



# Here they come: multiple new records of Indo-Pacific alien Mollusca in Tunisia

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**Abstract** Recent collecting along the Tunisian coast revealed the occurrence of many species of alien Mollusca, all of which had been reported in the past decades from the Levantine Sea. Baseline explorations of the Gulf of Gabès in 1982 and in the 2000s revealed that only a handful of species were then present. The new sampling in the Gulf of Gabès shows high increments of alien species associated to an algal bottom nearshore, in which non-indigenous species represent 22% of the total species identified but 70% of the total of individuals. This late arrival is interpreted as the consequence of progressive adaptation of the non-indigenous species to their novel environment which is progressively warming.

**Keywords** Alien mollusca · Gulf of Gabès · Columbelloidea · Secondary invasion

## Introduction

The spread of alien biota in the Eastern Mediterranean may be the most impressive impact of non-indigenous species in the marine realm worldwide. Por (1971) coined the term “Lessepsian migration”, alluding to the builder of the Suez Canal, but it has now become clear that not all Indo Pacific species reached the Mediterranean through the Suez Canal, and that shipping has a large share as their primary vector (Zenetos et al. 2012; Fig. 7).

The timing of this invasion has until recently left Tunisia outside the mainstream of Indo-Pacific aliens. A baseline exploration of the Gulf of Gabès was carried out in 1982 by Muséum National d’Histoire Naturelle, Paris and, although very little has been published based on this material, the intensity of collecting (described below in “Material and Methods”) would not have left undetected any of the aliens later reported on. At that time, only three Indo-Pacific alien species of molluscs were reliably reported from Tunisia (Antit et al. 2011): the pioneer *Pinctada radiata* (arrived in the 1890s) and the two sea-slugs *Melibe fimbriata* and *Bursatella leachii*. *Cerithium scabridum* and *Fulvia fragilis* arrived later in the 1990s (Passamonti 1996; Ben Souissi et al. 2003; Enzenroß & Enzenroß 2001; Antit et al. 2011) and are now at the forefront in the Western Mediterranean, reaching the coasts of Spain (Png-Gonzalez et al. 2023). Another baseline study was set by Italian expeditions to the Gulf of Gabès

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between 2000 and 2008 (Cecalupo et al. 2008), an intense effort which only added the cowry *Naria turdus* (Lamarck, 1811). Yet, the balance between Indo-Pacific aliens arrived through the Levantine Sea and aliens of Atlantic origin arrived through shipping was still maintained (Antit et al. 2011: Fig. 14).

Recent collecting along the coasts of Gulf of Hammamet and Gulf of Gabès revealed an unprecedented prominence of (mostly small) alien molluscs of Indo-Pacific origin. The aim of this paper is to document these occurrences and encourage further search for more species, knowing that a pool of about 200 alien molluscan species is already next door.

## Material and methods

### Baseline studies

The Muséum National d'Histoire Naturelle of Paris has carried out since 1980 a series of workshops in distinct south European and North African locations, with the purpose to collect material for collections and obtain a complete census of the species which could occur in a radius of ca. 10 km. For this, divers and shore collectors would sample daily during 1–2 months, in as many habitats as they could locate, using distinct collecting means (airlift pump, brush and basket, dredge, hand-picking). A provisional laboratory was set up, where the sorting was done under stereomicroscopes down to a size of 0.5 mm. Drawings and, in the later editions, photographs, were taken of the living animals, and the material was shared between MNHN and the Swedish Museum of Natural History, Stockholm. One of these workshops took place in May 1982, exploring the shore of the island of Djerba and the Bou Grara lagoon. This collecting effort is unlikely to miss any conspicuous alien species, and therefore the absence of a species in this material (seen by the second author) is taken as evidence for that species not having arrived in Gulf of Gabès at that time.

Cecalupo et al. (2008) reported the results of field trips which took place from 2000 to 2008, in which they collected on shore, mostly around the island of Djerba but also in several other localities including Kerkennah Islands and Zarzis. They reported (Cecalupo et al. 2008: Table 1) 339 species

down to the smallest size range and this work can also be taken as supporting absence of species at the corresponding dates.

### Recent collecting

Our study site is near the harbour of Zarzis in the Gulf of Gabes, in ca. 1 m depth on a rocky platform (33.29.6°N, 11.07.6°E) bordering to the East the pier, and covered with algae. The quantitative samples were taken from four quadrats of 0.25×0.25 m (totalizing 0.25 m<sup>2</sup>), first collecting the algal cover in a fine mesh bag, then using a brush to collect all the fauna from the substrate within the perimeter of the frame. The algae were washed in a bucket of fresh water so that the small animals came off, then the total residue (brushing and algae washing) was sifted through a series of meshes down to 0.5 mm and each fraction sorted by species under a binocular microscope. Additional qualitative samples were collected inside the harbour with particular attention to possible alien species. Only live-collected specimens were taken into account in the census.

### Species identification

Most species could be identified using general Mediterranean textbooks, e.g. Giannuzzi-Savelli et al. (1994–2003; 2014), Scaperrotta et al. (2009–2022), Cecalupo et al. (2008) and Gofas et al. (2011). Identification of alien species may be challenging, because possible taxa to be considered draw from a large pool of species worldwide. Zenetos et al. (2003) was the basis for the identification of alien species, but scattered additional sources have been consulted and are listed in the taxonomic discussions below.

