First record of Cotylorhiza tuberculata (Macri, 1778) from the Sea of Marmara

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ABSTRACT
Jellyfishes, which are one of the most important consumers in marine ecosystems, may have detrimental effects on fish stocks that have economic value. Therefore, identifying and monitoring jellyfish presence is important. We observed four individuals of symbiotic rhizostome scyphozoan Cotylorhiza tuberculata in the vicinity of the Princes’ Islands Archipelago, in the Northeast Sea of Marmara, Turkey in September 2020. Although this species is a common member of gelatinous plankton in the Mediterranean Sea, the present study is the first record from the Sea of Marmara.

Keywords: Cotylorhiza tuberculata, rhizostomae, scyphomedusae, jellyfish, Sea of Marmara

INTRODUCTION
Jellyfishes exhibit an important role in the marine food web as predators. Despite the fact that jellyfishes are low on the evolutionary tree, they generally feed high on marine food web, directly by eating fish eggs, larvae and juveniles and indirectly by competing with fishes for food (Mills, 2001; Purcell & Arai, 2001). In the blooming season they may even cause decreased depletion of fish stocks (Bilio & Niermann, 2004). Jellyfish blooms are possibly expedited by hypoxia, eutrophication, shipping, overfishing, bottom trawling, aquaculture, increased human activity on coastal regions, and global warming (Mills, 2001; Graham & Bayha, 2008; Boero, 2013). Jellyfish blooms are known to cause economic losses in fisheries and aquaculture by damaging nets, clogging the power plant cooling systems. Jellyfish blooms are also vectors of bacterial disease in aquaculture facilities and are responsible for harmful effects on tourism and human health (Ferguson et al., 2009; Nunes et al., 2015). Therefore, having knowledge of the exact distribution of jellyfish species is vital to draw up a strategy to prevent further damages.

In the Mediterranean Sea, there are six rhizostome jellyfish species. Among these jellyfishes, three of them are symbiotic, including Cotylorhiza tuberculata (Astorga, Ruiz, & Prieto, 2012). Symbiosis gives some advantages, such as nutrient support. This allows growth to be less dependent on the conditions of the surrounding environment for the zooxanthellae jellyfish. Furthermore, some fish species such as Salpa salpa and Trachurus trachurus use the tentacles of C. tuberculata as a habitat with the aim of protection and food supply (Öztürk et al., 2018).

C. tuberculata conclusively exhibits an intense top-down control on the food chain by selective feeding on diatoms, ciliates, larvae of some mollusks, and copepods (Pérez-Ruzafa et al., 2002). Individuals of this species are commonly found in a high quantity in the Aegean Sea (Balk, 1973; Kikinger, 1992), the Mediterranean Sea (Pérez-Ruzafa et al., 2002) and the Adriatic Sea (Benovic & Lucic, 2001). After being reported for the first time in Izmir Bay, in the Aegean Sea (Balk, 1973), this jellyfish has been recorded in different regions of the Aegean coast of Turkey (e.g. Gulsahin & Tarkan, 2013) and even in the vicinity of the Strait of Çanakkale (Alparslan, Doğu, & Özalp, 2011). The key
identifying characteristics of \( C. \) \( tuberculata \) are a flattened area throughout its margin and a cupola at the center of its bell which makes it look like a large fried egg from its dorsal side (see photos below). It also has lots of tentacles that have different lengths enclosing its eight lappets. Its numbers of tipped appendages with different colors ranging from bluish to purple are located between each of the oral arms. These oral arms are fragile, short and fused proximally and are typically eight in numbers in this species (Kikinger, 1992). The presence of unicellular symbiotic algae (i.e. zooxanthellae) give these colours to the jellyfishes. The medusae have sexual dimorphism, and instead of releasing individual sperm, it spawns spermatozeugmata. There is internal fertilization with embryogenesis which occurs inside the female oral arm canals. The life period of the medusae is generally about half a year due to decomposition of somatic tissue. The zooxanthellae-bearing medusae are potentially autotrophic and the only stage in the metagenetic cycle of the species that has no zooxanthellae is planula. The scyphistomae contain algal symbionts infection (Kikinger, 1992). Its size is generally up to 35-40 cm in diameter (Kramp, 1961). The present paper reports the first records of \( C. \) \( tuberculata \) from the Sea of Marmara.

