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Rapid Communication

First record of *Naso annulatus* (Quoy & Gaimard, 1825) and further records of *Scatophagus argus* (Linnaeus, 1766) and *Charybdis (Charybdis) natator* (Herbst, 1794) in the Mediterranean Sea

Ola Mohamed Nour[1], Sara A.A. Al Mabruk[2,3], Bruno Zava[4,5,*], Paola Gianguzza[6], Maria Corsini-Foka[7] and Alan Deidun[8]

[1]*Department of Biology and Geology, Faculty of Education, Alexandria University, 21526 Alexandria, Egypt*
[2]*Department of General Nursing Technology, Higher institute of Science and Technology, Cyrene, Libya*
[3]*Marine Biology in Libya Society, El Bayda, Libya*
[4]*Museo Civico di Storia Naturale, via degli Studi 9, 97013 Comiso (RG), Italy.*
[5]*Wilderness studi ambientali, via Cruillas 27, 90146 Palermo, Italy*
[6]*Department of Earth and Marine Science, University of Palermo, Via Archirafi 18, 90123, Palermo, Italy*
[7]*Hellenic Centre for Marine Research, Institute of Oceanography, Hydrobiological Station of Rhodes. Cos Street, 85100 Rhodes, Greece*
[8]*Department of Geosciences, University of Malta, Msida MSD 2080, Malta*

**Corresponding author*
E-mail: *wildernessbz@hotmail.com*

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Abstract

Here, we report the recent capture (October, November 2021) of the following three non-indigenous species (NIS) from the Indo-Pacific in the Mediterranean Sea: the fishes *Naso annulatus* and *Scatophagus argus* and the brachyuran *Charybdis* (*Charybdis*) *natator*. The record of the white margin unicorn fish *N. annulatus* from the island of Malta represents the first for this species from the basin. Both the spotted scat *S. argus* and the ridged swimming crab *C. natator* were found in Egyptian waters, in localities significantly far from ones previously reported. Possible vectors of introduction for these three NIS to the Mediterranean locations in question include Lessepsian migration, ship-mediated transport, aquarium release, and are briefly discussed.

Key words: non-indigenous species (NIS), vectors, citizen science, Egypt, Malta Island, white margin unicorn fish, spotted scat, ridged swimming crab

Introduction

One of the major threats to Mediterranean Sea biodiversity and associated ecosystem services is related to the introduction, establishment and dispersion of non-indigenous species (NIS, also known as non-native, alien, or exotic species) (Bianchi et al. 2012; Katsanevakis et al. 2014). Among successful NIS of fishes in the Mediterranean Sea, the majority of species are of Indo-Pacific origin and were introduced into the basin via the Suez Canal; other species, of diverse origin, have entered into the basin via aquarium escapees or ship-mediated transport (Zenetos et al. 2016; Galil et al. 2018; Zenetos and Galanidi 2020; Giovos et al. 2020; Golani et al. 2021). Furthermore, there are recent newcomers of Atlantic origin naturally expanding their distribution into the Mediterranean via the Gibraltar Strait (Deidun et al. 2021

Figure 1. The *Naso annulatus* individual spearfished on 27 October 2021 at Birzebbuga, Malta Island. Photo by Juan Carlos Vella Fenech.

and references therein). Concerning NIS of decapods in the Mediterranean Sea, most are also of Indo-Pacific origin and reached the Mediterranean Sea through the Suez Canal (Galil et al. 2015a).

The occurrence of the white margin unicorn fish *Naso annulatus* (Quoy & Gaimard, 1825) (Acanthuridae) in Maltese waters, and of the spotted scat *Scatophagus argus* (Linnaeus, 1766) (Scatophagidae) and the brachyuran *Charybdis* (*Charybdis*) *natator* (Herbst, 1794) (Crustacea, Decapoda, Portunidae) in Mediterranean Egyptian waters is hereby documented thanks to citizen observations. We briefly discuss the biological traits of the species as well as possible vectors of introduction.

Methods and results

Naso annulatus (Quoy & Gaimard, 1825)

On 27 October 2021 a single specimen of an unknown fish was captured through spearfishing at Birzebbuga, in the southern region of the island of Malta (35.809147°N; 14.539683°E), at 7 m of depth over a sandy seabed. The fish was photographed after gutting, and the photo was sent by the fisher to one of the authors (AD). Unfortunately, later, the fish was consumed.