### Repository of material

All the material used for this study will be conserved at Université de Tunis El Manar, Faculté des Sciences de Tunis under the supervision of the first author.

## Results

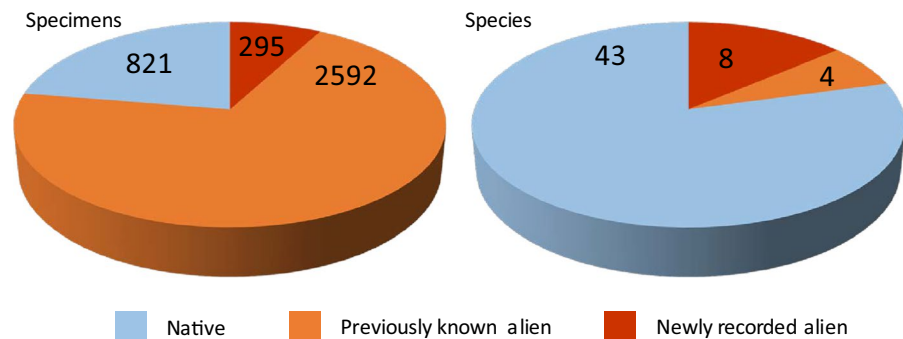
A total of 55 species represented by 3708 specimens (Table 1, Figs. 1, 2) were identified in the four replicates of the algal turf. Among these, 12

**Table 1** Species counts in the four replicas in the algal turf next to the harbour of Zarzis. Alien species are denoted by asterisks (\*: previously recorded in Tunisia; Bold and \*\*: new records)

Species	R1	R2	R3	R4	Total	Dominance
Class Gastropoda, subclass Vetigastropoda						
<i>Clanulus cruciatus</i> (Linnaeus, 1758)	2	0	0	0	2	0.05
<i>Gibbula racketti</i> (Payraudeau, 1826)	2	0	0	0	2	0.05
<i>Gibbula umbilicaris</i> (Linnaeus, 1758)	2	0	0	0	2	0.05
<i>Jujubinus gravinae</i> (Dautzenberg, 1881)	5	2	0	3	10	0.27
<i>Smaragdia viridis</i> (Linnaeus, 1758)	3			1	4	0.11
<i>Tricolia miniata</i> (Monterosato, 1884)	17	10	0	11	38	1.03
<i>Tricolia speciosa</i> (Mühlfeldt, 1824)	2	0	0	0	2	0.05
Class Gastropoda, subclass Caenogastropoda						
<i>Alvania mamillata</i> Risso, 1826	11	8	3	10	32	0.86
<i>Alvania montagui</i> (Payraudeau, 1826)	19	10	6	16	51	1.38
<i>Alvania rudis</i> (Philippi, 1844)	1	0	0	0	1	0.03
<i>Alvania subcrenulata</i> (Schwartz, 1869)	4	1	0	2	7	0.19
<i>Bittium reticulatum</i> (da Costa, 1778)	103	62	33	109	307	8.28
<i>Caecum trachea</i> (Montagu, 1803)	3	0	1	4	8	0.22
<i>Cerithiopsis</i> sp.	4	0	0	3	7	0.19
* <i>Cerithium scabridum</i> Philippi, 1848	101	70	21	99	291	7.85
<i>Cheirodonta</i> sp.	2	0	0	0	2	0.05
<i>Conus mediterraneus</i> (Bruguière, 1792)	3	0	0	0	3	0.08
<i>Echinolittorina punctata</i> (Gmelin, 1791)	3	0	0	0	3	0.08
<i>Gibberula miliaria</i> (Linné, 1758)	1	0	0	0	1	0.03
<i>Gibberula philippi</i> (Monterosato, 1878)	6	1	0	5	12	0.32
<i>Granulina marginata</i> (Bivona, 1832)	11	9	5	9	34	0.92
<i>Melanella</i> sp.	3	0	0	0	3	0.08
<i>Melarhaphe neritoides</i> (Linnaeus, 1758)	1	0	0	0	1	0.03
<i>Parastrophia asturiana</i> de Folin, 1870	2	0	2	0	4	0.11
<i>Pusillina inconspicua</i> (Alder, 1844)	2	0	0	0	2	0.05
<i>Pusillina philippi</i> (Aradas & Maggiore, 1844)	3	1	2	4	10	0.27
<i>Pusillina</i> sp.	2	5	4	7	18	0.49
<i>Rissoa auriscalpium</i> (Linnaeus, 1758)	0	0	0	4	4	0.11
<i>Rissoa guerinii</i> Récluz, 1843	1	0	0	0	1	0.03
<i>Rissoa similis</i> Scacchi, 1836	3	0	0	1	4	0.11
<i>Setia amabilis</i> (Locard, 1886)	1	0	0	0	1	0.03
** <i>Sticteulima lentiginosa</i> (A. Adams, 1861)	<b>23</b>	<b>14</b>	<b>8</b>	<b>19</b>	<b>64</b>	<b>1.73</b>
<i>Vermetus granulatus</i> (Gravenhorst, 1831)	1	0	0	0	1	0.03
** <i>Zafra selasphora</i> (Melvill & Standen, 1901)	<b>51</b>	<b>16</b>	<b>23</b>	<b>37</b>	<b>127</b>	<b>3.43</b>
Class Gastropoda, subclass Heterobranchia						
<i>Odostomia conoidea</i> (Brocchi, 1814)	2	0	0	0	2	0.05
* <i>Pyrgulina maiae</i> Hornung & Mermod, 1924	22	13	7	20	62	1.67
** <i>Cingula isseli</i> (Tryon, 1889)	<b>6</b>	<b>2</b>	<b>4</b>	<b>11</b>	<b>23</b>	<b>0.62</b>
** <i>Turbonilla edgarü</i> (Melvill, 1896)	<b>3</b>	<b>2</b>	<b>0</b>	<b>5</b>	<b>10</b>	<b>0.27</b>
** <i>Odetta zekiergeni</i> Öztürk 2013	<b>1</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>3</b>	<b>0.08</b>
** <i>Syrnola fasciata</i> Jickeli, 1882	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0.03</b>
<i>Retusa truncatula</i> (Bruguière, 1792)	2	0	0	0	2	0.05
<i>Haminaea</i> sp.	2	0	0	0	2	0.05
<i>Bulla striata</i> Bruguière, 1792	1	0	0	0	1	0.03