The Sea of Marmara is an inland sea which constitutes a transition region between the Black Sea and the Mediterranean Sea through the Straits of Istanbul and Çanakkale. Due to the constant two-layered water system, the Sea of Marmara plays a pivotal role in biodiversity of the seas that it connects. In the last decade, the Sea of Marmara has been exposed to heavy changes that induce jellyfish bloom and mucilage generation. In the beginning of 1990, the ctenophore \( M. \) \( leidyi \) was introduced into the Sea of Marmara and it damaged all ecosystems drastically (Isinibilir, Tarkan, & Kideys, 2004). Since then, \( B. \) \( ovata \), \( C. \) \( hysoscella \), \( L. \) \( tetraphylla \), \( A. \) \( vitrina \) and other alien jellyfish species have been introduced to the region, respectively (İnanmaz, Bekbolet, & Kıdeyş, 2002; Isinibilir, Yılmaz, & Piraino, 2010; Yılmaz, Isinibilir, Vardar, & Dursun, 2017). Recent studies have proved that the numbers of jellyfishes have been growing in the Sea of Marmara lately (İnanmaz, Yılmaz, Isinibilir, Vardar, & Dursun, 2017).

**MATERIALS AND METHODS**

On September 24th 2020, we observed and photographed four individuals of \( C. \) \( tuberculata \) (Figure 1) at about 1-2 m depth in the vicinity of the Büyükada, the Princes’ Islands, in the Sea of Marmara, while scuba diving (Figure 2). The umbrella diameters of specimens were estimated as 30 cm and the sea surface temperature was 22°C.

**RESULTS AND DISCUSSION**

\( C. \) \( tuberculata \) was first reported in the Mediterranean Sea by Macri in 1778. In recent decades, it has been occurring in exceedingly high abundance in some areas, particularly in the enclosed coastal areas and sub-basins of the Mediterranean Sea (Astorga, Ruiz, & Prieto, 2012). The main reason for the increasing number is warmer winter temperatures due to global warming (Prieto, Astorga, Navarro, & Ruiz, 2010). Although this species is a common member of gelatinous plankton in the Mediterranean Sea, the present study is the first record from the Sea of Marmara. The introduction of this species, which is already present in the

**Figure 1.** Live specimen of \( C. \) \( tuberculata \) in the Sea of Marmara (Photograph: Doğan Uğurlu).

**Figure 2.** Sampling location of \( C. \) \( tuberculata \).
Aegean Sea, presumably occurred either through the lower layer currents of the Çanakkale Strait or via the transportation of the ballast water from adjacent waters. There are two possible reasons why any polyps have not been found in the studies carried out in the Marmara Sea so far. It could be either due to C. tuberculata polyps’ small size or their cryptic life habit even though the polyps persist longer than the more visible medusae (Prieto, Astorga, Navarro, & Ruiz, 2010). The presence of jellyfishes in great size in diameter could be explained by the fast size increase in C. tuberculata, which is more significant than the size increase in other rhizostome jellyfishes (Kikinger, 1992).