Based on the available photo (Figure 1), the specimen was identified as *N. annulatus*, according to Fischer and Bianchi (1984) and Randall (1986, 1996a, 2001). The following features were observed (Figure 1): body ovoidal and compressed; a continuous, unnotched dorsal fin; caudal fin truncate, slightly emarginated; mouth small; least depth of caudal peduncle about 5 times in head length; two peduncular plates slightly visible; a relatively small median rostral projection anterior to eyes; angle of snout to base of projection about 55°. Colouration: olivaceous to brown, paler ventrally, no dark markings on head or body, edge of lips white, margin of dorsal fin white, caudal peduncle whitish, caudal fin with a posterior white margin, submarginally black, and whitish membranes slightly distinguishable. According to the above mentioned literature, our specimen, approximately 38 cm in total length, was at a subadult stage. Due to the low quality of the photo and the lack of the sample, no information was obtained on meristics or teeth. The main characteristics that led to distinguishing our specimen

from members of other co-generic species of the Red Sea and Western Indian Ocean included the following: the presence of the rostral projection, the profile of the snout from the upper lip to the base of projection (about 60° in *N. annulatus*), the colouration without dark lines or spots on the head or body, the caudal fin almost truncate with a white margin (Fischer and Bianchi 1984; Golani and Fricke 2018). Other morphologically similar species include *Naso brevirostris* (Cuvier, 1829) [profile of snout nearly vertical, lines and spots on body and head], *Naso elegans* (Rüppell, 1829) and *Naso hexacanthus* (Bleeker, 1855) [forehead without protuberance or horn], *Naso unicornis* (Forsskål 1775) [dorsal profile of snout forming an angle of about 45°, blue bands on dorsal and anal fins], *Naso brachycentron* (Valenciennes, 1835) [concavity in profile of back beneath anterior spinous portion of dorsal fin followed by a bump], and *Naso vlamingii* (Valenciennes, 1835) [a prominent bump on snout of adults just above mouth, lines and dots on body].

Remarks. The white margin unicorn fish *N. annulatus* is widely distributed in the Indo-Pacific region from the Red Sea and East Africa, including the Mascarene Islands, east to the Hawaiian, Marquesan and Tuamoto islands, north to southern Japan, and south to Lord Howe Island (Golani and Fricke 2018; Froese and Pauly 2021). The species has also been observed in the Galapagos Islands (Acuña-Marrero and Salinas-de-León 2013). It inhabits inshore coral reefs, rocks and sandstones to 40 m of depth, reaches a large size of 100 cm in total length and feeds on algae. It is of some commercial value (De Bruin et al. 1995) and exploited in the aquarium trade (Okemwa et al. 2009), although the species is not suitable for home aquariums (https://reefapp.net/en/encyclopedia/naso-annulatus).

The finding of *N. annulatus* in Maltese waters constitutes the first record for the Mediterranean Sea.

Scatophagus argus (Linnaeus, 1766)

On 25 October 2021 a single specimen of an unknown fish was caught by fishing rod (with bread as bait) at the most northwest section of the Suez Canal, Port Said Government, Egypt, from the famous platform known as De Lesseps (coordinates 31.2635°N; 32.31578°E). The fish was caught from a depth of about 3 m, over a mixed sandy-rocky substrate. The videos taken during the capture as well as photos of the freshly caught fish were promptly sent via social media to one of the authors (OMN) for identification, while later the sample was deposited into the collections of the Biological Museum of the Department of Biological and Geological Sciences, Faculty of Education, Alexandria University. The fisherman also posted one photo of the fish to a Facebook page that he created (Anglers tales, https://www.facebook.com/Anglerstales.eg/photos/a.2235320526715309/3022086644705356/, in which he asked if anyone else had seen that fish before in the Suez Canal.

