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RESEARCH ARTICLE

Recent Record of *Oceania armata* and Near-Past Records of Other Gelatinous Organisms in the Turkish Waters Presumably Derived by Basin-Scale Current

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Abstract: The present study reports the occurrence of *Oceania armata* in the Turkish Levantine Sea, and presents evidence to support a hypothesis established to link an increased recent and near-past records of many gelatinous zooplankton species in the Turkish seas, and particularly in the Turkish Levantine Sea to specific Mediterranean basin-scale currents (Atlantic-Ionian Stream and the Mid-Ionian Jet). One worldwide-distributed oceanic cnidarian specimen was collected from the surface water of a location of 36.59002° N and 29.02471° E by a SCUBA diver on January 18, 2019 in the eastern Mediterranean Sea. The hydrozoan specimen was then identified as *O. armata* and recorded for the first time in the Turkish Mediterranean coast and only second time in the Levant coast after about 30 years. This is the second report of the species from the Turkish waters, and the first report was from the Turkish Aegean coast. Recently, new records of the gelatinous species have increased from the Turkish marine coasts; Sea of Marmara, Aegean Sea, and Levantine Sea. Most of them are distributed in the West Mediterranean Sea, but are also present in the Adriatic Sea (East Mediterranean Sea). In the Mediterranean Sea, one branch of the Atlantic current (Atlantic-Ionian Stream) enters the eastern basin via the Mid-Ionian Jet, linked with the southern Adriatic current. Therefore, it is possible that zooplankton could have entered East Mediterranean by the Atlantic current through West Mediterranean.

Anahtar kelimeler:

Yeni kayıt
Hydrozoan
Zooplankton
Türk Levantin Denizi
Basen ölçekli akıntı

Oceania armata Türünün Türk Sularındaki Muhtemel Havza Ölçekli Akıntı Kaynaklı Son Kaydı ve Diğer Jeli Organizmaların Yakın Geçmişteki Kayıtları

Öz: Bu çalışma Türk Levantin Denizi'nde *Oceania armata* bulunurluğu rapor etmek, ve son ve yakın geçmişte Türk denizlerinde, özellikle Türk Levantine Denizinde birçok jeli zooplankton türlerinin artan kayıtları ile Akdeniz havza ölçekli akıntılar (Atlantik-Iyonyan akıntısı ve Orta-Iyonyan jet akıntısı) arasında bağlantı olduğu hipotezini desteklemek amaçı için ön görülmüştür. 18 Ocak 2019 tarihinde ve 36.59002° N and 29.02471° E koordinat noktasının yüzey suyundan SCUBA dalgıçı tarafından dünyada yaygın olan oseanik cnidarian bireyi toplanmıştır. Bu hydrozoan bireyi, *O. armata* olarak tanımlanmış ve Akdeniz'in Türk suları için ilk defa ve Levantin Denizi için 30 yıl aradan sonra kayıt edilmiştir. Bu, Türk suları için ikinci kayıttır ve ilk kayıt Ege Denizi'nin Türk sularından verilmiştir. Son zamanlarda, Türk deniz sularından (Ege Denizi, Marmara Denizi ve Levantin Denizi) jelli organizmaların yeni kayıtları artmaktadır. Bu türlerin birçoğu Batı Akdeniz'de dağılmaktadır ve Doğu Akdeniz'e ait Adriyatik Denizi'nde bulunmaktadır. Akdeniz'de Atlantik akıntısının bir dalı (Atlantik-Iyonyan akıntısı), Adriyatik akıntısı ile bağlantılı olan Orta-Iyonyan jet akıntısı ile doğu havzasına girmektedir. Bu yüzden, Batı Akdeniz boyunca yer alan Atlantik akıntısı ile zooplanktonun Doğu Akdeniz'e girebilme olasılıkları vardır.