Jellyfishes are known as crucial consumers in all marine ecosystems, and thus they play an important role by reconstituting zooplankton communities (Mills, 2001). Their diet affects various fish species directly and indirectly (Brodeur, Suchman, Reese, Miller, & Daly, 2008). The Sea of Marmara is determined as a eutrophic sea (Tufekci, Balkis, Beken, Ediger, & Mantikci, 2010). High zooplankton abundance allows for a fast growth rate and large individuals of Cotylorhiza tuberculata (Kikinger, 1992). Moreover, eutrophic conditions in the Sea of Marmara may also lead to the occurrence of medusae in great sizes. Fast temperature increases in waters of the Marmara Sea have been occurring in the last several decades (Turan & Gurlek, 2016). Since C. tuberculata is a species that easily blooms in mild winters and long summers (Ruiz, Prieto, & Astorga, 2012), rising sea water temperature could precipitate its bloom in the Sea of Marmara. It has been reported in the studies conducted in the Sea of Marmara that some jellyfishes caused a shift in the temporal regime between jellyfish-dominated systems and crustacean-dominated systems, have caused the depletion of zooplankton, and have ultimately collapsed commercially important fish stocks (Yilmaz, 2015; Yilmaz & Isinibilir, 2016). Cotylorhiza tuberculata consume the microplanktonic food effectively until late autumn, when the degradation begins to occur because of the decreased photosynthetic process by reduced daylight period. Therefore, sub-umbrellar muscles weaken and decreased mesoglea flexibility leads to a reduction in the umbrellar pulsations thus reducing the food capture capacity of oral arms (Kikinger, 1992). In any C. tuberculata bloom event in the Sea of Marmara, we may observe a similar diet pattern which causes a reduction in the zooplankton community. As a consequence of increased jellyfish populations, fisheries and economies might be affected worldwide (Richardson, Bakun, Hays, & Gibbons, 2009). The Sea of Marmara is the second most important fisheries ground for Turkey (Yilmaz, Akay, & Gumus, 2008). Therefore, any increasing effects on jellyfish populations could cause detrimental impacts on fisheries (Yilmaz & Isinibilir, 2016). In conclusion, monitoring the abundance and distribution of C. tuberculata in the Marmara Sea, which is considered to be a biological corridor or transition region between the Mediterranean and the Black Sea, is vital to understand better the changes it may cause in the pelagic food web.

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Ethics committee approval: The authors declare that this study does not include any experiments with human or animal subjects.

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REFERENCES

1. Alparslan, M., Doğu, S. & Özalp, B. (2011). Importance of Jellyfishes and Their Distribution around the Çanakkale Strait. In Workshop on Jellyfish and Other Gelatinous Species in Turkish Marine Waters 20-21 May 2011 (p. 78). ISBN: 978-975-8825-27-1

2. Astorga, D., Ruiz, J. & Prieto, L. (2012). Ecological aspects of early life stages of Cotylorhiza tuberculata (Scyphozoa: Rhizostomeae) affecting its pelagic population success. In Jellyfish Blooms IV (pp. 141-155). Springer, Dordrecht. [CrossRef]

3. Balk, S. (1973). Izmir Körfezi’ye Cıvavında Bulunan Deniz Analarının (Scyphozoa, Coelenterata) Taksonomik ve Ekolojik Özellikleri Üzerine Araştırmalar. - Ege Üniversitesi Fen Fakültesi İlim Raporları, s. 179: 1-15, İzmir.

4. Benovic, A. & Lucic, D. (2001). Jellyfish outbreaks: natural cycle or stress response effect. In Gelatinous zooplankton outbreaks: theory and practice. CIESM Workshop Series, Monaco, Vol. 14, pp. 59-63. Retrieved from https://ciesm.org/catalog/index.php?article=1014 (accessed 02.02.20)

5. Bilio, M. & Niermann, U. (2004). Is the comb jelly really to blame for it all? Mnemiopsis leidyi and the ecological concerns about the Caspian Sea. Marine Ecology Progress Series, 269, 173-183. [CrossRef]

6. Boero, F. (2013). Review of jellyfish blooms in the Mediterranean and Black Sea. General Fisheries Commission for the Mediterranean. Studies and Reviews, 92(1).

