2021-03-09

The role of social media in compensating for the lack of field studies: five new fish species for the Mediterranean Egypt

Al Mabruk, SAA

10.1111/jfb.14721
Journal of Fish Biology
Wiley

The role of social media in compensating for the lack of field studies: five new fish species for the Mediterranean Egypt

Sara A.A. Al Mabruk[1,2], Abdulghani Abdulghani[3], Ola Mohamed Nour[4], Mohammed Adel[5], Fabio Crocetta[6], Nikolaos Doumpas[7], Periklis Kleitou[8], Francesco Tiralongo[9, 10]*

[1]Zoology Department, Faculty of Science, Omar Al-Mokhtar University, El Bayda, Libya
[2] Marine Biology in Libya Society, El Bayda, Libya
[3] Department of Marine Resources, Omar Al-Moukhtar University, ElBayda, Libya
[4] Department of Biology and Geology, Faculty of Education, Alexandria University, Alexandria, Egypt
[5] Head of the Egyptian CMAS spearfishing committee, Egypt
[6] Department of Integrative Marine Ecology, Stazione Zoologica Anton Dohrn, I-80121 Naples, Italy
[7] iSea, Environmental Organization for the Preservation of Aquatic Ecosystems, Thessaloniki, Greece
[8] Marine and Environmental Research (MER) Lab Ltd, Zygi, Cyprus
[9] Department of Biological, Geological and Environmental Sciences, University of Catania, Catania, Italy
[10] Ente Fauna Marina Mediterranean, Avola, Italy

*Correspondence: Francesco Tiralongo, Department of Biological, Geological and Environmental Sciences, University of Catania, Catania, Italy. Email: francesco.tiralongo@unict.it

Abstract

In the Mediterranean Sea, where biological invasions constitute a serious threat, the combination of citizen science and social networks amplified the power of proper field studies, recording species that would have otherwise presumably pass unnoticed. Based on data collected on several Facebook groups, we hereby first report the presence of five fish taxa (*Kyphosus* sp., *Heniochus intermedius*, *Pomacanthus imperator*, *Pomacanthus maculosus* and *Abudefduf* sp.) new for the Mediterranean Egypt, revise their distribution in the Mediterranean Sea, and discuss their possible introduction pathways. Finally, we provide some considerations on the potentiality of social media for citizen science projects.

KEYWORDS: non-indigenous species, Lessepsian immigrants, Facebook groups, citizen science, social networks.

The Mediterranean Sea represents one of the main biodiversity hotspots in the world, hosting over 8500 macroscopic species and a fish diversity of about 700 species (Bianchi & Morri, 2000; Coll *et al.*, 2010; Psomadakis *et al*., 2012). Its biodiversity is threatened by non-indigenous species (NIS) –

i.e. those introduced outside their natural range directly or indirectly by human activities (Essl *et al*., 2018), with about 1000 taxa recorded from the basin and introduced via pathways such as shipping, aquaculture, and corridors (Katsanevakis *et al*., 2014a; Zenetos *et al*., 2017). The Mediterranean Sea is also increasingly colonized by species of Atlantic origin that presumably entered the area through the Strait of Gibraltar (Crocetta *et al*., 2013; Canning-Clode & Carlton, 2017).

Monitoring species movements over the years represents an important target for the study of marine biodiversity on a large spatial scale and to address fundamental ecological questions across a diverse range of contexts and guide conservation practices and management (Kremen *et al*., 1994; Manley *et al*., 2004). Particular attention should be also paid to the early detection of NIS that may become invasive and cause adverse ecological and socioeconomic threats at a local or Mediterranean scale level (Katsanevakis *et al*., 2014b). In this view, citizen science constitutes a useful and efficient tool even in widely-studied biogeographic marine regions such as the Mediterranean Sea, and the use of social media amplifies data collection in a relatively short period of time (Ambrose-Oji *et al*., 2014; Bariche & Azzurro, 2016; Liberatore *et al*., 2018; Azzurro & Tiralongo, 2020). Indeed, in recent decades, the emergence of internet and crowdsourcing platforms provide an unprecedented source of diverse and accessible ecological data made available thanks to citizen scientists that researchers only beginning to explore (Kobori *et al*., 2016; Giovos *et al*., 2019; Tiralongo *et al*., 2019a). In this context, Facebook groups dealing with marine biodiversity and/or fishing activities cover a fundamental role in grouping people with a common interest in sharing photos/videos and offer novel opportunities for regular spatio-temporal data on "oddities", which improve the knowledge on the ecology, occurrence and distribution of the selected species (e.g. Giovos *et al*., 2019; Tiralongo *et al*., 2019b, 2020).