**Table 1** (continued)

Species	R1	R2	R3	R4	Total	Dominance
Class Bivalvia						
* <i>Arcuatula senhousia</i> (Benson in Cantor, 1842)	4	1	1	5	11	0.30
* <i>Brachidontes pharaonis</i> (P. Fischer, 1870)	651	479	426	585	2141	57.76
<i>Cardita calyculata</i> (Linnaeus, 1758)	1	0	0	0	1	0.03
<i>Gregariella petagnae</i> (Scacchi, 1832)	2	0	0	1	3	0.08
<i>Irus irus</i> (Linné, 1758)	61	32	43	66	202	5.45
** <i>Isognomon bicolor</i> (C. B. Adams, 1845)	3	0	1	1	5	0.13
<i>Modiolus barbatus</i> (Linnaeus, 1758)	2	1	0	0	3	0.08
<i>Musculus costulatus</i> (Risso, 1826)	1	0	0	0	1	0.03
<i>Mytilaster minimus</i> (Poli, 1795)	3	0	0	3	6	0.16
<i>Petricola lithophaga</i> (Retzius, 1788)	1	0	0	0	1	0.03
* <i>Pinctada radiata</i> (Leach, 1814)	57	25	27	40	149	4.02
<i>Venerupis geographica</i> (Gmelin, 1791)	3	5	1	11	20	0.54
<b>Total</b>	1227	769	618	1094	3708	

**Fig. 1** Proportions of native, known alien and newly recorded alien species in the sampling of the algal turf at Zarzis

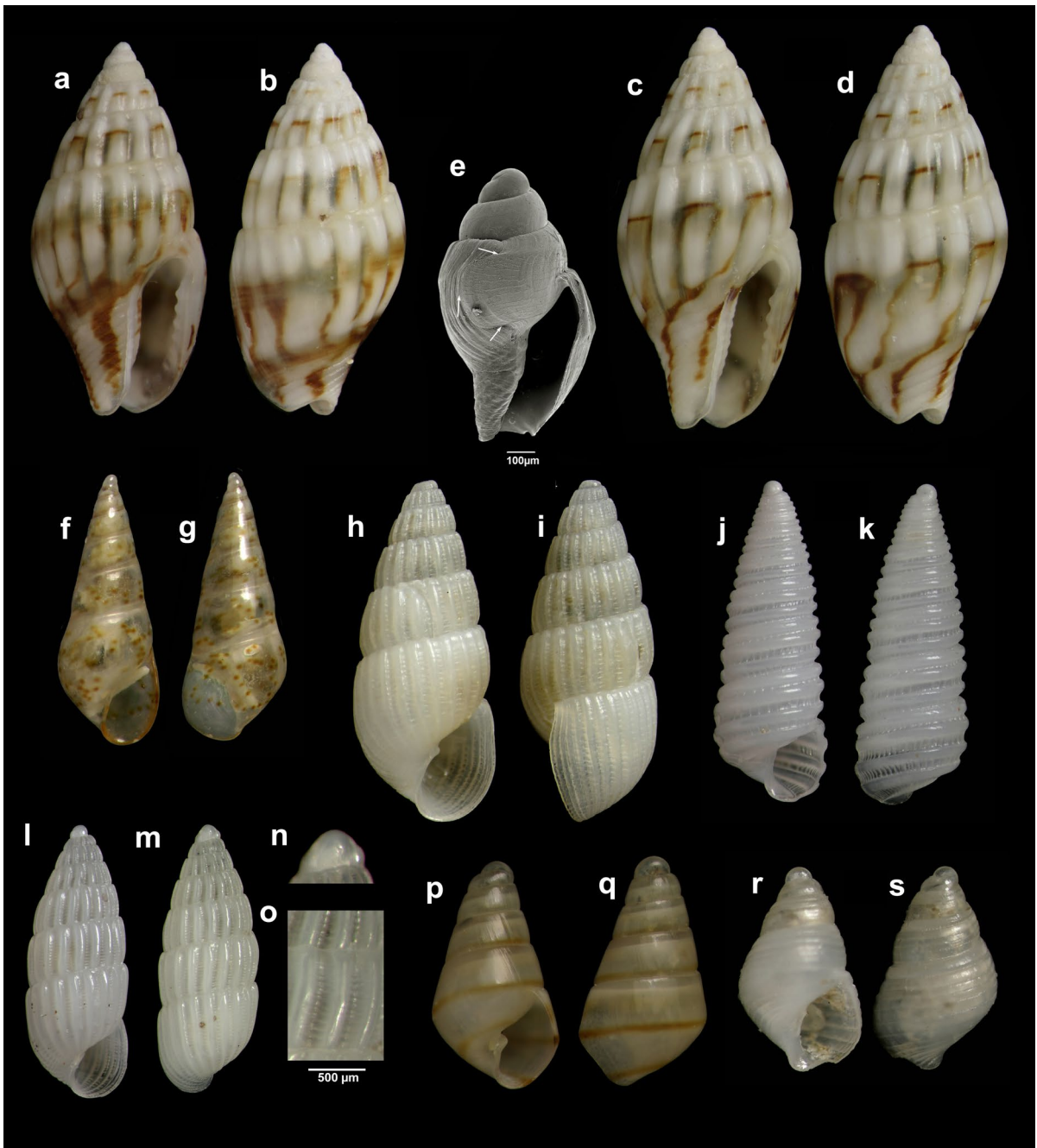
species represented by 2887 specimens belong to alien species, of which 7 are newly recorded for Tunisian waters: the bivalve *Isognomon bicolor* (C. B. Adams, 1845) and the gastropods *Sticteulima lentiginosa* (A. Adams, 1861), *Zafra selasphora* (Melvill & Standen, 1901), *Syrnola fasciata* (Jickeli, 1882), *Cingula isseli* (Tryon, 1889), *Turbonilla edgarii* (Melvill, 1896), *Odetta zekiergeni* Öztürk 2013. *Pyrgulina maiiae* Hornung & Mermod, 1924, recorded in 2024 (Christidis et al 2024), can be considered along with this list of newcomers.

