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Authors

Trainito, Egidio
Doneddu, Mauro
Furfaro, Giulia

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A new perspective on the distribution of *Camachoaglaja africana* (Pruvot-Fol, 1953) and *Biuve fulvipunctata* (Baba, 1938) (Gastropoda, Cephalaspidea) in the Mediterranean and the NE Atlantic

EGIDIO TRAINITO¹, MAURO DONEDDU², GIULIA FURFARO^{3,4*}

¹*Genoa Marine Centre Stazione Zoologica Anton Dohrn Istituto Nazionale di Biologia, Ecologia e Biotecnologie Marine Villa del Principe, Piazza del Principe 4, 16126 Genoa, Italy*

²*Via Carlo Felice 52/A, 07100 Sassari, Italy*

³*Department of Science and Biological and Environmental Technologies - DiSTeBA, University of Salento, Via Prov.le Lecce-Monteroni, 73100 Lecce, Italy*

⁴*National Biodiversity Future Center (NBFC), 90133 Palermo, Italy*

*corresponding author, e-mail: giulia.furfaro@unisalento.it

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SUMMARY

During underwater monitoring, one specimen of *Camachoaglaja africana* and one of *Biuve fulvipunctata* were found at the ‘Tavolara Punta Coda Cavallo’ Marine Protected Area, allowing to expand the known Mediterranean range of distribution of these two species. The finding of both species constitutes the first report for NE Sardinia and the whole Tyrrhenian Sea. By coupling data obtained from the analysis of social media and those present in the bibliography it was also possible to speculate on alternative pattern of distribution of these two species at a global scale. Finally, it is also confirmed the importance of repeated monitoring activities over time on the mooring buoys which act as steppingstone habitats for epifauna or for larval settlement and that are capable to provide important additional information on local biodiversity.

INTRODUCTION

The discovery of non-indigenous or cryptogenic species in the Mediterranean has become increasingly common and widespread (Galil 2008, Azzola et al. 2022, Garzia et al. 2022, Mioni and Furfaro 2022, Trainito et al. 2022a). Actually, the patterns of diffusion and the

sequence of findings are often subject of discussion since the dispersion phenomena can be masked by the methods of detection (Trainito et al. 2022b). In fact, while there are areas in which research on biodiversity has a solid historical basis, in many other Mediterranean coasts there is either no research activity or it is sporadic and often random. This is particularly

true for a group of Mollusca, the marine Heterobranchia. In fact, in some specific areas non-native or cryptogenic species are more frequently reported due to the helpful activity of research institutes, naturalistic associations, individual specialists or citizen scientists who systematically investigate well-defined areas (Trainito et al. 2022, Rizgalla et al. 2023). On the other hand, the practice of reporting uncommon species on various online platforms by citizen scientists (divers, underwater photographers, or simple snorkelers) is constantly expanding, also favoured by the spreading of social media. Sharing data on social media chats is becoming an effective tool, improving knowledge on biodiversity, and the practice of posting images, the way that allows experts to be directly in contact with the observers and retrieve additional useful information. In the case of marine heterobranchs, these ways of collecting information are even more precious considering the often small dimensions of these organisms, and in many cases their cryptic body colour patterns or bashful behaviour.

This brief communication reports the discovery of two species belonging to the Aglajidae family, of possible extra Mediterranean origin, as the first report for the Sardinia waters and for the entire Tyrrhenian Sea (Sectors 2 and 3 in Renda et al. 2022). The findings took place within the ‘Tavolara Punta Coda Cavallo’ Marine Protected Area (M.P.A.), as a confirmation that the systematic research activity is the best way to shed lights on the biodiversity living in a specific area and that the mooring buoys can host a great and heterogeneous fouling community, allowing the discovery of rare or neglected organisms previously unreported (Furfaro et al. 2019). Data mining on the Web gave further results, confirming the considerable amount of information available and pourable to the scientific context. The aim of this work is to: 1) investigate the diversity of marine heterobranchs present in the study area; 2) update the real

geographical range of these species and 3) offer a new perspective on their global distribution.

MATERIALS AND METHODS

On 28/08/2020, at 5 m depth (water temperature was 25 C°), at the end of a scuba dive in Secca del Papa 2 (40.915171°N 9.747818°E; ‘Tavolara Punta Coda Cavallo’ M.P.A.) served by a mooring buoy for diving, the jumper and the chain were, as usual, meticulously checked as they were covered by a turf composed mainly by algae and hydroids. A portion of the turf was collected for subsequent in-depth laboratory analysis.