This is even more true for areas that received scarce attention due to objective constrains, such as the Mediterranean Egyptian coast, a region that also constitutes the frontline for the Lessepsian species spreading through the Suez Canal (Mavruk & Avsar, 2007; Galil *et al*., 2017). In fact, despite the Egyptian Mediterranean coastline extends for more than 1000 km, it has so far received little attention by the scientific community, with records of rare or non-indigenous species often scattered in specialist literature produced by few authors (e.g. Halim & Rizkalla, 2011; Moussa & Zenetos, 2015, 2016; Moussa *et al*., 2016; Akel, 2017a, 2017b; Akel & Rizkalla, 2017; Al Mabruk *et al*., 2020).

We hereby contribute to widen the knowledge of the local biota by reporting the presence of five fish taxa new from the Mediterranean coastline of Egypt, revising their distribution in the Mediterranean Sea, and discussing their possible introduction pathways.

Data were collected through periodic and regular search in Egyptian fishing groups on Facebook™ (Tuna – تونة; صيادين اسكندرية الريس عبدالله الصياد; خبراء الغوص و الصيد بالهربون; جروب الصياد

السكندرى; صيآدين في بحر مطروح; PATHOS Egypt; محترفي صيد الاسكندرية و الساحل; صيد السمك فى مصر; صيادين
اسكندرية والصيد بالهاربون) conducted during the entire year 2020. When one or more photos/videos of species of interest (non-indigenous and rare fish species) were posted in a group, the author of the posting was soon contacted in order to obtain additional data about the record (date, location, geographical coordinates, depth, fishing method, and notes) and to verify its credibility for the validation of the observation. For each species here reported, literature review of known Mediterranean records per species was performed.

Class Actinopterygii Klein, 1885

Order Perciformes Bleeker, 1863

Family Kyphosidae Jordan, 1887

Genus Lacepède, 1801

Kyphosus sp.

Material examined: 1 specimen (photo), Alexandria – El Montazah beach (31°17'27.4"N 30°01'17.6"E), 30th March 2017, 9 m, sandy bottom, *legit* Mohamed Khamis (Figure 1A).

Remarks: As the present specimen was not preserved, we cannot provide an identification at a species level. However, only two species of *Kyphosus* are recognized as being present in the Mediterranean Sea, namely *Kyphosus sectatrix* (Linnaeus, 1758) and *Kyphosus vaigiensis* (Quoy & Gaimard, 1825) (see Mannino *et al*., 2015). These species are both widely distributed in all oceans, including the Atlantic and Indo-Pacific regions and the Red Sea (Mannino *et al*., 2015). *Kyphosus sectatrix* was recorded in the western and central Mediterranean Sea since the 19th century, and recently reported also from Greece (Kiparissis *et al*., 2012). On the other hand, records of *K. vaigiensis*, although more recent, extend from the western to the eastern part of the basin (see Francour & Mouine, 2008; Orsi-Relini *et al*., 2010; Ligas *et al*., 2011; Azzurro *et al*., 2013; Mannino *et al*., 2015; Goren *et al*., 2016; Michailidis & Rousou, 2017; Kiyaga *et al*., 2019). Both fish are pelagic inshore species, but often also occur offshore under floating objects or ships. In the Mediterranean Sea, specimens were caught in shallow waters (generally up to 16 m on rocky or mixed bottom) with both recreational and professional fishing gears (Francour & Mouine, 2008; Orsi-Relini *et al*., 2010; Ligas *et al*., 2011; Kiparissis *et al*., 2012; Azzurro *et al*., 2013; Mannino *et al*., 2015; Kiyaga *et al*., 2019). The present sighting constitutes the first record of the genus *Kyphosus* in the Mediterranean waters of Egypt.

Family Chaetodontidae Rafinesque, 1815

Genus *Heniochus* Cuvier, 1816

Heniochus intermedius Steindachner, 1893

Material examined: 1 specimen (photo), El Dabaa – Marsa Matruh (31°04'07.4"N 28°28'13.7"E), 16th November 2017, 13 m, mixed bottom (sand and rocks), *legit* Fathi Nagi Abou Nagi (Figure 1B).

Remarks: Species identification was performed following Pyle (2001). Early Mediterranean records of this species, widespread in the Indo-West Pacific and the Red Sea (Erguden *et al*., 2016), date back to 2002, when a single specimen was observed in Turkey (Gökoglu *et al*., 2003). The species was subsequently recorded in Lebanon (2011: Bariche, 2012), again in Turkey (2011: Erguden *et al.*, 2016), and in Israel (2014: Tsadok *et al*., 2015) and Malta (2014: Evans *et al*., 2015). All specimens were recorded in 3–19 m depth on hard substrates. The present sighting constitutes the first record of the species in the Mediterranean waters of Egypt.