Introduction

The Mediterranean Sea hosts a rich and diverse marine life that is comparatively well-studied (Vasilakopoulos et al., 2017). Although it is considered to be a biodiversity hotspot (Coll et al., 2010), it is under increasing threat from pollution, over-exploitation and climate change (Cuttelod et al., 2009). The eastern Mediterranean Sea is well open to the new records of marine organisms, specifically the gelatinous organisms. In the Eastern Mediterranean, biodiversity is also threatened by invasive alien species including the gelatinous organisms (Galil, 2007). These gelatinous alien species span most animal phyla and have created new communities altering the Mediterranean ecosystem (Coll et al., 2010); for instance, a new medusa species, *Chrysaora pseudoocellata* Mutlu,

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Tulay, Olguner & Yılmaz 2020 has recently been established in the eastern Mediterranean Sea (Mutlu et al., 2020; Douek et al., 2020).

The zooplankton, especially gelatinous organisms can be easily drifted by water currents. This may suggest that there could be a relationship between the current direction and occurrence and transportation of the zooplankton in space as atmospheric-oceanographic relation is in progress to shift and change the regime (Vasilakopoulos et al., 2017). Currents are one of the ways to introduction of a zooplankter living in a known marine environment to another suitable area for potential establishment (Mutlu et al., 2020; Mutlu and Özvarol, 2022).

Recently, new introductions of zooplankton, especially gelatinous zooplankton which are common in the West Mediterranean Sea and the Atlantic Ocean have been recorded in the Turkish marine coasts (Table 1).

Table 1. Near-past records of gelatinous zooplankton in the Turkish marine coasts

Taxa	Regions	Citations
One ctenophore	Bosporus exit to Black Sea	Öztürk et al., 2011
Sixteen hydrozoans, One scyphozoan	Sea of Marmara	İşinibilir et al., 2015a, b; 2019
One hydrozoan	Sea of Marmara	Yılmaz et al., 2017
Two scyphozoans, One hydrozoan, One thaliacean	Sea of Marmara	İşinibilir et al., 2022
Two hydrozoans	Aegean Sea	Gülşahin et al., 2013, 2016
One hydrozoan	Northernmost Aegean Sea	İşinibilir et al., 2021
One lobat ctenophore	Turkish water	Gülşahin and Türker, 2017
One new scyphozoan	Levant Sea	Mutlu et al., 2020
One lobat ctenophore	Levant Sea	Gokoglu and Galil, 2020
One cydippid ctenophore	Levant Sea	Mutlu and Özvarol, 2022
Two eumedusoid hydrozoans, One lobat ctenophore	Levant Sea	Mutlu and Karaca, 2022

A hydrozoan medusa, *Oceania armata* Kölliker, 1853 was recorded in the Turkish Aegean coast (Gülşahin et al., 2016). Type locality of *O. armata* is the Mediterranean and additionally the species overspread coasts of Senegal and Gambia, Canary Islands, Cape Verde, Azores, Portugal, Spain; West Indies; Japan, New Zealand, Tasman Sea extending northernmost to Portugal in European waters (Mayer, 1910). Previous Mediterranean occurrences of *O. armata* were reported from the Tyrrhenian Sea and the Adriatic Sea (Madin, 1991). Last records of *Oceania armata* in the eastern Mediterranean waters were reported from the Adriatic Sea (Lučić et al., 2009), Egyptian waters (Dowidar, 1983), Lebanese waters (Goy et al., 1991) and the Aegean Sea as a basin sea of the Mediterranean Sea (Gülşahin et al., 2016).

In the Mediterranean Sea, one branch of the Atlantic current (Atlantic-Ionian Stream) enters the eastern basin via the Mid-Ionian Jet, linked with the southern Adriatic current (Fig. 1 in Poulain et al., 2013). Therefore, it is possible that zooplankton enter the East Mediterranean by the Atlantic currents through West Mediterranean. For instance, in recent sample collections in 2019 June/July, two hydrozoans, *Gastroblasta raffaelei* Lang, 1886 and *Podocorynoides minima* (Trinci, 1903) were observed for the first time for the Turkish Mediterranean coast, and the Levantine Sea (Mutlu and Doğukan, 2022), and a ctenophore species, *Hormiphora plumosa* M. Sars, 1859 as well (Mutlu and Özvarol, 2022). Recently, a copepod species from the Adriatic Sea has been found in the Turkish Mediterranean coast (Güler Sıla Duman, pers. comm., Akdeniz University, unpublished data).