On 04/02/2023, at 5 m depth (water temperature was 14 C°), at the end of a scuba dive in Cala Cicale (40.895333°N 9.705600°E; ‘Tavolara Punta Coda Cavallo’ M.P.A.) served by a mooring buoy for diving, the same inspective procedure was applied. A portion of turf was collected containing an organism, unidentifiable *in situ*.

Samples were photographed *in vivo* with a Nikon D3X camera and subsequently preserved in 96% ethanol for further investigations. The two specimens were catalogued with the vouchers RM3_2381 and RM3_2792 and stored in the collection of Roma Tre University (Rome, Italy).

After the identification through bibliographic comparison, the research on the web took place on Google and Google scholar search platforms using the current species names (*Camachoaglaja africana*, *Biuve fulvipunctata*) and their known synonyms (*Chelidonura africana*, *Chelidonura fulvipunctata*, *Chelidonura italica*, *Chelidonura leopoldoi*) as the key words. Finally, the results of the web search were verified by consultation of the original images thanks to the authors of each photo that shared their useful shots.

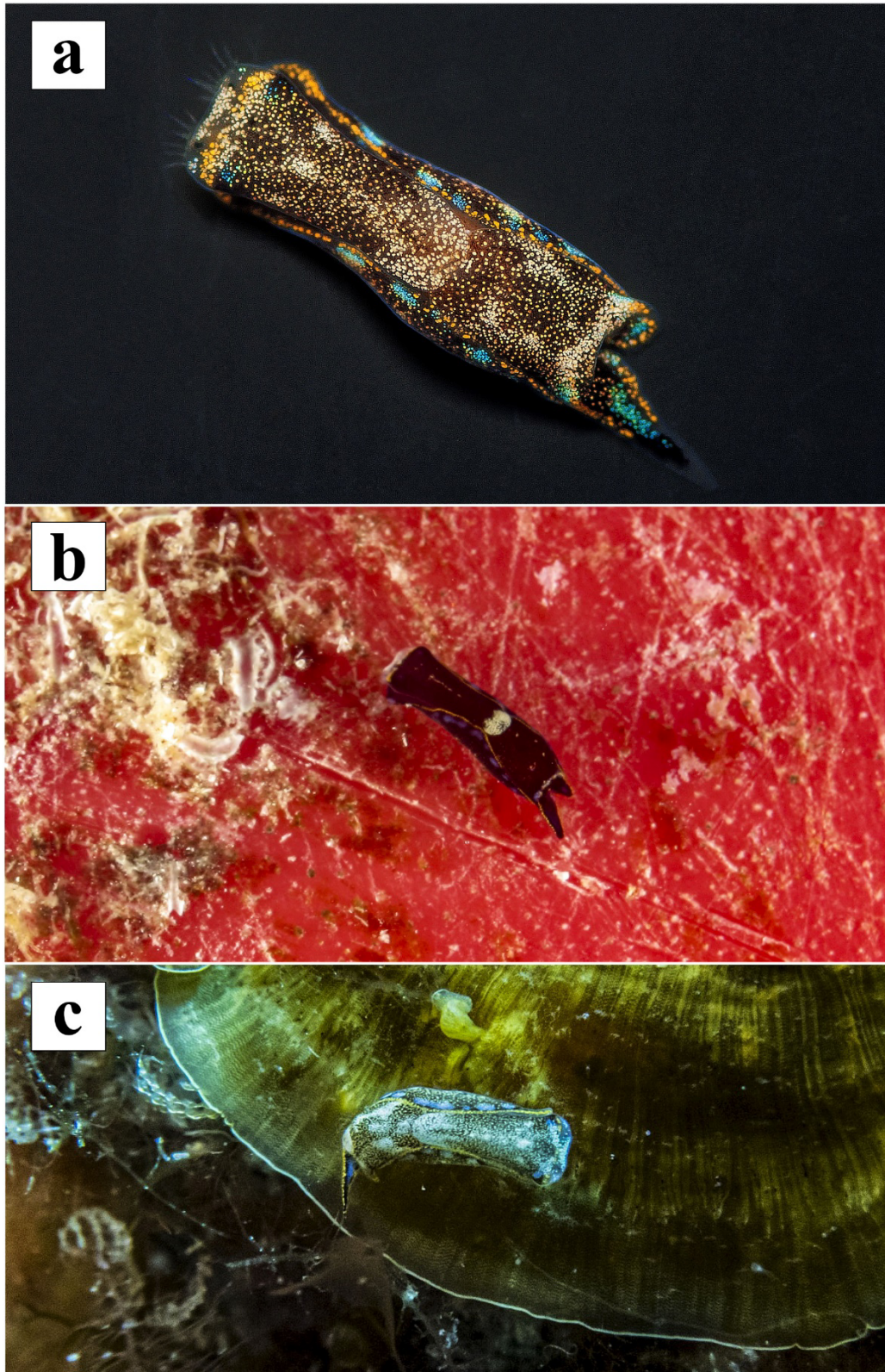


Figure 1. *Camachoaglaja africana*: a. Secca del Papa 2, 'Tavolara Punta Coda Cavallo' M.P.A., Italy, 28/08/2020, 3 mm. (Voucher RM3_2381); b. Occhio di Dio, 'Tavolara Punta Coda Cavallo' M.P.A., Italy, 17/05/2016; c. Scoglio del Medico, Ustica, Italy, 2023.

RESULTS

The observation in the laboratory allowed to identify the specimen collected on 28/08/2020 (Voucher RM3_2381) as *Camachoaglaja africana* (Pruvot-Fol 1953) (Fig. 1a).

Identification took place based on the external morphological features described by Pruvot-Fol (1953) in Plate III Fig. 37-38-39 (Fig.

2), and following Martinez et al. (2002). In particular, the specimen had (i) a blackish background colour, scattered with white spots mainly concentrated both at the anterior and posterior part of the cephalic shield and at the posterior end of the mantle (ii) an orange line delimiting the parapodial lobes and the caudal processes and (iii) iridescent blue spots on the edge of the parapodia and caudal processes.