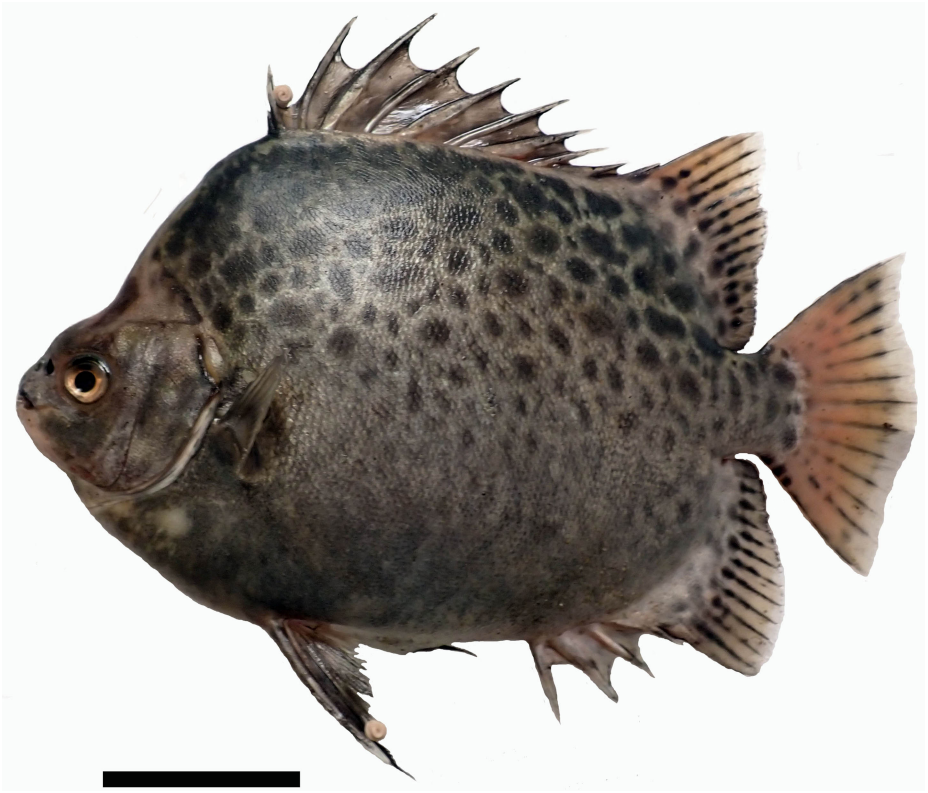

Figure 2. The de-frozen specimen of *Scatophagus argus* captured on 25 October 2021 at Port Said, Egypt (scale bar = 5 cm). Photo by Ola Mohamed Nour.

The specimen, 23.5 cm in total length and 435 g in weight (Figure 2), was identified as *S. argus*, following Kottelat (2001) and Golani et al. (2013). Dorsal fin XI+18, Anal fin IV+14, Ventral I+5, Pectoral 17, Caudal 13. Body quadrangular, strongly compressed; forehead steep, head concave above eyes, mouth small, large eyes. Dorsal fin with membranes deeply incised between spines, a deep notch between spinous and soft parts of dorsal fin; caudal fin double emarginated. Colouration: body silvery, dark spots of irregular shape more evident in the upper portion of sides than in lower; small dark spots on soft rays of dorsal and anal fins and at base of caudal fin. Morphometric measurements given in Table 1 were carried out according to Fischer and Bianchi (1984).

Remarks. The spotted scat *S. argus* is native to the Indo-Pacific region, with a range distribution from the Malay Archipelago, Philippines, China, Australia, South and South East Asia, especially India and Sri Lanka, to the Persian Gulf; the species is reported from the southern Kuril Islands, Russia (Gupta 2016; Jawad 2018). According to most of the current literature, *S. argus* does not occur in the Red Sea (e.g. Golani and Fricke 2018), although Rajasuriya (2014) included the Red Sea as part of the species' native range. The spotted scat is an euryhaline fish, widely distributed in freshwater, brackish water, and marine habitats, usually found in estuaries and mangrove swamps, surf zone of beaches, coastal mudflats, and harbours (Fischer and Bianchi 1984; Randall 1996b; Gupta 2016). The species attains 38 cm in length, feeds on bottom detritus, algae and small benthic invertebrates and

Table 1. Morphometric measurements of the *Scatophagus argus* specimen from Port Said, Egypt