Further collecting inside the harbour of Zarzis yielded more specimens of *Isognomon bicolor* in a more adult stage and another new record, that of a species of *Chama* tentatively identified as *Chama asperella* Lamarck, 1819 (Fig. 3). Those bivalves were not seen in former field trips to the same place and were first noted during the summer of 2024.

## Discussion

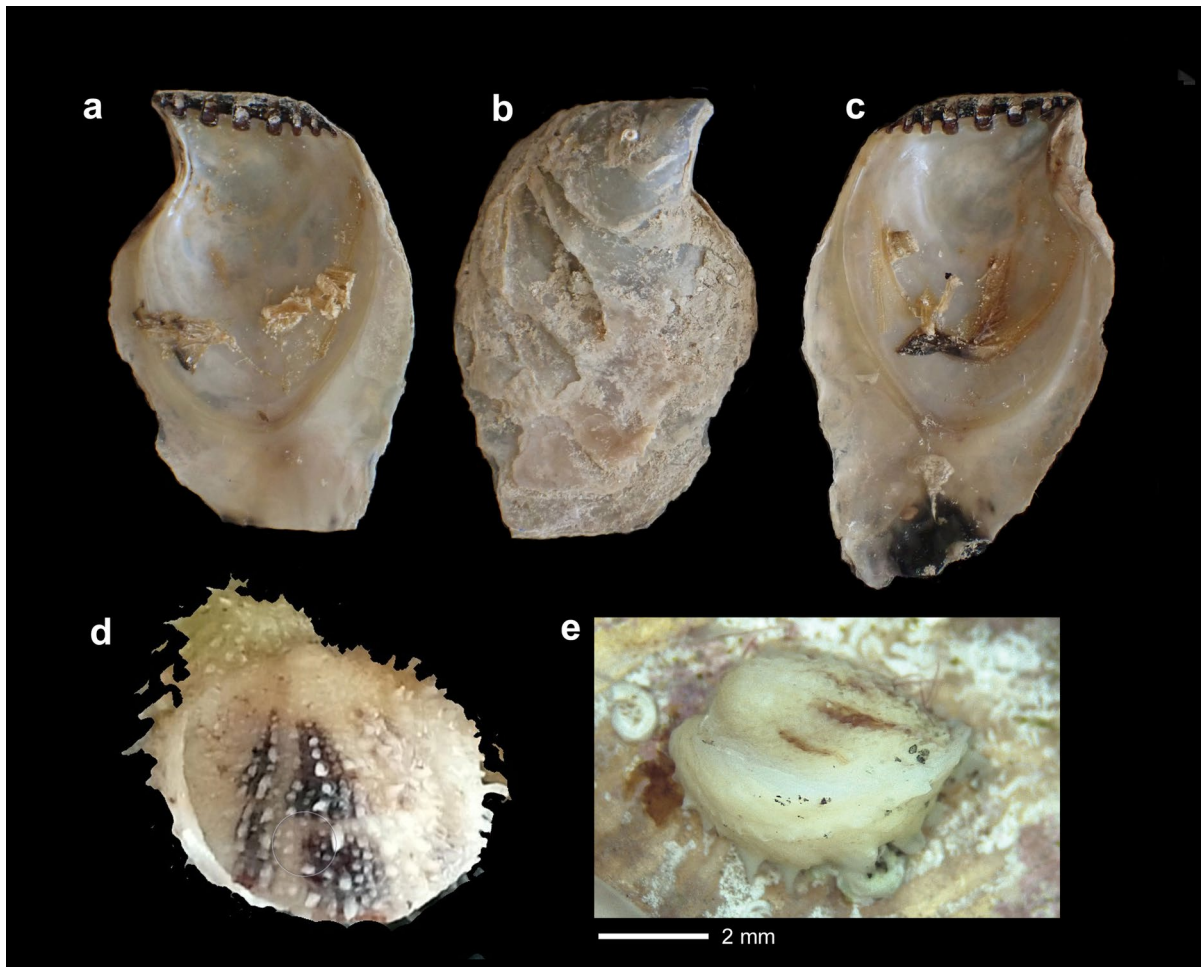
### Taxonomic notes

*Zafra selasphora* (Melvill & Standen, 1901): The identification of the small columbellid here identified as *Zafra selasphora* has been controversial. Four species of *Zafra* have been reported so far in the Eastern Mediterranean (Zenetos et al. 2003; Öztürk et al. 2015): *Z. savignyi* (Moazzo, 1939), *Z. selasphora* (Melvill & Standen, 1901), *Z. obesula* (Hervier, 1899) and *Z. pumila* (Dunker, 1860). The first two have been confused for many years, albeit *Z. savignyi* can be readily distinguished: the inner part of the outer lip bears an elongate, smooth bulge instead of the series of denticles found in the other species here discussed, and the columella has a distinct, thick fold (see Zenetos et al. 2003: 128) which is



**Fig. 2** Alien micromolluscs recorded for the first time in Tunisia, from the algal turf outside Zarzis harbour. **a–d** *Zafra selasphora* (Melvill & Standen, 1901), 3.4 and 3.6 mm. **e** *Zafra selasphora*, recently settled juvenile showing protoconch and incipient teleoconch. the arrows point to the protoconch/teleoconch limit, where the upper and lower sinuses correspond to the veliger larva's velum. **f–g** *Sticteulima lentiginosa*

(A. Adams, 1861), 1.9 mm. **h–i** *Pyrgulina maiiae* Hornung & Mermod, 1924, 3.7 mm. **j–k** *Cingula isseli* (Tryon, 1889), 3.2 mm. **l–m** *Turbonilla edgarrii* (Melvill, 1896), 2.5 mm. **n–o** Protoconch and microsculpture of the same shell. **p–q** *Syrnola fasciata* (Jickeli, 1882), 1.7 mm. **r–s** *Odetta zekiergeni* Öztürk 2013, 1.7 mm

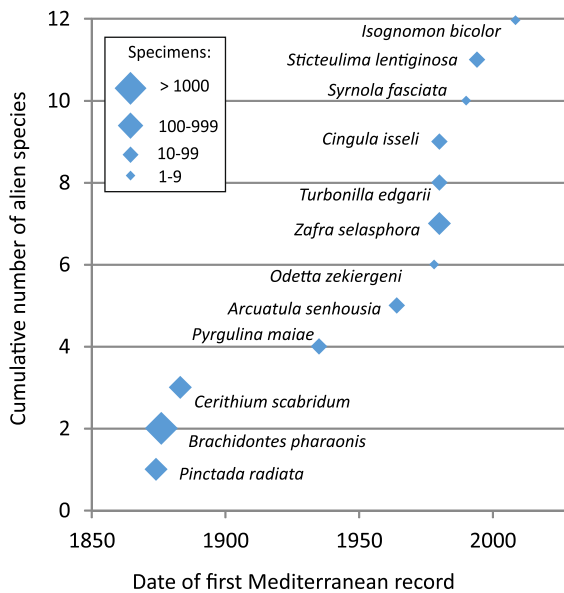


**Fig. 3** Alien bivalves recorded for the first time in Tunisia, from the harbour of Zarzis. **a-c** *Isognomon bicolor* (C. B. Adams, 1845), height 23.5 mm. **d** *Chama asperella* Lamarck, 1819, length 10 mm. **e** *Chama asperella* cemented to rock, length 7 mm

not seen in the other three species. *Zafra pumila* is also distinctive with much more crowded ribs and a colour pattern which is uniform or with spiral lines, but devoid of the zigzag flames seen in the other three species (Öztürk et al. 2015: Fig. 5). The species now identified as *Z. selasphora* was first recorded from Israel in 1980 and in 1986 from Turkey (Palazzi 1993; van Aartsen 1997) and then tentatively identified as *Z. troglodytes* (Souverbie, 1866). The latter species, originally described from New Caledonia and also with planktotrophic development, is virtually indistinguishable from *Z. selasphora* on adult shell characters but differs in having a keeled protoconch (smoothly rounded whorls in *Z. selasphora*), see Sleurs (1987: plate D Fig. 7) and Boyer et al. (2022:

holotype of *Z. troglodytes* illustrated Fig. 94–96). *Zafra obesula* somewhat resembles *Z. selasphora* but differs in a stouter profile and above all a narrow, oblique aperture (Öztürk et al. 2015: Fig. 4 B–C; Monsecour and Raines, 2024: Fig. 4 M–N). In our opinion, the specimen from Turkey figured by Öztürk et al., 2015: Fig. 4A is just one more specimen of *Z. selasphora* (a view with which Dr. Öztürk now agrees after correspondence).

*Turbonilla edgarii* (Melville, 1896): This species is readily distinguished from other similar pyramidellids e.g. *Pyrgulina maiae*, by the protoconch, which has a coiling axis tilted 90° with respect to the adult shell axis (Fig. 2n), whereas in *Pyrgulina* spp. (e.g. *P. maiae*) it is tilted 180° i.e.