However, *O. armata* has occurred no longer in the Levantine and eastern Mediterranean Sea excluding the Adriatic Sea. The present study was aimed to report occurrence of *O. armata* in the Turkish Mediterranean coast, and to alert either its succession from the Aegean Sea to the eastern Mediterranean Sea, or transportation of the Adriatic species via the Atlantic current entering the eastern basin via the Ionian jet linked with the southern Adriatic current with enhancement of near-past records of the other gelatinous zooplankton.

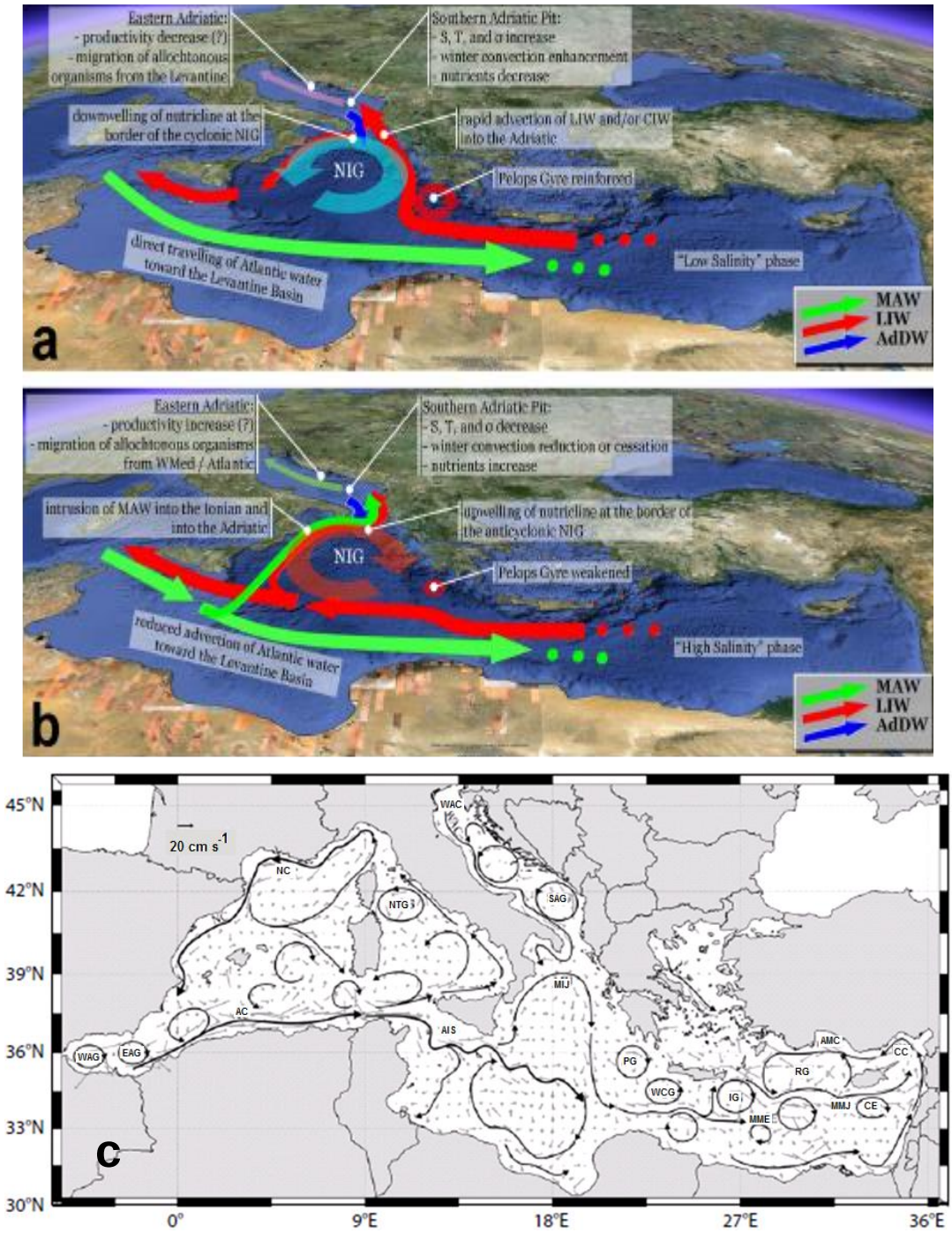

Figure 1. Formation and influence of the cyclonic Northern Ionian Gyre (NIG); (a) anticyclonic NIG (b) derived by the Adriatic–Ionian BiOS interaction (MAW; the Modified Atlantic Water, LIW; Levantine Intermediate Water, and AdDW; Adriatic Dense Water) (from Civitarese et al., 2010), and Mediterranean Sea surface geostrophic circulations and currents (c) measured by the drifters, and then schematized by Poulain et al. (2013)