Travaux de l'Institut Scientifique Chérifien, n° 5, 1952.



Hélène Gantès delin. et pinx.

Dreux-Barry, imp., janvier 1952.

OPISTHOBRANCHES DE LA COTE ATLANTIQUE DU MAROC

Figure 2. *Camachoaglaja africana*: original drawings, modified from Pruvot-Fol, 1953, Plate III Fig. 37–39.

The individual alive and fully extended was 3 mm long. Results from the web search revealed three additional records for the examined area. The first one concerns specimens photographed in Cagliari (Sardinia, Italy) by A. Piras in 2005 and published on <http://www.seaslugforum.net/showall/chelafri>. The relative pictures depicted juveniles possibly belonging to *C. africana*, however, due to the low quality of the images and the absence of an

adult individual, these findings remain doubtfully attributed to the species in question. The second one, dating back to 17/05/2016, regards an individual, photographed in the ‘Tavolara Punta Coda Cavallo’ M.P.A. (Sardinia, Italy) on the almost bare surface of the mooring buoy in the dive site named Occhio di Dio (40.896533°N, 9.707200°E) at the depth of 5 m (*vide* M. Munaretto; available at www.biologiamarina.org) (Fig. 1b). The third

one is about a specimen photographed on August 2023 in Ustica (Sicily, Italy) at Scoglio del Medico (38,712197°N, 13,175136°E) at 5 m depth (*vide* Elisa Manganelli; available at <https://sailingbubbles.com/>) (Fig. 1c). An additional record from the Bahamas (https://www.reeflex.net/tiere/11138_Camachoaglaja_africana.htm) should be corrected since it is the misidentification of *Camachoaglaja*

berolina (Er. Marcus and D. B-R. Marcus 1970). The ones here reported constitute the first records of *C. africana* for Sardinia and for the whole Tyrrhenian Sea. The new finding together with bibliographical and web collected data, allowed to highlight the body colour pattern variability and to improve the current known range of distribution of this species (Table 1 and Fig. 3).

Table 1. Localities of the currently known global distribution of *Camachoaglaja africana*.