**Fig. 4** Cumulative count of alien molluscan species found at Zarzis as a function of the year of first record.

the apex of the protoconch is immersed in the first teleoconch whorl. Its allocation in *Turbonilla* is questionable because species of that genus never have a columellar fold (quite obvious in *T. edgarii*), but we do not know of a genus which would agree better with this combination of characters. Solving this question is beyond the scope of this paper and we retain the accustomed placement (e.g. Zenetos et al. 2003).

*Odetta zekiergeni* Öztürk 2013 was described with a Turkish type locality although it is obviously non-indigenous in the Mediterranean. The shell is small, conical, with a protoconch axis tilted ca. 130° with the shell axis and with a definite tooth in the aperture. Unlike any native Mediterranean pyramidellid, there are distinct spiral grooves on the spire whorls. A superficially similar species is *Leucotina natalensis* E. A. Smith, 1910 (reported as *Adelactaeon amoenus* (A. Adams, 1851) by Zenetos et al. 2003, reidentified by van Aartsen & Hori 2006), but there is no tooth on the columella, the embryonic whorls make an angle of about 150° with the shell axis (van Aartsen & Hori 2006) and the last whorl is also more rounded. *Odetta zekiergeni* was compared by Öztürk (2013) to several Atlantic and Eastern Pacific species, but its origin is unknown. Similar shells have been reported from the Tyrrhenian Sea (Tempesti et al. 2022), also as aliens.

*Isognomon bicolor* (C. B. Adams, 1845) was first recorded in 2015 from the coast of Israel (Mienis et al. 2016) and identified as *Isognomon legumen* (Gmelin, 1791) with the prejudice that alien species detected in the Levantine Sea should be of Indo-Pacific origin. Nevertheless Garzia et al. (2022) have shown, based on DNA data, that the Mediterranean alien species of *Isognomon* is the Caribbean *I. bicolor*.

*Chama asperella* Lamarck, 1819 was first recorded in the Mediterranean (southern Turkey by Mifsud & Ovalis 2007, Cyprus by Delongueville & Scaillet 2010) under the name *Chama aspersa* Reeve, 1846. Ovalis & Zenetos (2007) recorded both as separate species, following in that Delsaerd (1986); nevertheless Huber (2010) considered that *aspersa* should be treated as a *nomen dubium*, and that the valid name for this common Indo-Pacific species was *Chama asperella*. It lives on the exposed surface of very shallow hard substrates and is morphologically similar to the native *Chama gryphoides* Linnaeus, 1758, except for commonly having a colour pattern of red-brown bands radiating from the umbo on the right (non-attached) valve. Because the first records were in Greece and Turkey and not in the Levantine Sea, Ovalis & Zenetos (2007) proposed that ship fouling is the most likely mode of transport, although dispersal through the Suez Canal is not excluded.

#### Role of the invaders in the community

The large numbers in this community are achieved by filter feeders *Brachidontes pharaonis* and *Pinctada radiata*, both alien, and the scavengers *Cerithium scabridum* (alien) and *Bittium reticulatum* (native). The trophic group of *Zafra selasphora* has yet to be determined, as its family Columbellidae includes both carnivorous and herbivorous species (de Mantenon 1999). In the species count of aliens, the prevalence of Pyramidellidae which are ectoparasites on molluscs or polychaetes (and also *Sticteulima*, ectoparasite of echinoderms) is remarkable. These aliens had to adapt to different host species in their newly acquired environment. Quite surprisingly, Pyramidellidae are one of the most successful families in invading the Mediterranean and the high prevalence of epizotic parasite molluscs was already noted in the Levantine Sea (Oliverio & Taviani 2003).

## Timing of the invasion

All the species reported here for the first time in Tunisia have previous records elsewhere in the Eastern Mediterranean basin i.e. their arrival in Tunisia is the result of secondary spreading. Data from other groups shows that some time must elapse before newcomers to the Mediterranean become prevalent. The species of fishes of Indo-Pacific origin which reached the Eastern Mediterranean earlier have been shown to be more common or prevalent than newcomers (Golani 1998: Fig. 1). Likewise, in our material (Fig. 4), the alien species which achieve high abundance are old settlers in the Mediterranean, with the exception of *Zafra selasphora* for which the planktotrophic development can explain facility for a more rapid spread. Most of the other species, including all Pyramidellidae, have pelagic larvae but with a small (<2) number of larval whorls indicating that the pelagic phase is not very long, sufficient for local dispersal but not for long-distance.

## Dwindling biodiversity in Gulf of Gabès

It has been postulated (Hobbs and Hunneke 1992; Stachowicz et al. 1999) that disturbance and impoverishment alter biological diversity and weaken the resilience of ecosystems, thus creating favourable conditions for the establishment and spread of invasive species. It has been shown (Ben Rais Lasram et al. 2016; Mosbahi et al. 2021) that Gulf of Gabès is a region with unique biota but seriously affected by human activities such as overfishing, trawling, and industrial pollution. Faced with the degradation of biodiversity, Tunisian authorities have developed since the 2000s a comprehensive sustainable management strategy aimed at addressing the causes of biodiversity loss and have recognized the importance of an integrated approach to protecting natural resources. This work, though factual numbers, documents the decline of native diversity in the Gulf of Gabès caused by human activities and natural events such as climate change.

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**Author contributions** This study was conceived of and designed by MA and SG. MA did the field work, sorting of the material, preliminary identifications and analysis. SG confirmed identifications and made photographs. All authors edited the manuscript.

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**Data availability** The data used in the study are available from the first author on reasonable request.