Measurements	cm
Total length	23.5
Standard length	19.4
Head length	5.2
Eye diameter	1.1
Inter orbital distance	0.5
Snout length	1.7
Upper jaw length	0.9
Lower jaw length	0.8
Pre dorsal fin length	6.1
Pre pectoral fin length	4.9
Pre pelvic fin length	6.3
Pre anal fin length	14.1
Body depth	12.3
Caudal peduncle length	1.5
Pelvic fin length	4.9
Pectoral fin length	2.4
Longest dorsal spine (4^{th})	4.3
Longest anal spine (2^{nd})	2.5

dwells in small to large schools (Fischer and Bianchi 1984; Froese and Pauly 2021). It requires the marine environment for reproduction, but juveniles and subadults inhabit freshwaters, estuaries and mangrove swamps (Golani et al. 2013). It is important as an ornamental fish, and in many places, it is appreciated as a culinary item (Kottelat 2001; Gupta 2016; U.S. Fish and Wildlife Service 2019). According to Jawad (2018), the fin spines of *S. argus* inflict venomous injection, with variable symptoms depending on the size of the fish and the quantity of venom injected.

The spotted scat *S. argus* was introduced, probably through aquarium release, in the Northern Gulf of Mexico, Florida, in 1992, and in the Southeast Coast of Florida, Atlantic Ocean, in 2011 (U.S. Fish and Wildlife Service 2019). In the Mediterranean Sea, *S. argus* was first recorded in 2007 from Maltese waters, where a small population appeared initially established, after its introduction most likely via aquarium escape (Zammit and Schembri 2011). The finding of *S. argus* in the Gulf of Gabès, south-eastern Tunisia, in 2017 (Kousteni et al. 2019) is questionable as the specimen depicted in the photograph could be a juvenile of a native pelagic species of Centrolophidae and the weather conditions reported in the note ("after a strong north-easterly wind") are consistent with this interpretation.

Port Said, Egypt, is the second location in the Mediterranean Sea where *S. argus* has been found, significantly far (about 1700 km in a straight line) from the site of the above mentioned record from the island of Malta. The species is reported here for the first time in Egyptian Mediterranean waters.

Charybdis (*Charybdis*) *natator* (Herbst, 1794)

On 15 November 2021, a single unknown crab was caught off Nelson's Island, Abu-Qir Bay, Alexandria, Egypt (31.47461°N; 30.10583°E) by a local

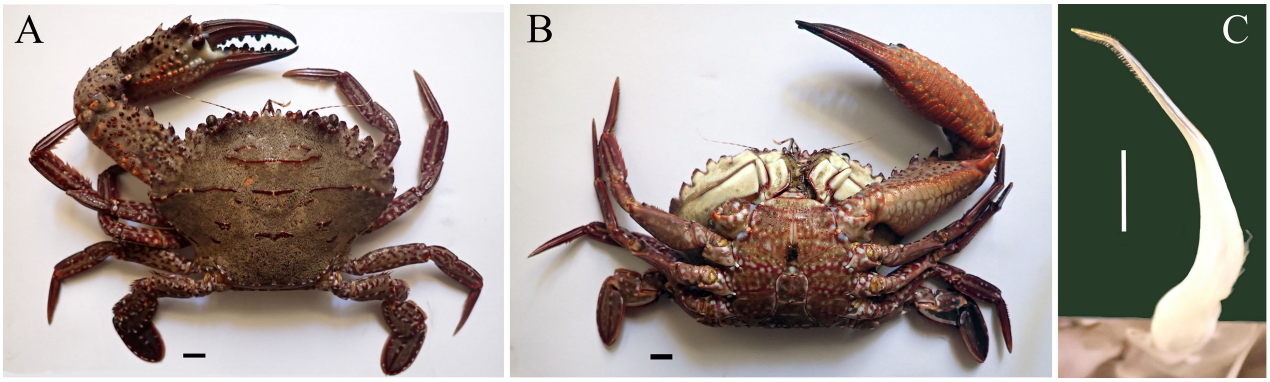

Figure 3. The male *Charybdis* (*Charybdis*) *natator* from Abu-Qir Bay, Alexandria, Egypt, 15 November 2021. (A) dorsal, (B) ventral (black scale bars = 10 mm), and (C) frontal view of the right gonopod 1 (white scale bar = 5 mm). Photos by Ola Mohamed Nour.

fisherman, who provided the video of its capture and the sample to one of the authors (OMN). The specimen was collected by a trammel net called a "Kanar" in Arabic, over a sandy bottom at a depth of approximately 6 m. The catch included many others species, mainly the swimming blue crab *Portunus segnis* (Forsskål, 1775), and the cuttlefish *Sepia officinalis* Linnaeus, 1758.