Locality		Author	Coordinates	
1	Témara, Marocco	Pruvot-Fol 1953	6.955305 W	33.933105 N
2	Dakar, Senegal		17.473104 W	14.673175 N
3	Secche della Meloria, Livorno, Italy	Sordi 1980	10.219000 E	43.548000 N
4	Cabo de Palos, Murcia, Spain	Templado et al. 1983	0.704592 W	37.629914 N
5	Islas de Las Palomas, Algeciras, Spain	Garcia and Garcia 1984	5.433333 E	36.063333 N
6	La Ballenera, Algeciras, Spain, Spain		5.426666 E	36.081666 N
7	Cabo de Gata, Spain	Ballesteros et al. 1986	2.183333 E	36.716666 N
8	El Hierro, Canarias, Spain	Ortea et al. 1996	17.997739 W	27.824609 N
9	Il Qajjenza et al.loc., Malta	Perrone and Sammut 1997	14.531300 E	35.833482 N
10	Sao Miguel, Azores	Gosliner 1998	25.625921 W	37.732816 N
11	Salina Bay, Qawra, Malta	Mifsud 1998	14.428424 E	35.953773 N
12	Playa del Hombre, Tenerife, Canarias, Spain	Martinez et al. 2002	16.331551 W	28.566552 N
13	N Porto Santo Island, Madeira		16.323898 W	33.107714 N
14	Porto do Abrigo, Porto Santo Island, Madeira		16.334306 W	33.075975 N
15	Baja do Ponta Delgada, Sao Miguel, Azores		25.664333 W	37.733165 N
16	Cagliari, Italy	Piras 2005	9.152565 E	39.182896 N
17	Susak, Croatia	Turk 2006	14.313862 E	44.512353 N
18	Faial, Azores	Malaquias et al. 2009	28.608365 W	38.536260 N
19	Mosteiros, Azores	Malaquias et al. 2014	25.832229 W	37.889538 N
20	Isla del Toro, Mallorca, Balears, Spain	Darder 2010; Lopez-Arenas i Cama 2016	2.471943 E	39.462049 N
21	Cala d'Aiguafreda, Spain	Salvador 2017	3.228431 E	41.963440 N
22	Portorose, Slovenia	Lipej et al. 2017	13.590846 E	45.514290 N
23	Messina, Italy	Villari and Scuderi, 2017	15.572376 E	38.189481 N

Locality		Author	Coordinates	
24	Baia d'Argento, Taranto, Italy	Alemanno 2018	17.330558 E	40.362594 N
25	Zadar, Croatia	Prkic et al. 2018	15.199720 E	44.131122 N
26	Split, Croatia		16.410410 E	43.516347 N
27	Epanomi Cape, Greece	Manousis et al. 2020	22.898482 E	40.374152 N
28	Porto Pirrone, Italy	Furfaro et al. 2020	17.328036 E	40.357719 N
29	Campomarino, Italy		17.528189 E	40.292989 N
30	Isola dei Conigli, Porto Cesareo, Italy		17.882664 E	40.258930 N
31	Gallipoli, Italy		17.997292 E	40.076305 N
32	S. Maria al Bagno, Italy		17.996230 E	40.125161 N
33	Forum bathing area, Barcelona, Spain	Parera et al. 2020	2.232577 E	41.415604 N
34	Eastern Sicily (Catania, Aci Trezza and Santa Tecla), Italy	Lombardo and Marletta, 2022a	15.120028 E	37.530528 N
			15.126778 E	37.533917 N
			15.166361 E	37.566083 N
			15.184722 E	37.639778 N
			15.181167 E	37.637583 N
35	Occhio di Dio, 'Tavolara Punta Coda Cavallo' M.P.A., Italy	fide M. Munaretto (www.biologiamarina.org)	9.707200 E	40.896533 N
36	Secca Papa 2, 'Tavolara Punta Coda Cavallo' M.P.A., Italy	Present paper	9.747818 E	40.915171 N
37	Scoglio del Medico, Ustica, Italy	fide E. Manganelli (https://sailingbubbles.com)	13.175136 E	38.712197 N

