

Re-occurrence of the invasive jellyfish *Phyllorhiza punctata* von Lendenfeld, 1884 in the coast of Egypt and spreading pattern in the Mediterranean

Fedekar MADKOUR¹, Nourhan ELNAGAR¹ and Nurçin KILLI^{2*}

1. Marine Science Department, Faculty of Science, Port Said University

2. Basic Science Department, Faculty of Fisheries, Muğla Sıtkı Koçman University, Muğla, Turkey

* Corresponding author, N. Killi, E-mail: nurcinkilli@mu.edu.tr

In memory of Fedekar MADKOUR...

Received: 30. September 2020 / Accepted: 08. February 2021 / Available online: 05 December 2021 / Printed: December 2021

Abstract. The Australian spotted jellyfish *Phyllorhiza punctata* is native to the southwestern Pacific and was introduced to the western tropical Atlantic by the mid-20th century. *Phyllorhiza punctata* first appeared in the Mediterranean off the Israeli coast in 1965. Since then, it has been reported at various coastal waters along the Mediterranean either as few specimens or recently as swarms, especially in the western basin. The first record of *P. punctata* in the Mediterranean was in 1991 on El-Arish coast from Egypt. After this record, this species was reported on November 28, 2018 in Port Said, on the southeastern Mediterranean coast of Egypt, in this study. Therefore, this record confirms the re-occurrence of this species in Egypt coasts and reveal the spreading pattern of *P. punctata* in the Mediterranean.

Key words: Alien species, Australian spotted jellyfish, Scyphomedusae, southwestern Mediterranean

Introduction

The Australian spotted jellyfish, *Phyllorhiza punctata* von Lendenfeld, 1884 (Cnidaria: Scyphozoa: Rhizostomeae) is a tropical species native to the southwestern Pacific. It was first described from Port Jackson, eastern Australia (von Lendenfeld 1884). Then it was recorded from Hawaii during 1941-1945 (Devaney & Eldridge 1977), San Diego, California in 1981 (Larson & Arneson 1990) and Philippines (Heeger et al. 1992).

By mid-twentieth, *P. punctata* have invaded several tropical and subtropical areas of the Atlantic Basin. The species is thought to have been transported as a result of shipping via Panama Canal to form established populations in several places in the western Atlantic Ocean (Silveira & Cornelius 2000). The invasion of *P. punctata* into the western Atlantic was documented in a chronological sequence with no direct evidence of either the translocation routes, source populations, or the mechanisms by which the translocation has occurred (Bolton & Graham 2004). The species was first observed off the coast of SE and S Brazil in 1955 by Moreira (1961) but wrongly described as a new species: *Mastigias scintillae*. Years later, it was collected from the northeastern coast off Bahia by Mianzan & Cornelius (1999) who revised the name considering *Mastigias scintillae* as synonymous with *P. punctata*. Again, many sightings were reported along the southern coasts of Paraná and Santa Catarina (Haddad & Nogueira 2006) and in the northeast (Ceará) (Morandini et al. 2006).

Phyllorhiza punctata was first recorded in the Caribbean Sea in Laguna Joyuda, Puerto Rico by Cutress (1971), and its population got established there after 1980's (Garcia 1990, Garcia & Durbin 1993). In 1993, it appeared in the northern Gulf of Mexico in isolated bays along the Louisiana coast (Graham et al. 2003). Subsequently, it invaded the Indian River Lagoon on the Atlantic coast of Florida in 2001 (Graham et al. 2003). Finally, *P. punctata* was recorded for the first time in Laguna de Mandinga, on the southwestern Gulf

of Mexico as a single specimen in 2006. Between 2007 and 2008, three adult specimens were collected and later between 2009 and 2010, a great number of juveniles and adults were observed (Ocaña-Luna et al. 2010). Since then, no reports have been published to document the occurrence of this species in the Atlantic Ocean.