7. Brodeur, R. D., Suchman, C. L., Reese, D. C., Miller, T. W. & Daly, E. A. (2008). Spatial overlap and trophic interactions between pelagic fish and large jellyfish in the northern California Current. Marine Biology, 154(4), 649-659. [CrossRef]

8. Ferguson, H., Delannoy, C., Nicolson, J., Sutherland, D., Crumlish, M. & Hay, S. (2009). Jellyfish as vectors of bacterial disease for farmed fish. Nature Precedings, 1-1. [CrossRef]

9. Graham, W. M. & Bayha, K. M. (2008). Biological invasions by marine jellyfish. In Biological invasions (pp. 239-255). Springer, Berlin, Heidelberg. ISBN 978-3-540-77375-7 [CrossRef]

10. Gulsahe, N. & Tarkan, A. N. (2013). Seasonal distribution of Scyphozoa (Cnidaria) and Ctenophora species in Gökova Bay, Mugla, Turkey. Rapp Comm int Mer Médit, 40, 538.

11. İnanmaz, O. E., Bekbolet, M. & Kideys, A. E. (2002). A new scyphozoan species in the Sea of Marmara: Chrysaora hysoscella (Linné, 1758). In: Proceedings of 3rd International Symposium on Nature, Environment, and Science, İzmir. Academic Research Publishing, 179-185. [CrossRef]

12. Isinibilir, M., Tarkan, A. N. & Kideys, A. E. (2004). Decreased levels of the nitrogenous compounds (NH3, NO2, NO3) in the zooplankton during jellyfish-dominated systems in the Aegean Sea, presumably due to the jellyfish C. tuberculata (Macri, 1778). Acta Hydrobiologica, 48(2), 141-152. [CrossRef]

13. Isinibilir, M., Tarkan, A. N. & Kiraz, S. (2009). On the introduction of a new jellyfish species, Cotylorhiza tuberculata (Macri, 1778), into the Sea of Marmara. Aquatic Invasions in the Black, Caspian, and Mediterranean Seas. Ankara, Turkey, TÜBITAK, pp. 857-859.

14. Isinibilir, M., Tarkan, A. N. & Kideys, A. E. (2004). Decreased levels of the nitrogenous compounds (NH3, NO2, NO3) in the zooplankton during jellyfish-dominated systems in the Aegean Sea, presumably due to the jellyfish C. tuberculata (Macri, 1778). Acta Hydrobiologica, 48(2), 141-152. [CrossRef]

15. Inanmaz, Ö. E., Bekbolet, M. & Kideys, A. E. (2002). A new scyphozoan species in the Sea of Marmara: Chrysaora hysoscella (Linné, 1758). In: Proceedings of 3rd International Symposium on Nature, Environment, and Science, İzmir. Academic Research Publishing, 179-185. [CrossRef]

16. Kramp, P. L. (1961). Synopsis of the medusae of the world. In: Mediterranean Sea. General Fisheries Commission for the Mediterranean. Reports of the Working Group on Aquatic Invasions in the Black, Caspian, and Mediterranean Seas (pp. 141-155). Springer, Dordrecht. ISBN 978-1-4020-2152-7 [CrossRef]

17. Kramp, P. L. (1961). Synopsis of the medusae of the world. In: Mediterranean Sea. General Fisheries Commission for the Mediterranean. Reports of the Working Group on Aquatic Invasions in the Black, Caspian, and Mediterranean Seas (pp. 141-155). Springer, Dordrecht. ISBN 978-1-4020-2152-7 [CrossRef]

18. Kikinger, R. (1992). Cotylorhiza tuberculata (Cnidaria: Scyphozoa)-Life history of a stationary population. Marine Ecology, 13(4), 333-362. [CrossRef]

19. Kramp, P. L. (1961). Synopsis of the medusae of the world. In: Mediterranean Sea. General Fisheries Commission for the Mediterranean. Reports of the Working Group on Aquatic Invasions in the Black, Caspian, and Mediterranean Seas (pp. 141-155). Springer, Dordrecht. ISBN 978-1-4020-2152-7 [CrossRef]
Macrì, D.S. (1778). Nuove osservazioni intorno la storia naturale del polmone marino degli antichi. Retrieved from: http://books.google.it/books?id=wJw-AAAAAcAAJ&printsec=frontcover&dq=inauthor:%22Saverio+MACRI%22&hl=it&sa=X&ei=vFi5UYrAJ8Ku7Ab.Jk4H4BA&ved=0CEAQ6AEwAg#v=onepage&q&f=false (accessed on 02.10.2020).