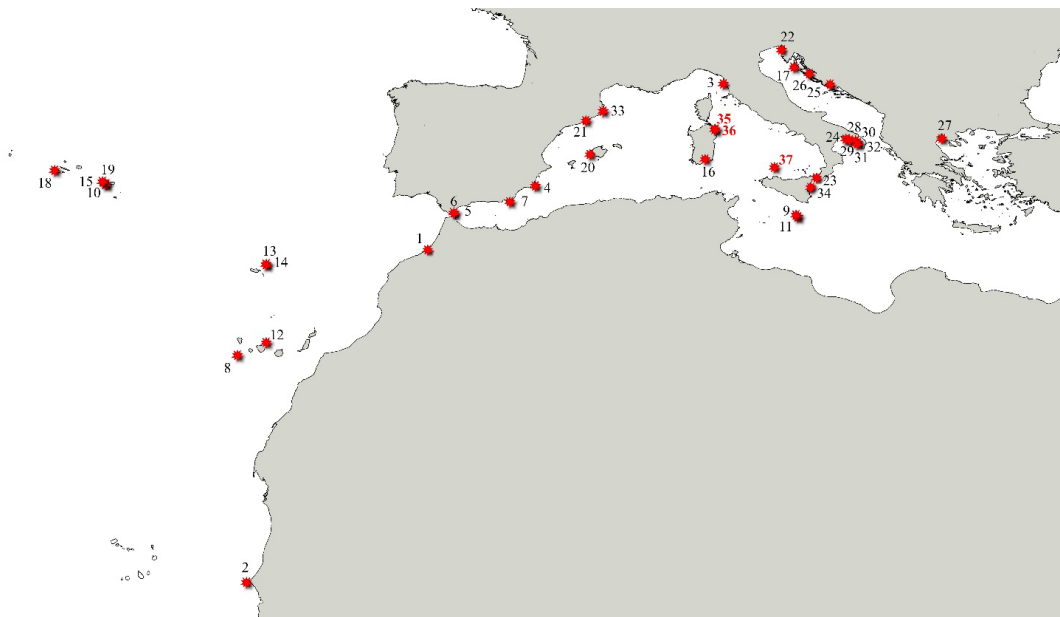


Figure 3. *Camachoaglaja africana*: Current global known distribution (numbers refer to Table 1: in red, localities added in present paper).

The in-depth observation in the laboratory allowed to identify the second collected specimen (Voucher RM3_2792) as *Biuve fulvipunctata* (Baba 1938) (Fig. 4). Despite the species has a wide range of patterns and colours in the various zones of its distribution area, the specimen examined showed the characteristic features of this species: the yellowish-white W-shaped mark on the anterior part of the cephalic shield, the median dorsal stripe of similar colour, the

greyish-brown background colour with fine whitish-yellow speckling and with large yellow-orange spots scattered over the dorsum, the typical long and thin tail on the left side of the mantle shield with bluish spots and the whitish foot. When fully stretched out, the individual was 17 mm long and in a lit environment it sought shelter under the turf fragments, conspicuously contracting the body to almost form a sphere of a few millimetres in diameter.