Since the opening of the Suez Canal in 1869, several Red Sea Lessepsian migrants have invaded the Mediterranean Sea (Por 1978). During the last decade, the three alien Scyphomedusae species (*Cassiopea andromeda* Forsskål 1775, *Rhopilema nomadica* Galil Spanier & Ferguson, 1990 and *Phyllorhiza punctata*) have been observed on several coasts of the Mediterranean Sea (Galil et al. 1990). *Cassiopea andromeda* Forsskål 1775 is the first known Lessepsian Scyphomedusa that entered the Mediterranean Sea via the Suez Canal (Galil et al. 1990). The large stinging Lessepsian jellyfish species, *R. nomadica* is considered a highly invasive species with probably the largest mass occurrences in different parts of the Mediterranean Sea (Madkour et al. 2019). These records, together with the expansion of *C. andromeda* (Özbek & Öztürk 2015) and *P. punctata* (Galil et al. 2009, Gueroun et al. 2015), show that the biodiversity of the Mediterranean Sea has been changing since the establishment of alien jellyfish species.

On the Egyptian coast of the Mediterranean Sea, the invasive Scyphozoan species, *R. nomadica* was reported in mass aggregation from Port Said coast during 2015-2017 (Madkour et al. 2019) while *P. punctata* was recorded from El-Arish coast in 1986 (Atta 1991). In the present study, we record the re-occurrence of *P. punctata* in the Egyptian Mediterranean Sea at Port Said.

Material and Methods

Four specimens of *P. punctata* were found stranded on the beach at Port Said, on the Egyptian coast of the Mediterranean Sea (31°27'N 32°30'E) (Fig. 1) on 28 November 2018. The medusae of jellyfishes were preserved in 4% formalin for identification following Mayer



Figure 1. Sampling location on the Egyptian Mediterranean coast at Port Said.

(1910) and Kramp (1961). Surface seawater temperature and salinity values of the collected location were measured using the Multi-probe device (Aquaread AP 5000).

Results

The stranded medusae of *P. punctata* were found in association with *R. nomadica* bloom. The umbrellas of the observed specimens were nearly semi-spherical with average bell diameter of 45.3 cm (ISD: 4.3). The exumbrella had white crystalline inclusions, giving the appearance of spots. It had eight thick branching oral arms with rounded ends. The medusae were brown colored (Fig. 2) which seems to be a characteristic pattern found in tropical and subtropical jellyfishes (Djehri et al. 2019). Surface seawater temperature was 21°C and the salinity 39 psu.

From the available literature, it was possible to construct a chronological map for the invasive dispersal of *P. punctata* in the Mediterranean (Fig. 3). This species was first recorded

in the eastern Levantine province as a single specimen collected from the coast of Israel in 1965 (Galil et al. 1990), followed by three specimens from the most eastern Egyptian coast at El-Arish in 1986 (Atta 1991). The jellyfish did not persist in the eastern Levantine basin and disappeared for many years until it reappeared again on the Israeli coasts as few specimens collected off Shikmona in 2005 and 2006, in addition to another 12 specimens collected off Ashdod in 2009 (Galil et al. 2009). The ephyrae and medusae of *P. punctata* were recorded in the Ionian coast of Greece between 2005 and 2006 (Abed-Navandi & Kikinger 2007). In 2009, this species was recorded from Sardinia, Italy (Boero et al. 2009) and İskenderun Bay, Turkey in 2010 (Çevik et al. 2011). A year later in 2011, a swarm of *P. punctata* was encountered in Sülüngür Lake which is inside of Köyceğiz-Dalyan Lagoon System, on the southern Aegean coast of Turkey by Gülşahin & Tarkan (2012) while one adult specimen was observed in the coastal waters of Lattakia Port in Syria by Durgham (2011). Later on, the species was recorded in the western Mediterranean from the lagoon of Bizerte, Tunisia (Gueroun et al. 2015). Recently, small swarms were sighted at different localities off the northeast coast of the island of Malta in 2016 (Deidun et al. 2017). Supporting information to Figure 2 is provided in Table 1.

Discussion

The pathway of entry of the tropical jellyfish *P. punctata* into the Mediterranean Sea is unknown and has not been evidenced. However, the first appearance in the eastern Levantine basin suggests the entry from the Red Sea via the Suez Canal (Galil et al. 1990). The first record of the species in 1965 (Galil et al. 1990), was followed by a long temporal gap before its subsequent occurrence in different location in the Mediterranean. The disappearance of *P. punctata* from the Mediterranean for some years could be related to the fact



Figure 2. The Australian spotted jellyfish, *Phyllorhiza punctata*, stranded specimens on the coast of Port Said, Egypt (photos by Nourhan Elnagar).