The sample, a male of 204 g in weight, lacked the right cheliped. It was identified as *C.* (*Charybdis*) *natator* following Crosnier (1962), Apel and Spiridonov (1998) and Abbas et al. (2016).

Fully in agreement with the description of Apel and Spiridonov (1998), the following main morphological characters of the *C.* (*Charybdis*) *natator* specimen were observed (Figure 3A, B): median and submedian frontal teeth not prominent beyond lateral; carapace covered with a dense pubescence. Granular ridges on carapace: a pair of short protogastrics, uninterrupted meso- and metagastrics and a pair of epibranchials. Posterior carapace with a pair of sinuous cardiacs and three pairs of mesobranchial ridges. Front (excluding inner orbital lobe) shorter than posterior border; median and submedian teeth with rounded apices, laterals triangular, separated from submedians by a V-shaped notch. Anterolateral border with six teeth (including the exorbital tooth). Left cheliped granular and pilose; anterior border of merus armed with three spines and tubercles between them; manus with five spines on upper surface, outer and inner surfaces granular, lower surface with transverse squamiform ridges. Propodus of natatory legs with posterior margin serrated. Penultimate segment of male abdomen subquadrate with lateral borders parallel and rounded distally. Gonopod 1 moderately curved, tip slender and elongate; spines extending from tip to about half of neck, a row of spinules decreasing in size along mesial border (Figure 3C). Colouration: pubescence on the dorsal surface of the carapace brownish, granules and transverse carapace ridges dark red; anterolateral teeth, ambulatory legs and the ventral surface mottled with violet and white. The ratio between carapace width (100.04 mm) and carapace length (67.41 mm) of the specimen was 1.48, a value included in the range of 1.4–1.5 reported by Apel and Spiridonov (1998).

Remarks. The ridged swimming crab *C.* (*Charybdis*) *natator* is widely distributed in the Indo-West Pacific region, common in the Red Sea up to the Gulf of Suez, found on sand and rocks at depths ranging from 3 to 55 m (Apel and Spiridonov 1998; Abbas et al. 2016). The species was first detected in the Mediterranean Sea in 2020 from the Tunis southern lagoon, western basin (Orfanidis et al. 2021).

The current record of *C.* (*Charybdis*) *natator* is the second for the Mediterranean Sea and the first from Egyptian Mediterranean waters.

Discussion

The first record of the NIS *N. annulatus* in the Mediterranean Sea, hereby reported from the western Ionian Sea (Maltese Islands) should be considered as a casual finding. A successful introduction of this Indo-Pacific fish can be ascertained only after the documentation of further Mediterranean records of the species, including multiple individuals of both sexes across a broad size range. Although the species belongs to the Red Sea ichthyofauna (Golani and Fricke 2018) and is easily distinguishable from native species, at least at the juvenile and adult stages, its arrival to Maltese waters via Lessepsian migration appears unlikely due to the significant distance from the Suez Canal and the lack, to date, of any other records for the species that would document a range expansion. Nevertheless, the successive building to increase the size of the Suez Canal, and its recent further expansion could facilitate a faster passage of Red Sea biota through this corridor (Galil et al. 2015b, 2017, 2018), besides enhancing the entrance of newcomers into the basin via shipping-mediated transport as a result of an increase in maritime traffic. Therefore, shipping cannot be excluded as a potential vector of the introduction of *N. annulatus* to Malta, as is the case for other tropical or subtropical NIS fish detected worldwide and in the Mediterranean basin (Ricciardi 2016; Insacco and Zava 2017; Zenetos et al. 2020; Golani et al. 2021; Al Mabruk et al. 2021). Being a well-known ornamental fish, its occurrence in Malta could also be explained through aquarium release as it has been hypothesized for other species (Deidun et al. 2020; Giovos et al. 2020).