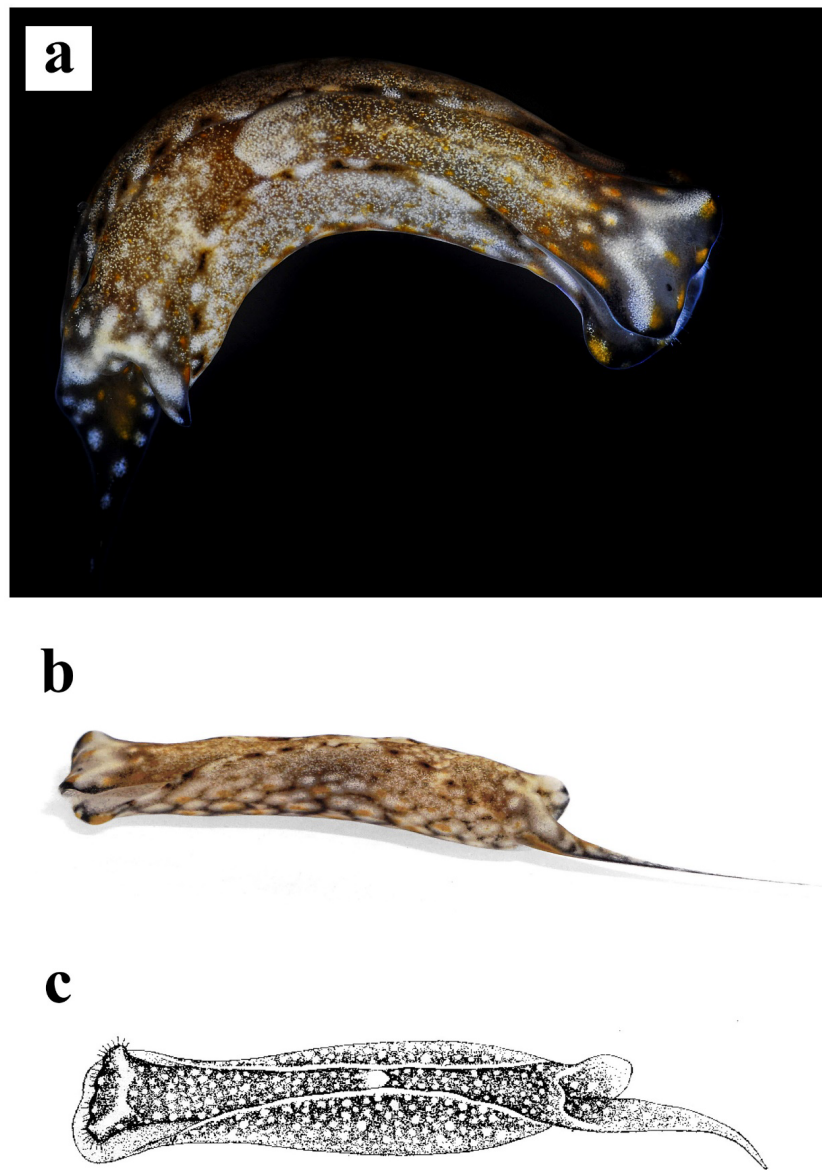


Fig. 1.—*Chelidonura fulvipunctata*. (L. 15 mm).

Figure 4. *Biuve fulvipunctata*. a. Dorsal view of the specimen (Voucher RM3_2792) from Cala Cicale, ‘Tavolara Punta Coda Cavallo’ M.P.A., Italy, 17 mm. b. Lateral view of the same individual (Voucher RM3_2792) c. original drawing from Baba (1938).

This is the first observation for Sardinia and the whole Tyrrhenian Sea. A broad search on the web allowed the addition of recent reports concerning the Canary Islands (Spain) (Dennis

Rabeling 2021). The new finding, bibliographical and web collected data allowed to reconstruct the current distribution range of the species (Table 2 and Fig. 5).

Table 2. *Biuve fulvipunctata*: Global distribution and localities of the currently known distribution in the Mediterranean Sea and the Atlantic Ocean.

Locality		Author	Coordinates	
1	Selimiye, Antalya, Turkey	Swennen 1961	31.39061 E	36.76468 N
2	Ashqelon, Israel	Mienis and Gat 1987	34.58604 E	31.66211 N
3	Ghar Lapsi, Malta	Perrone and Sammut 1997	14.4247528 E	35.8272667 N
4	North-west side of Malta	Sammut and Perrone 1998	14.3257444 E	35.9847278 N
5	South-west side of Malta		14.4588333 E	35.8175611 N
6	Cyclops Cave, Protaras, Cyprus	Tsiakkiros and Zenetos 2011	34.0766111 E	34.9862056 N
7	Agios Georgios Alamanou Limassol, Cyprus		33.2199167 E	34.7063611 N
8	Agay, Saint-Raphael, France	Horst 2015	06.0429306 E	43.4263361 N
9	S'Algar, Menorca I., Spain	Malaquias et al. 2016a	04.3508333 E	40.0311111 N
10	Off Mediterranean Beach Hotel, Limassol, Cyprus	Malaquias et al. 2016b	33.1314550 E	34.7075980 N
11	Lago di Faro Messina, Italy		15.6273361 E	38.2608778 N
12	N San Felipe, Gran Canaria, Spain	Herrero-Barrencia et al. 2016	15.59798 W	28.14314 N
13	Punta de Pasito Blanco, Gran Canaria, Spain		15.62248 W	27.74739 N
14	El Tamaduste, El Hierro, Spain		17.94512 W	27.79640 N
15	Charco Mansoi, El Hierro, Spain		17.92546 W	27.84905 N
16	Charco Azul, El Hierro, Spain		18.03948 W	27.76155 N
17	San Juanito, Punta del Hidalgo, Tenerife, Spain		16.32961 W	28.57593 N
18	Messina Harbour, Italy	Villari and Scuderi, 2017	15, 563493 E	38.193555 N
19	Voluja bay, Marina, Croatia	Petani and Crocetta 2019	16.08028 E	43.48306 N
20	Santa Tecla, Acireale, Italy	Lombardo and Marletta 2020b	15.184157 E	37.639923 N
21	Cape Epanomi, Thermaikos Gulf, Greece	Manousis et al. 2020	22.898482 E	40.374152 N
22	Faro de Puerto Calero, Lanzarote, Canarias, Spain	Rabeling 2021	13.705461 W	28.915523 N
23	Playa Chica, Lanzarote, Canarias, Spain		13.668885 W	28.918140 N