Material and Methods

During an acoustic survey along the Turkish Mediterranean coast during December 2018-January 2019, a medusa specimen was captured from the surface waters at the location 36.59002° N and 29.02471° E by a SCUBA diver on January 18, 2019 (Fig. 2). The specimen was then preserved in a borax-buffered 3% formaldehyde on board of R/V '*Akdeniz Su*'.

The specimen was identified following the descriptions for the specimen diagnosed by Mayer (1910), Madin (1991) and Schuchert (2004). Bell shape and form, number of marginal tentacles, number and shape of lips, nematocyst warts, and gonad and manubrium locations in subumbrella were taken into consideration for the identification of the specimen. Furthermore, bell height and diameter were measured under a microscope.

During the survey, either physical, chemical and optical environmental parameters were measured on site or water samples were collected for future analysis. Physical parameters measured using a multi-parameter probes (YSI, HiTech) included temperature, pH, and salinity and optical and chemical parameters were Secchi depth, NO_2+NO_3, NH_4, and PO_4, SiO_2, chlorophyll *a* and TSM (Total suspended matter). One liter of the water was filtered through CF/C for each of the nutrients and TSM and through CF/F filters for chl *a*, and then all of filtered water and filters was stored at -20 ºC until measurement.

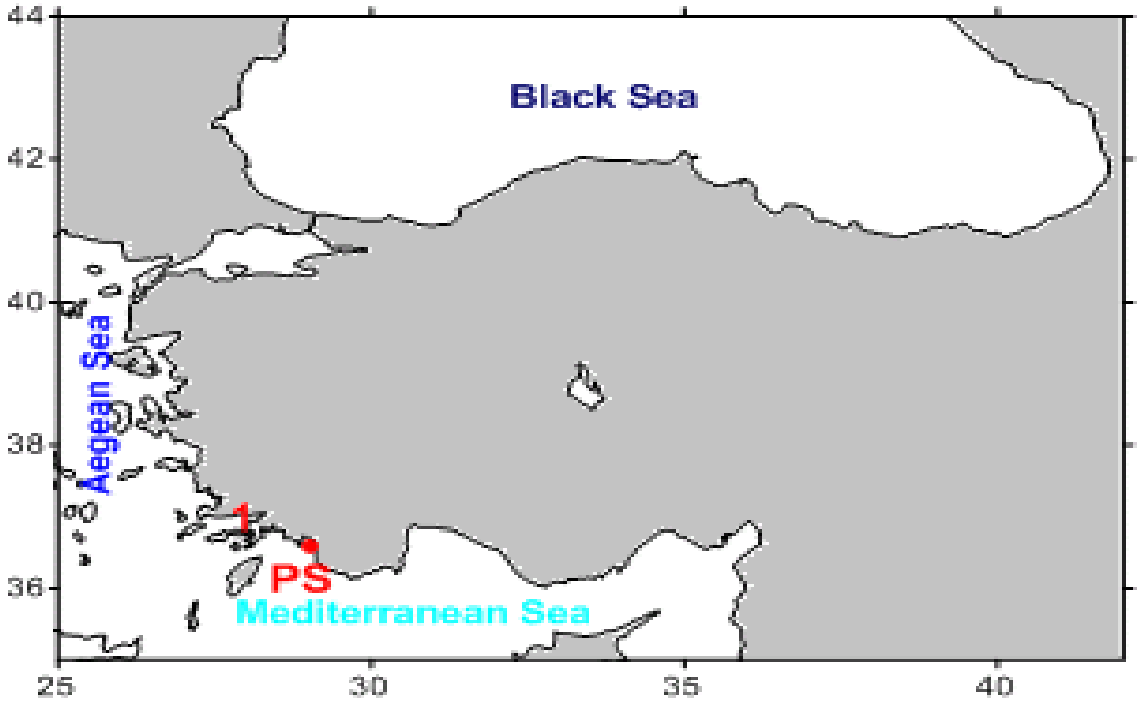

Figure 2. Locations of occurrence of *Oceania armata* along the Turkish Aegean coasts (1; Gelibolu cove in Gökova Gulf (Gülşahin et al. 2016), and in the Turkish Mediterranean Sea PS; present study, red dot)

In the laboratory, the nutrients were measured following the standard procedures: Ammonium (mg NH_4/l), nitrate (mg NO_3/l), nitrite (mg NO_2/l), phosphate (mg PO_4/l), and silicon dioxide (mg SiO_2 /l) were measured using the methods of 4500-NH_4 B, 4500 $N0_3$-E, 4500 $N0_2$-B, 4500-P E, and 4500-SiO 2 Silica, respectively (APHA, 1999). Total suspended solids (material was dried in an oven at 60 ºC for 24 h, and then weighed before the weight of the dried membrane was subtracted from the total dry weight), and chlorophyll *a* (chl-*a*) using a method described by Lorenzen (1967). Secchi disk depth was recorded once at each station.

Results and Discussion

Physical parameters of sea surface waters of the sampling station (PS) were as follows: temperature 18.1 ºC, salinity 38.8 PSU, oxygen 9.56 mg/l, and pH 9.01. Chemical and optical parameters are given in Table 2. Environmental data, especially salinity and nutrient levels indicated effects of the cyclonic and anticyclonic NIG derived by the Adriatic–Ionian BiOS interaction on the northern Levantine Sea (particularly the present study area) as discussed below.