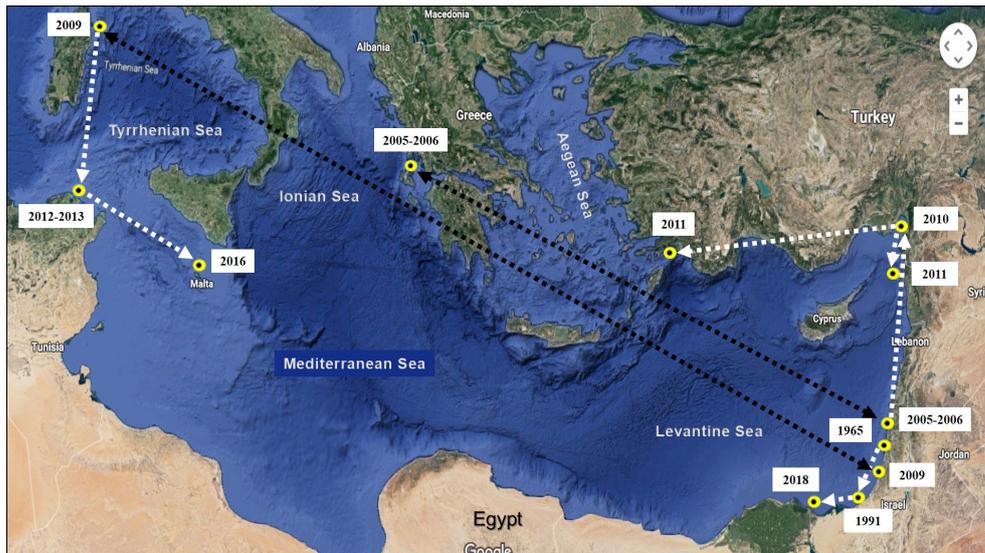


Figure 3. Hypothesized spreading pattern of *Phyllorhiza punctata* throughout the Mediterranean Sea since its first appearance in 1965 to date with the new records in the Egyptian coast. Key: black arrows refer to simultaneous sightings; white arrows refers to suggesting route for successive chronological existence.

Table 1. Records of *Phyllorhiza punctata* in the Mediterranean Sea (as plotted in Figure 3).

Coastal zone	Location	Regional sea	Sighting date	Population status	Published reference
Israel	Beit Yanai	Levantine	1965	Single specimen	Galil et al. 1990
Egypt	El-Arish	Levantine	July 1986	3 specimens	Atta 1991
Greece	Bay of Vlyho, Lefkada	Ionian	September 2005, 2006	Many specimens (ephyrae, adult)	Abed-Navandi & Kikinger 2007
Israel	Shikmona	Levantine	January 2005	Single specimen	Galil et al. 2009
	Kiryat Yam, Haifa Bay		Oct. 14, 2006	2 specimens	
	Ashdod		July 27, 2009	Many specimens	
Italy	Sardinia	Tyrrhenian	2009	Single specimen	Boero et al. 2009
Turkey	Bay of İskenderun	Levantine	Oct. 24, 2010	Single specimen	Çevik et al. 2011
Syria	Lattakia Port	Levantine	August 9, 2011	Single specimen	Durgham 2011
Turkey	Sülüngür Lake	Aegean	Sep. 27, 2011	Outbreak (adult)	Gülşahin & Tarkan 2012
Tunisia	Bizerte lagoon	Tyrrhenian	Aug. 15, 2012	1 ephyra, 2 juveniles	Guerron et al. 2015
			Sep.-Nov. 2012.	Outbreak (adult)	
			Aug.-Oct. 2013	Outbreak (adult)	
Malta and Italy	Salini salt pans	West Med. Ionian	Oct.-Nov. 2016	Several specimens	Deidun et al. 2017
	Gulf of Taranto		July 2011	Single specimen	
Egypt	Port Said Port	Levantine	Nov. 28, 2018	4 specimens	Present study