Locality		Author	Coordinates	
24	Off Hotel Fariones, Lanzarote, Canarias, Spain		13.664771 W	28.918715 N
25	Castillo de Santa Catalina, Cádiz, Spain.	Patiño Gómez et al. 2022	6.309028 W	36.532583 N
26	Cala Cicale, 'Tavolara Punta Coda Cavallo' M.P.A., Sardinia, Italy	Present paper	9.705600 E	40.895333 N

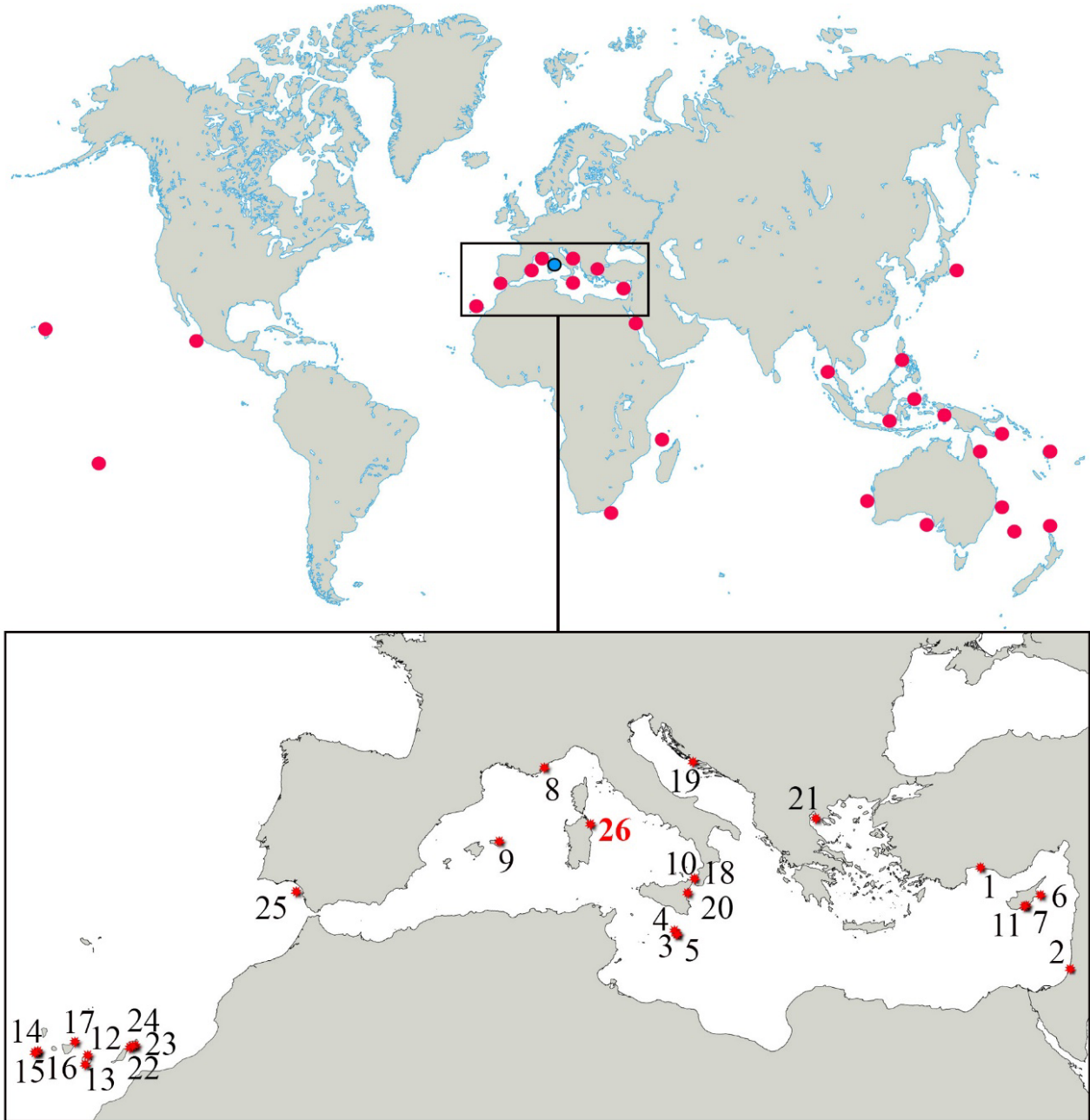


Figure 5. *Biuve fulvipunctata*: Global and detailed distribution in the Mediterranean Sea and the Atlantic Ocean. Numbers refer to Table 2: blue dot (upper map) and number in red (lower map) indicate the locality added in present paper.

