelatinous organisms. Furthermore, the increase in coastal structures provides suitable environments for the polyp forms of these organisms, leading to their proliferation along coastlines. Despite all this, some jellyfish species are consumed as food in countries like China, Korea, and Japan. However, in Mediterranean countries, where consumption is not a common practice, the success rate of these organisms in establishing themselves has increased with rising water temperatures. Therefore, there is a need to find alternative uses for *Cnidaria* species. In recent years, venoms isolated from nematocysts have attracted interest in cancer research. In studies of antitumor activity, *Cnidaria* compounds have been of great interest. The phylum *Cnidaria* is a large, diverse, and ecologically important group of marine invertebrates containing over 11,000 extant species. Over 3,000 marine natural products have been identified from this phylum alone, many of which have emerged in the last decade (Rocha et al., 2011). Another interesting source of *Cnidaria* species for bioprospecting is the marine aquarium industry (Rocha et al., 2011).

Statements and Declarations

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Declarations

Conflict of interest

The authors declare no conflict of interest.

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