## Declarations

**Conflict of interest** The authors have no relevant financial or non-financial interests to disclose.

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## References

- Antit M, Gofas S, Salas C, Azzouna A (2011) One hundred years after *Pinctada*: an update on alien Molluscs in Tunisia. *Med Mar Sci* 12(1):53–73. <https://doi.org/10.12681/mms.53>
- Ben Rais Lasram F, Hattab T, Halouani G, Romdhane MS, Le Loc'h F, Albouy C (2016) Cumulative human threats on fish biodiversity components in Tunisian waters. *Med Mar Sci* 17(1):190–201. <https://doi.org/10.12681/mms.1373>
- Ben Souissi J, Rezig M, Zaouali J (2003) Appearance of invasive species in the southern lake of Tunis. In: Özhan E (ed) In: Proceedings of the sixth International Conference on the Mediterranean Coastal Environment (MEDCOAST 03), October 7–11, vol 2. Ravenna, p 911–922
- Boyer F, Pelorce J, Gori S (2022) Révision des Columbellidae de l'île de Masirah Oman, Partie 1: genres *Smithena* gen. nov., *Anachis* H. Adams & A. Adams 1853, *Zafra* A. Adams 1860 et *Parvanachis* Radwin 1968. *Novapex* 23(3):87–110

- Cecalupo A, Buzzurro G, Mariani M (2008) Contributo alla conoscenza della macrofauna del Golfo di Gabès (Tunisia) Quaderni della Civica Stazione Idrobiologica di Milano 31(1–173):1–92
- Christidis G, Ammar Izdihar A, Antit M, Barhoum YM, Brundu G, Colletti A, Crocetta F, Desiderato A, Digenis M, Gökoğlu M, Grech D, Kleitou P, Kondylatos G, Kosoglou I, Kvesić Ivanković M, Lazarakis G, Lezzi M, Mazziotti C, Metaxakis M, Michail C, Mucciolo S, Nejašmić J, Okudan ES, Öndes F, Oruç AÇ, Peristeraki P, Renoult JP, Tanduo V, Tuney I, Yilmaz M, Žuljević A, Gerovasilieou V (2024) New alien Mediterranean biodiversity records. *Med Mar Sci* 25(2):453–479
- Delongueville C, Scaillet R (2010) Echantillonnage de mollusques invasifs et premiere signalisation de *Chama aspersa* Reeve, 1846 à Chypre Nord. *Novapex Société* 11(1):3–7
- Delsaerd A (1986) Red Sea Malacology I. Revision of the Chamidae of the Red Sea. *Gloria Maris* 25(3):73–125
- DeMaintenon MJ (1999) Phylogenetic analysis of the Columbellidae (Mollusca: Neogastropoda) and the evolution of herbivory from carnivory. *Invert Biol* 118(3): 258–288 <https://doi.org/10.2307/3226997>
- Enzenroß L, Enzenroß R (2001) Untersuchungen über das Vorkommen mariner Mollusken in Tunesischen Gewässern. *Schrift Malakozool* 17:45–62
- Garzia M, Furfaro G, Renda W, Rosati A-M, Mariottini P, Giacobbe S (2022) Mediterranean spreading of the bicolor purse oyster, *Isognomon bicolor*, and the chicken trigger, *Malleus* sp., vs. the Lessepsian prejudice. *Med Mar Sci* 23(4):777–788. <https://doi.org/10.12681/mms.29218>
- Giannuzzi-Savelli R, Pusateri F, Palmeri A, Ebreo C (1994–2003). *Atlante delle conchiglie marine del Mediterraneo Vol 1 (Archaeogastropoda)*. Roma. Edizioni Evolver vol 1: p 125 (1994); Vol 2: p 258 (1997); Vol 3: p 127 (1999); Vol 4(1): p 298 (2003)
- Giannuzzi-Savelli R, Pusateri F, Micali P, Nofroni I, Bartolini S (2014). *Atlante delle conchiglie marine del Mediterraneo, Volume 5 (Heterobranchia)*. Palermo, Edizioni Danaus p. 1–111 with 41 unnumbered plates (figs. 1–363), appendix p. 1–91
- Gofas S, Moreno D, Salas C (Eds.) (2011). *Moluscos marinos de Andalucía*. Servicio de Publicaciones e Intercambio Científico, Universidad de Málaga, Málaga.b Vol 1: p i–xvi, 1–342; Vol 2: p i–xii, 343–798
- Golani D (1998) Impact of Red Sea fish migrants through the Suez Canal on the aquatic environment of the Eastern Mediterranean. *Yale Sch for Env Stud Bull Ser* 103:375–387