DISCUSSION

The taxonomic history of *Camachoaglaja africana* does not appear linear and does not seem to be fully resolved to date. It was described as *Chelidonura africana* from specimens collected at Dakar (Senegal) and Témara (Atlantic Morocco) in a very succinct way and mainly based on three drawings reported in the original illustrative plates (Pruvot-Fol 1953) (Fig. 2). It was consolidated with the filing of a neotype collected in Tenerife (Canary Islands, Spain) by Martínez et al. (2002): in the same paper, they definitively placed in synonymy *Chelidonura italica* Sordi, 1980, described on samples from the sea of Livorno, in Ligurian Sea, following Renda et al. (2022). Martínez et al. (2002), considered as irrelevant the differences between the specimens from Gibraltar, the eastern Spanish coast, Malta, Madeira, Azores and Canary Islands published by various authors and all assigned to *C. africana*. Another species was established from Canarian specimens as *Chelidonura leopoldoi* Ortea et al. (1996). Recently *C. africana* has been reported in the Adriatic Sea (Turk and Furlan 2011). In the most recent taxonomic revision based on a genetic evidence (Zamora-Silva and Malaquias 2017), *C. africana* has been moved to the currently accepted genus *Camachoaglaja* and *C. leopoldoi* defined as its junior synonym. Nowadays, both the congeneric *C. italica* and *C. leopoldoi* are considered on WoRMS as synonyms of *C. africana* (Mollusca Base 2023). The current known distribution of *C. africana* and the short time elapsed between the first description along the Western African Coast (1953) and the first findings in the Mediterranean (in 1976 Sordi wrote that he had already found this species since many years north of Isola d'Elba, in the Ligurian Sea) make it very plausible that it is a species with primeval NE Atlantic-Mediterranean distribution and therefore that it should not be considered as introduced.

Biuve fulvipunctata was originally described from Kii Peninsula, Japan (Baba 1938), and is currently widespread in the Indo-

Pacific Ocean (Gosliner 1987, Gosliner et al. 2015). The sequence of Mediterranean findings of *B. fulvipunctata* was first reconstructed and updated by Malaquias et al. (2016b) and more recently by Lombardo and Marletta (2020b). The first and to date only one finding in the Adriatic Sea took place in 2018 (Petani and Crocetta 2019). The report contained in this communication demonstrates that the geographical range of distribution of this species should be expanded with the inclusion of the Tyrrhenian Sea (Table 1 and Fig. 3). There are no records from the Mediterranean African shores, but this is common to other non-indigenous and/or cryptogenic species and could be explained by the minor research effort operated along those coasts that is, when present, restricted to punctiform geographic sites.

Regarding the Atlantic area, within June and October 2016, many *B. fulvipunctata* individuals were found in six different localities of the Canary Islands expanding the distribution range of this species to NE Atlantic Ocean (Herrero-Barrencua et al. 2016). In the same year and before the publication of these last findings, a controversy arose regarding the possible anti-Lessepsian migration of the species from the Mediterranean Sea to the Red Sea (Malaquias et al. 2016b; Galil et al. 2016). However, understanding the dispersal pathway of a species is a challenging field of research which cannot be separated from a massive sampling effort throughout the geographic range of the species and possibly corroborated by a haplotype network analysis. At the present we can only speculate that *B. fulvipunctata* findings in the NE Atlantic and its wide distribution along the Mediterranean basin, suggest a possible cosmopolitan scenario (Table 2 and Fig. 5). The latter hypothesis is even more realistic if considering the small sizes of this species and its inconspicuous appearance. Furthermore, Aglajidae generally burrow in sand or mud or live under rocks (Gosliner 1987), characteristics that make it difficult to find these species even in areas where research is highly developed and long-lasting in time.

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