Mills, C. E. (2001). Jellyfish blooms: Are populations increasing globally in response to changing ocean conditions? Hydrobiologia, 451(1-3), 55-68. [CrossRef]

Nunes, P. A., Loureiro, M. L., Piñol, L., Sastre, S., Voltaire, L. & Canepa, A. (2015). Analyzing beach recreationists’ preferences for the reduction of jellyfish blooms: Economic results from a stated-choice experiment in Catalonia, Spain. PloS one, 10(6), e0126681. [CrossRef]

Öztürk, B., Topaloğlu, B., Sumen, S.G., Turan, C., İşinibilir, M., Aktaş, Ş. & Özen, Ş. (2018). Jellyfish of the Black Sea and Eastern Mediterranean Waters. Turkish Marine Research Foundation (TUDAV) Publication No.48, Istanbul, Turkey pp. 75. ISBN 978-975-8825-40-0

Pérez-Ruzafa, A., Gilabert, J., Gutiérrez, J. M., Fernández, A. I., Marcos, C. & Sabah, S. (2002). Evidence of a planktonic food web response to changes in nutrient input dynamics in the Mar Menor coastal lagoon, Spain. In Nutrients and Eutrophication in Estuaries and Coastal Waters pp. 359-369. Springer, Dordrecht. ISBN 978-90-481-6123-2 [CrossRef]

Prieto, L., Astorga, D., Navarro, G. & Ruiz, J. (2010). Environmental control of phase transition and polyp survival of a massive-outbreaker jellyfish. PloS one, 5(11), e13793. [CrossRef]

Purcell, J. E. & Araújo, M. N. (2001). Interactions of pelagic cnidarians and ctenophores with fish: a review. Hydrobiologia, 451(1-3), 27-44. [CrossRef]

Richardson, A. J., Bakun, A., Hays, G. C. & Gibbons, M. J. (2009). The jellyfish joyride: causes, consequences and management responses to a more gelatinous future. Trends in ecology & evolution, 24(6), 312-322. [CrossRef]

Ruiz, J., Prieto, L., & Astorga, D. (2012). A model for temperature control of jellyfish (Cotylorhiza tuberculata) outbreaks: A causal analysis in a Mediterranean coastal lagoon. Ecological Modelling, 233, 59-69. [CrossRef]

Tüfekçi, V., Balkis, N., Beken, Ç. P., Ediger, D., & Mantikci, M. (2010). Phytoplankton composition and environmental conditions of the mucilage event in the Sea of Marmara. Turkish Journal of Biology, 34(2), 199-210.

Turan, C., & Gürlek, M. (2016). Climate change and biodiversity effects in Turkish Seas. Natural and Engineering Sciences, 1(2), 15-24. Turan, C., & Gürlek, M. (2016). Climate change and biodiversity effects in Turkish Seas. Natural and Engineering Sciences, 1(2), 15-24. [CrossRef]

Yılmaz, I. N. & Isinibilir, M. (2016). Zooplankton of the Sea of Marmara. The Sea of, 376.

Yılmaz, I. N. (2015). Collapse of zooplankton stocks during Liriope tetraphylla (Hydromedusa) blooms and dense mucilaginous aggregations in a thermohaline stratified basin. Marine Ecology, 36(3), 595-610. [CrossRef]

Yılmaz, I. N., Isinibilir, M., Vardar, D. & Dursun, F. (2017). First record of Aequorea vitrina Gosse, 1853 (Hydrozoa) from the Sea of Marmara: a potential invader for the Mediterranean Sea. Zoology in the Middle East, 63(2), 178-180. [CrossRef]

Yılmaz, S., Akay, A. S. & Gümüş, E. (2008). Fisheries sector in Turkish economy and marketing of fishery products. J Akdeniz Univ Agric Fac, 21(2), 265–272.