- Hobbs RJ, Hunneke LF (1992) Disturbance, diversity, and invasion: Implications for conservation. *Cons Biol* 6: 324–337. <https://doi.org/10.1046/j.1523-1739.1992.06030324.x>
- Huber M (2010). *Compendium of bivalves. A full-color guide to 3,300 of the world's marine bivalves. A status on Bivalvia after 250 years of research*. ConchBooks, Hackenheim, p 901. 1 CD-ROM
- Mienis HK, Rittner O, Shefer S, Feldstein T, Yahel R (2016) First record of the Indo-Pacific *Isognomon legumen* from the Mediterranean coast of Israel (Mollusca, Bivalvia, Isognomonidae). *Triton* 33:9–11
- Mifsud C, Ovalis P (2007) *Chama aspersa* Reeve, 1846 (Bivalvia: Chamidae) another established Lessepsian invader in the Mediterranean Sea. *Novapex* 8(1):27–28
- Monsecour K, Raines BK (2024) New species and genus of Columbellidae (Gastropoda: Buccinoidea) from the Western Pacific. *Zootaxa* 5514(4):353–367. <https://doi.org/10.11646/zootaxa.5514.4.4>
- Mosbahi N, Pezy JP, Neifar L, Dauvin JC (2021) Ecological status assessment and non-indigenous species in industrial and fishing harbours of the Gulf of Gabès (central Mediterranean Sea). *Environ Sci Poll Res* 28:65278–65299. <https://doi.org/10.1007/s11356-021-14729-1>
- Oliverio M, Taviani M (2003) The Eastern Mediterranean Sea: tropical invasions and niche opportunities in a “Godot Basin” *Biogeographia—J Integrat Biogeogr* vol 24 (special issue: Marine biogeography of the Mediterranean Sea: patterns and dynamics of biodiversity Part I): p 313–218. <https://doi.org/10.21426/B6110004>
- Ovalis P, Zenetos A (2007) On the establishment of two more alien Mollusca (*Chama aspersa* Reeve, 1846 and *Chama asperella* Lamarck, 1819) in the Eastern Mediterranean. *Med Mar Sci* 8(2):97–100. <https://doi.org/10.12681/mms.158>
- Öztürk B (2013) *Odetta zekiergeni* a new species of Pyramidellidae (Mollusca: Gastropoda) from the eastern Mediterranean Sea. *Zootaxa* 3691(2):295–298. <https://doi.org/10.11646/zootaxa.3691.2.9>
- Öztürk B, Recevik M, Geyran K (2015) New alien Molluscs in the Mediterranean Sea. *Cah Biol Mar* 56(3): 205–212.
- Passamonti M (1996) Nuova segnalazione per le coste Tunisine di *Papyridea papyracea* (Gmelin 1791) (Bivalvia: Cardidae). *Boll Malacol* 32(5–8):153–156
- Png-Gonzalez L, Comas-González R, Calvo-Manazza M, Follana-Berná G, Ballesteros E, Díaz-Tapia P, Falcón JM, García Raso JE, Gofas S, González-Porto M, López E, Ramos-Esplá AA, Velasco E, Carbonell A (2023) Updating the national baseline of non-indigenous species in Spanish marine waters. *Diversity* 15(5):630. <https://doi.org/10.3390/d15050630>
- Por FD (1971) One hundred years of Suez Canal – a century of Lessepsian migration: retrospect and viewpoints. *Syst Zool* 20:138–150. <https://doi.org/10.2307/2412054>
- Scapperotta M, Bartolini S, Bogi C (2009–2022) Accrescimenti, stadi di accrescimento dei molluschi marini del Mediterraneo. *L’Informatore Piceno, Cupra Marittima*. Vol I: p 167 (2009); Vol II: p 176 (2010); Vol III: p 184 (2011); Vol IV: p 184 (2012); Vol V: p 192 (2013); Vol VI: p 192 (2014); Vol VII: p 192 (2015); Vol VIII: p 208 (2016); Vol IX: p 192 (2018); Vol X: p 212 (2019); Vol XI: p 160 (2022)
- Sleurs W (1987) The marine microgastropods from the Northern coast of Papua New Guinea (Mollusca: Gastropoda) III Family Columbellidae (Subfamily Pyreninae) with description of two new species. *Indo-Malayan Zool* 4: 33–68, pl A–D
- Stachowicz JJ, Whitlatch RB, Osman RW (1999) Species diversity and invasion resistance in a marine ecosystem. *Science* 286:1577–1579. <https://doi.org/10.1126/science.286.5444.1577>