that it does not form any swarms. Since some of the jellyfish species blooms every year in the same locations while others bloom randomly (Gülşahin & Sağdıç 2016). *P. punctata* has a symbiotic relationship with the zooxanthellae (Garcia & Durbin 1993) which causes some morphological differences in jellyfish. For example: Australia, Caribbean and western US populations have zooxanthellae and are brown colored while Gulf of Mexico population has no symbionts and no color (Bolton & Graham 2004). Jellyfish take energy from zooxanthellae by photosynthesis and give housing and nutrient to these symbionts. However, in the absence of symbionts, *P. punctata* consumes copepods and other zooplankton (Graham et al. 2003). One of the differences between zooxanthellate and non-zooxanthellate jellyfish is the ability of forming bloom. Zooxanthellate jellyfishes generally do not form bloom like as non-zooxanthellate jellyfishes because it is thought that symbiosis with zooxanthellae limits jellyfish pulses to catch the prey (Dawson & Hamner 2009).

In addition, alien species are seen incidentally if they do

not form any aggregations. Citizen science is therefore required to follow this alien jellyfish. For example, *P. punctata* was recorded recently for the first time in Libya by Rizgalla & Crocetta (2020) via social data shared by a fisherman.

From the constructed chronological map of *P. punctata* records in the Mediterranean Sea, it could be noticed that the spread pattern was not necessarily similar to that of the Erythrean alien species, such as *R. nomadica* and *C. andromeda* which follow the cyclonic Levantine current (Malanotte-Rizzoli et al. 1997). In the Levantine basin, the chronological existence showed sequential upward direction, starting from the Israeli and Egyptian coasts ending at the Turkey coasts in the northern Levantine. In the most western Mediterranean, *P. punctata* advection occurred southward starting from Italy passing by Tunisia and ending in Malta. Simultaneous existence was reported from the Israeli coast with Greece in 2005-2006 and with Sardinia, Italy in 2009.

Since all the sighting locations of *P. punctata* along the Mediterranean basin are harbors, we believe that shipping is

the sole mean of transportation for the translocation of the polyp stage of this species inside ship hulls. Larson & Arneson (1990) reported *P. punctata* from California (Eastern Pacific) for the first time and declared that polyps of this species were transported by fouling.

Phyllorhiza punctata is an abundant tropical species in coastal areas such as estuaries, lagoons and bays where food is most abundant (Graham et al. 2003). Recent large outbreaks along some coasts (Gülşahin & Tarkan 2012, Gueroun et al. 2015) indicate that the conditions of most coasts of the Mediterranean Sea have increasingly altered to support the establishment of estuaries, bays and lagoons inhabitant species. The pattern shown by the species indicates that it tolerates a wide range of temperature and salinity. Killi et al. (2020) found that *P. punctata* had the third high risk score among 45 jellyfish species according to a risk identification tool called, Aquatic Species Invasiveness Screening Kit (AS-ISK). The establishment of this species in the Mediterranean Sea (Rizgalla & Crocetta 2020) and its tolerance to environmental parameters were the main reasons in resulting of this outcome. Hence, it could suggest that *P. punctata* may spread towards the western Mediterranean Sea. In addition, the successful spread of the warm water affinity species is another hallmark of the current warming trend of the Mediterranean Sea.

In conclusion, this study showed that *P. punctata* is going forward to spread and has increased in the Mediterranean Sea. Therefore, future studies are needed to determine the spread of this non-native species in future climatic conditions.

Acknowledgement. This paper is dedicated to the memory of Fedekar MADKOUR.