The specimen was identified as *Oceania armata* with the following description: The bell diameter was 5 mm, and the bell height was about 5 mm. Diameter of the bell was identical to bell height measurement. The entire jelly tissue bell was thin. The marginal tentacle count was 84 in total and the tentacles tapering were double-rowed. The bell shape was pyriform, not in a complete hemisphere with flat bell-top. The species had 4 slender radial canals joining manubrium and a simple ring canal. Number of the lips on mouth was 4, they were large and curved extending to the middle of the bell in the subumbrella, and nematocyst warts in knob-shape of sphere fringed the lips on margin of the mouth (Fig. 3).

Genus *Oceania* differs from the genus *Turritopsis* by having stalked nematocyst clusters along the mouth (Schuchert, 2004). Stefano Piraino (pers. comm.) stated differences between genus *Turritopsis* and *Oceania* medusae as follows: "Large *Turritopsis* and *Oceania* medusae resemble each other quite closely. Both have large cells at the proximal end of their radial canals which are continued along the manubrium as four perradial ribs, resembling claws that clasp the manubrium. *Oceania* differs from *Turritopsis* in having stalked nematocyst clusters along it mouth, while they are without a distinct stalk in *Turritopsis*. In addition, the manubrium base of *O. armata* is somewhat constricted. This allows distinguishing even badly preserved material (Kramp, 1965)".

Table 2. Seafloor depth (depth), Secchi disk depth (SDD), temperature (T), salinity (S), pH (pH), dissolved oxygen (Ox), chlorophyll-*a* (chl-*a*), total suspended matter (TSM), and the essential nutrients of the sea surface (prefix S) and near-bottom waters (prefix N) of the stations (PS, Fig. 2) where the gelatinous species was found

Variables	PS
Depth (m)	20
SDD (m)	12
ST (ºC)	17.6
NT (ºC)	17.5
SS (PSU)	38.9
NS (PSU)	38.8
SpH	8.99
NpH	8.98
SOx (mg/l)	9.35
NOx (mg/l)	9.65
SChl-*a* (µg/l)	0.299
STSM (mg/l)	0.058
NTSM (mg/l)	0.071
$SSiO_2$ (µM)	48.81
$NSiO_2$ (µM)	32.06
SNO_2+NO_3 (µM)	1.87
NNO_2+NO_3 (µM)	6.26
SNH_4 (µM)	193.42
NNH_4 (µM)	323.60
SPO_4 (µM)	8.37
NPO_4 (µM)	12.93

Up to now, a specimen of *O. armata* has not been recorded for the Turkish coast of the Levantine Sea, and the Mediterranean Sea (Çinar et al., 2014). *Oceania armata* was recently recorded from the Turkish coastal waters, being previously found along the Turkish coast (Gelibolu cove in Gökova bay) of the Aegean Sea (Gülşahin et al., 2016). The present study showed that succession of *O. armata* was extended to the Turkish Mediterranean coast.