At the present stage of knowledge, it is also difficult to explain the occurrence of the NIS *S. argus* at the northern mouth of the Suez Canal, Egypt. The spotted scat *S. argus* is an euryaline fish, able to survive in diversified habitats, and Port Said harbor and the Nile Delta close to it are both suitable habitats for this species. As mentioned above, the multiple records from Maltese waters might indicate the existence of a viable population in the central Mediterranean (Zammit and Schembri 2011). An expansion of the hypothesized Maltese population toward the southern and eastern regions of the basin appears, nevertheless, extremely unlikely. Although the unmistakable aspect of this fish, immediately noted by the Egyptian fisherman involved in the present study, to date the species has not been detected along the extended Libyan and Egyptian coasts prior to

its arrival at Port Said. Aquarium release could be considered as a possible pathway, although pet shops for marine ornamental fishes and home aquaria are not common in Egypt. An introduction via Lessepsian migration seems more plausible, but it appears improbable since the Red Sea is generally not included in the natural range of *S. argus*. On the other hand, a ship-mediated pathway of introduction directly from Indo-Pacific regions is not to be excluded. For example, a drastic ship-translocation of *Chlorurus rhakoura* Randall & Anderson, 1997, a species unreported in the Red Sea and found in southeastern Sicily, has been widely discussed by Insacco and Zava (2017), to explain its first occurrence in the central Mediterranean. Another hypothesis is a ship-mediated secondary mode of introduction of the species that allowed a direct jump from the central to the eastern Mediterranean. The record of *S. argus* increases the number of NIS fishes of Indo-Pacific origin recorded in Mediterranean Egyptian waters to at least 65 (Nour et al. 2021; Adel et al. 2022).

As mentioned above, *C.* (*Charybdis*) *natator* was recently detected for the first time in the Mediterranean Sea from Tunisian waters, probably introduced via shipping (Orfanidis et al. 2021). The presence of *C.* (*Charybdis*) *natator* in Egyptian Mediterranean waters, far from the Tunisian coasts, appears quite surprising. The vicinity of the Suez Canal and its wide occurrence in the Red Sea (Abbas et al. 2016; Abo-Hashesh et al. 2020) could suggest an introduction in Egyptian waters via the Suez Canal through Lessepsian migration or through shipping, as discussed above for *N. annulatus*. Furthermore, it is not to be excluded that a certain population might already have been established along the Levantine coasts, but remains undetected or neglected or confused with other crabs. Further records along the Levantine region will help to clarify the entrance pathway of the species. The finding of *C.* (*Charybdis*) *natator* reported in the present study increases the number of NIS brachyurans in the Egyptian Mediterranean waters to 20 species, of which 18 species are of Indo-Pacific origin, and only two are from the Atlantic Ocean (Abdelsalam and Ramadan 2016; Moussa et al. 2016; Abdelsalam et al. 2018 and references therein).

Citizen science is increasingly supplementing conventional scientific surveys in documenting sporadic and widely distributed phenomena, including the introduction of NIS, especially within data-deficient regions where scientific monitoring infrastructure is undeveloped (e.g. Deidun et al. 2021). By virtue of their flexibility and cost-effectiveness, citizen science protocols are especially congenial for north African coastal areas, including those of Libya and Egypt, where an inadequate amount of monitoring capacity has resulted in a lack of marine ecological data. Despite this, citizen science campaigns conducted in these regions have to contend with the caveat of unreliable digital infrastructure (e.g. intermittent internet service) which undermine the effectiveness of social media platforms promoting the same campaigns. As a result, a direct approach, involving a constant liaison with

fishers and other key marine stakeholders, is more effective in these regions, although social platforms can further the impact of the same campaigns.

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Authors' contribution

Conceptualization, methodology, validation, data curation, investigation, writing – original draft, OMN, SAAA, BZ, PG, MCF and AD; Writing – review and editing, BZ, PG, MCF and AD; Supervision, MCF; Resources, AD. All authors participated and commented in various aspects of discussing the results to achieve the final manuscript. The authors read and approved the final manuscript.

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