References

- Abed-Navandi, D., Kikinger, R. (2007): First record of the tropical Scyphomedusa *Phyllorhiza punctata* von Lendenfeld, 1884 (Cnidaria: Rhizostomeae) in the Central Mediterranean Sea. *Aquatic Invasions* 2: 391-394.
- Atta, M.M. (1991): The Scyphomedusae of the Mediterranean coast of El Arish. *Journal of the Egyptian German Society of Zoology* 6(A): 251-256.
- Boero, F., Putti, M., Trainito, E., Prontera, E., Piraino, S., Shiganova, T. (2009): First records of *Mnemiopsis leidyi* (Ctenophora) from the Ligurian, Tyrrhenian and Ionian Seas (Western Mediterranean) and first record of *Phyllorhiza punctata* (Cnidaria) from the Western Mediterranean. *Aquatic Invasions* 4(4): 675-680.
- Bolton, T.F., Graham, W.M. (2004): Morphological variation among populations of an invasive jellyfish. *Marine Ecology Progress Series* 278: 125-139.
- Çevik, C., Deric, O.B., Çevik, F., Cavas, L. (2011): First record of *Phyllorhiza punctata* von Lendenfeld, 1884 (Scyphozoa: Rhizostomeae: Mastigiidae) from Turkey. *Aquatic Invasions* 6(1): S27-S28.
- Cutress, C.E. (1971): *Phyllorhiza punctata* in the tropical Atlantic. *Proceedings Associations Island Marine Laboratories of Caribbean, Cumana* 9: 14.
- Deidun, A., Sciberras, J., Sciberras, A., Gauci, A., Balistreri, P., Salvatore, A., Piraino, S. (2017): The first record of the white-spotted Australian jellyfish *Phyllorhiza punctata* von Lendenfeld, 1884 from Maltese waters (western Mediterranean) and from the Ionian coast of Italy. *BioInvasions Records* 6(2): 119-124.
- Devaney, D.M., Eldridge, L.G. (1977): Reef and shore fauna of Hawaii. Section 1: Protozoa through Ctenophora. Bishop Museum Press, Honolulu.
- Djehghri, N., Pondaven, P., Stibor, H., Dawson, M.N. (2019): Review of the diversity, traits, and ecology of zooxanthellate jellyfishes. *Marine Biology* 166: 1-19.
- Dawson, M.N., Hamner, W.M. (2009): A character-based analysis of the evolution of jellyfish blooms: adaptation and exaptation. *Hydrobiologia* 616:193-215.
- Durgham, H. (2011): First Records of *Phyllorhiza punctata* von Lendenfeld, 1884 (Cnidaria: Rhizostomeae) from the Mediterranean Coast of Syria. *International Journal of Oceans and Oceanography* 5(2): 153-155.
- Galil, B.S., Spanier, E., Ferguson, W.W. (1990): The Scyphomedusae of the Mediterranean coast of Israel, including two Lessepsian migrants new to the Mediterranean. *Zoologische Mededelingen* 64: 95-105.
- Galil, B.S., Shoval, L., Goren, M. (2009): *Phyllorhiza punctata* von Lendenfeld, 1884 (Scyphozoa: Rhizostomeae: Mastigiidae) reappeared off the Mediterranean coast of Israel. *Aquatic Invasions* 4: 481-483.
- Garcia, J.R. (1990): Population dynamics and production of *Phyllorhiza punctata* (Cnidaria: Scyphozoa) in Laguna Joyunda, Puerto Rico. *Marine Ecology Progress Series* 64: 243-251.
- Garcia, J.R., Durbin, E. (1993): Zooplanktivorous predation by large Scyphomedusae *Phyllorhiza punctata* (Cnidari: Scyphozoa) in Laguna Joyunda, Puerto Rico. *Journal of Experimental Marine Biology and Ecology* 173: 71-93.
- Graham, W.M., Martin, D.L., Felder, D.L., Asper, V.L. (2003): Ecological and economic implications of a tropical jellyfish invader. *Biological Invasions* 5: 53-69.
- Gueroun, S.K.M., Daly Yahia, K.O., Deidun, A., Fuentes, V., Piraino, S., Daly Yahia, M.N. (2015): First record and potential trophic impact of *Phyllorhiza punctata* (Cnidaria: Scyphozoa) along the north Tunisian coast (South Western Mediterranean Sea). *Italian Journal of Zoology* 82(1): 95-100.