Recently, new introductions of zooplankton, especially gelatinous zooplankton which were common in West Mediterranean Sea and the Atlantic Ocean increased in the Turkish marine coasts; the Sea of Marmara in 2019-2021 (İşinibilir et al., 2019, 2022), the northernmost Aegean Sea in 2021 (İşinibilir et al., 2021), the Levantine Sea in 2018-2020 (Mutlu et al., 2020; Gokoglu and Galil, 2020; Mutlu and Özvarol, 2022; Mutlu and Karaca, 2022; Guler Sıla Duman, pers. comm, Akdeniz University). Such increases in recent introductions may be associated with the Bimodal Oscillating System, BiOS (Civitarese et al., 2010). The BiOS has changed the flow direction of the North Ionian Gyre (NIG) from cyclonic to anticyclonic circulation, or vice versa, once every 10 years, depending on the severe winter condition and convection (Civitarese et al., 2010; Poulain et al., 2013). This change in the NIG induced circulation of the Atlantic current based on decadal time scale. The Ionian jet pumped the waster toward the East Mediterranean (Poulain et al., 2013) as the NIG became cyclonic circulation creating upwelling linked with the Southern Adriatic current. Therefore, the decadal NIG stimulated physicochemical hydrograph and ecosystem to change in the eastern Mediterranean Sea (Civitarese et al., 2010). The first NIG induced by the BiOS was noticed in 1988, followed by 1998, and 2008-2009 (Civitarese et al., 2010; Poulain et al., 2013). Occurrence of the recent intensive new introductions of the zooplankton in the Turkish marine coasts during 2018-2020 (İşinibilir et al., 2019, 2021; 2022; Mutlu et al., 2020; Gokoglu and Galil, 2020; Mutlu and Özvarol, 2022; Mutlu and Karaca, 2022) was well coincided with the repetitive mechanism of the BiOS as the NIG turned to the cyclonic circulation every ten years. This could explain a reason of presence of relatively less saline waters, and high-concentrated nutritional waters during the present study (Table 2), and in summer in 2019 (surface water salinity of 37.4-37.6 PSU, and the nutrients; NO_2+NO_3 of 0.30-0.51 µM, NH_4 of 43.9-67.2 µM, and PO_4 of 1.41-3.39 µM) during a study by Mutlu and Karaca (2022). In 2019, summer nutrients could be relatively low as compared to that in winter because of the primary production (chl-*a*, Table 2) occurred in the spring. Summer salinity in the present study area reached up to 39.9-40 PSU in 2010-2011 (Mutlu et al., 2022), and 2014-2015 (de Meo et al., 2018) when the concentrations of the nutrients were relatively low (Mutlu et al., 2022; de Meo et al., 2018) compared to that in 2019 (Mutlu and Karaca, 2022).

A new record of a ctenophore species, *Hormiphora plumosa* which is common in the Tyrrhenian Sea and Adriatic Sea (Madin, 1991; Batistić et al., 2007) has recently been reported for the Levantine Sea from the same location of the present study where *O. armata* occurred simultaneously (Mutlu and Özvarol, 2022). In the Mediterranean Sea, one branch of the Atlantic current enters the eastern basin via the Ionian jet in connection with the southern Adriatic current (Poulain et al., 2013). Thus, it is highly possible that *O. armata* could enter the eastern Mediterranean by the Atlantic currents through the western Mediterranean as postulated for *H. plumosa* by Mutlu and Özvarol (2022).