- Tempesti J, Langeneck J, Romani L, Garrido M, Lardicci C, Maltagliati F, Castelli A (2022) Harbour type and use destination shape fouling community and non-indigenous species assemblage: A study of three northern Tyrrhenian port systems (Mediterranean Sea). *Mar Poll Bull* 174:113191. <https://doi.org/10.1016/j.marpolbul.2021.113191>
- van Aartsen JJ (1997) *Anachis* nel Mediterraneo: una nota sulla distribuzione. *La Conchiglia* 24(282):29
- van Aartsen JJ, Hori S (2006) Indo-Pacific migrants into the Mediterranean. 2. *Monotigma lauta* (A.Adams, 1853) and *Leucotina natalensis* Smith, 1910 (Gastropoda, Pyramidellidae). *Basteria* 70:1–6
- Zenetos A, Gofas S, Russo G, Templado J (2003) CIESM Atlas of exotic species in the Mediterranean: Vol 3 Molluscs. CIESM Publishers, Monaco, p 376
- Zenetos A, Gofas S, Morri C, Rosso A, Violanti D, Garcia Raso JE, Cinar ME, Almogi-Labin A, Ates AS, Azzurro E, Ballesteros E, Bianchi CN, Bilecenoglu M, Gambi MC, Giangrande A, Gravili C, Hyams-Kaphzan O, Karachle PK, Katsanevakis S, Lipej L, Mastrototaro F, Mineur F, Pancucci-Papadopoulou MA, Ramos Espla A, Salas C, San Martin G, Sfriso A, Strefaris N, Verlaque M (2012) Alien species in the Mediterranean Sea by 2012 A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD) Part 2. Introduction trends and pathways. *Medit Mar Sci* 13(2):328–352. <https://doi.org/10.12681/mms.327>

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