- Gülşahin, N., Tarkan, A.N. (2012): The first record of *Phyllorhiza punctata* von Lendenfeld, 1884 from the southern Aegean Coast of Turkey. *Aquatic Invasions* 1: 41-44.
- Gülşahin, N., Sağdıç, O. (2016): What do we know about the stinging beauty of the sea? p.147 In: 5th International Jellyfish Bloom Symposium, May 30-June 3, 2016, Barcelona, Spain.
- Haddad, M.A., Nogueira, M.Jr. (2006): Reappearance and seasonality of *Phyllorhiza punctata* von Lendenfeld (Cnidaria, Scyphozoa, Rhizostomeae) medusae in southern Brazil. *Revista Brasileira de Zoolgia* 23(3): 824-831.
- Heeger, T., Piatkowski, U., Moeller, H. (1992): Predation on jellyfish by the cephalopod *Argonauta argo*. *Marine Ecology Progress Series* 88: 293-296.
- Killi, N., Tarkan, A.S., Kozic, S., Copp, G.H., Davison, P.I., Vilizzi, L. (2020): Risk screening of the potential invasiveness of non-native jellyfishes in the Mediterranean Sea. *Marine Pollution Bulletin* 150: art.110728.
- Larson, R.J., Arneson, A.C. (1990): Two medusae new to the coast of California: *Carybdea marsupialis* (Linnaeus 1758), a cubomedusae and *Phyllorhiza punctata* von Lendenfeld, 1884, a rhizostome scyphomedusae. *Bulletin of the Southern California Academy of Sciences* 89(3): 130-136.
- Madkour, F.F., Hanafy, M.H., Zaghloul, W.S. (2019): Record of aggregation of alien tropical Scyphozoan *Rhopilema nomadica* Galil, 1990 in the Mediterranean coast of Egypt. *International Marine Science Journal* 1(2): 1-7.
- Malanotte-Rizzoli, P., Manca, B.B., D'Alcala, M.R., Theocharis, A., Bergamasco, A., Bregant, D., Budillon, G., Civitarese, G., Georgopoulos, D., Michelato, A., Sansone, E., Scarazzato, P., Souvermezoglou, E. (1997): A synthesis of the Ionian Sea hydrography, circulation and water mass pathways during POEM-Phase 1. *Progress in Oceanography* 39(3): 153-204.
- Mianzan, H.M., Cornelius, P.F.S. (1999): Cubomedusae and Scyphomedusae. pp 513-559. In: Boltovskoy, D. (eds.), *South Atlantic Zooplankton*. Backhuys Publishers, Leiden.
- Morandini, A.C., Soares, M.O., Matthews-Cascon, H., Marques, A.G. (2006): A survey of the Scyphozoa and Cubozoa (Cnidaria, Medusozoa) from the Ceará coast (NE Brazil). *Biota Neotropica* 6(2): 1-8.
- Moreira, M.G.B.S. (1961): Sobre *Mastigias scintillae* sp. nov. (Scyphomedusae, Rhizostomeae) das costas do Brasil. *Boletim do Instituto Oceanografico da Universidade de São Paulo, São Paulo* 11: 5-30.
- Ocaña-Luna, A., Sánchez-Ramírez, M., Aguilar-Durán, R. (2010): First record of *Phyllorhiza punctata* von Lendenfeld, 1884 (Cnidaria: Scyphozoa, Mastigiidae) in Mexico. *Aquatic Invasions* 5(1): S79-S84.
- Özbek, E.Ö., Öztürk, B. (2015): The new location record of *Cassiopea andromeda* (Forsskål, 1775) from Asin Bay, Gulf of Güllük, Muğla, Aegean coast of Turkey. *Journal of the Black Sea/Mediterranean Environment* 21(1): 96-101.
- Rizgalla, J., Crocetta, F. (2020): First record of *Phyllorhiza punctata* von Lendenfeld, 1884 (Cnidaria: Scyphozoa: Rhizostomeae) in Libya through social media data mining. *BioInvasions Records* 9(3): 490-495.
- Silveira, F.L., Cornelius, P.F.S. (2000): New observations on medusae (Cnidaria, Scyphozoa, Rhizostomeae) from northeast and south Brazil. *Acta Biologica Leopoldensia, São Leopoldo* 22: 9-18.
- von Lendenfeld, R. (1884): Über eine Übergangsform zwischen Semostomen und Rhizostomen. *Zoologischer Anzeiger* 5: 380-383.