Civitarese et al. (2010) and Poulain et al. (2013) concluded that flow and circulation direction of the decadal NIG was stimulated by the weather conditions, increasing severity of winter condition recently developed in the global scale of the atmosphere in time. In conclusion, near-past records of the gelatinous and copepod zooplankton were well coincided with decadal regime of the basin-scale water current in the Mediterranean Sea.

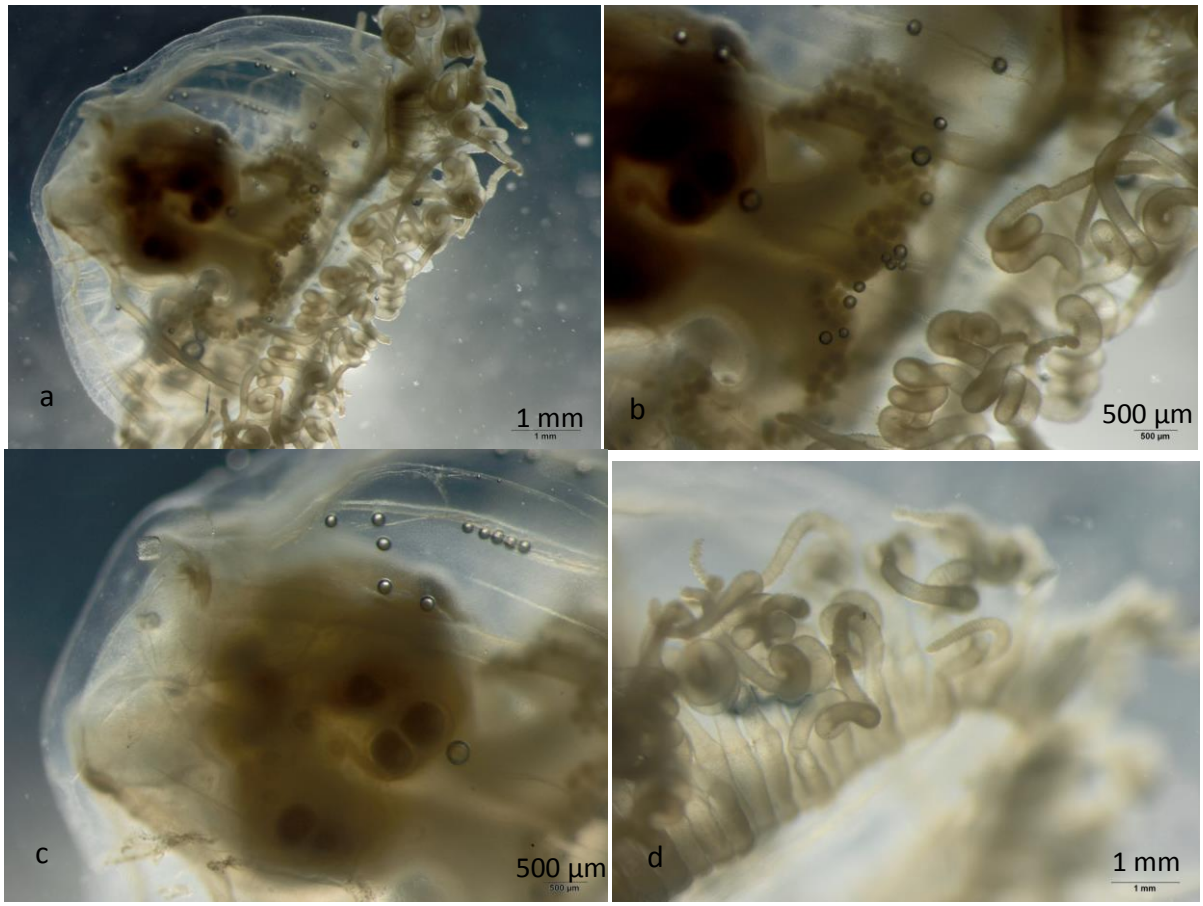

Figure 3. Lateral view of *Oceania armata* specimen preserved in the formalin solution (a), mouth lips fringed by the sphere nematocyst cluster (b), manubrium and gonad (c), and marginal tentacles of the umbrella (d)

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Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

All authors contributed to the preparation of the manuscript.

Ethics Approval

Ethics committee approval is not required for this study.

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