Family Pomacanthidae Jordan & Evermann, 1898

Genus *Pomacanthus* Lacepède, 1802

Pomacanthus imperator (Bloch, 1787)

Material examined: 1 specimen (photo), El Dabaa – Marsa Matruh (31°05'12.2"N 28°26'12.3"E), 15th May 2019, 12 m, mixed bottom (sand and rocks), *legit* Fathi Nagi Abou Nagi (Figure 1C).

Remarks: Species identification was performed following Golani *et al*. (2010). The first Mediterranean record of this species, widely distributed in the Indo-Pacific region (Randall, 2007), dates back to 2009 (Golani *et al*., 2010), when a single specimen was caught in Israel. The species was subsequently recorded in Syria (2017 and 2018: Capapé *et al*., 2018; Saad *et al*., 2018) and in Turkey (2019: Gurlek *et al*., 2019). All specimens were caught in 5–40 m depth on rocky and sandy bottoms. The present sighting constitutes the first record of the species in the Mediterranean waters of Egypt.

Pomacanthus maculosus (Forsskål, 1775)

Material examined: 1 specimen (photo), Alexandria (31°12'43.4"N 29°53'02.8"E), 27th August 2019, 10 m, mixed bottom (sand and rocks), *legit* Ahmed Elbarawy (Figure 1D); 1 specimen (photo),

Alexandria (31°18'36.7"N 30°04'23.7"E), 27th September 2019, 5 m, sandy bottom, *legit* Frass Fathy; 1 specimen (photo), Alexandria (31°13'26.1"N 29°53'56.3"E), 5th May 2020, 20 m, sandy bottom, *legit* Mohamed Hussein; 1 specimen (photo), Alexandria (31°16'14.7"N 29°59'17.5"E), 26th September 2020, 12 m, mixed bottom (sand and rocks), *legit* Mohammad Adel.

Remarks: Species identification was performed following Allen *et al*. (1998). The first Mediterranean record of this species, whose natural distribution extends from the Red Sea and Persian Gulf to Mozambique (Allen *et al*., 1998), dates back to 2009, when two specimens were observed in Lebanon and another specimen was caught in Israel (Bariche, 2010; Salameh *et al*., 2012). More recently, a specimen was recorded in Malta in 2012 (Evans *et al*., 2016). Three specimens were spearfished and one caught with trolling line in 10–25 m depth on rocky and mixed bottoms. The present sightings constitute the first records of the species in the Mediterranean waters of Egypt.

Family Pomacentridae Bonaparte, 1831

Genus *Abudefduf* Forsskål, 1775

Abudefduf sp.

Material examined: 1 specimen (video), Al Montazah-Askandria (31°17'39.3"N 30°01'10.4"E), 30th March 2013, 3 m, mixed bottom (sand and rocks), *legit* Mohammad Adel (Figure 1E).

Remarks: As the present specimen was not sampled, we cannot provide an identification at a species level. Four non-native *Abudefduf* species were recorded in the Mediterranean Sea so far, although the majority of the records regard the Atlantic *A. saxatilis* (Linnaeus, 1758) and the Indo-Pacific *A. vaigiensis* (Quoy & Gamard, 1825), that were recorded from all over the Mediterranean Sea (see Osca *et al*., 2020; Pirkenseer, 2020; Zenetos & Miliou, 2020; Dragičević *et al*., 2021). All specimens were generally observed in very shallow waters, in 2–4 m depth on hard bottoms. The present sighting constitutes the first record of the genus *Abudefduf* in the Mediterranean waters of Egypt.

This study reports five new fish taxa for the Mediterranean waters of Egypt, whose data were collected through various Facebook groups dedicated to fishery. Notwithstanding the evident limitations of this approach and the absence of concrete material, three of them were positively identified up to species level, namely *Heniochus intermedius*, *Pomacanthus imperator* and *Pomacanthus maculosus*, while the two remaining species were only identified up to genus level. With regards the former group of species, the details acquired are consistent with bathymetric range

(coastal shallow waters) and habitat type (mixed bottom) commonly reported in the literature from the Mediterranean Sea (see above). However, present sightings fill a gap in their known distribution and those of *P. maculosus* also double the number of individuals recorded so far from the entire Mediterranean basin from 4 to 8 specimens. These taxa all have a native distribution in the Indo-Pacific region, including the Red Sea, and were often considered as Lessepsian immigrants (Gökoglu *et al*., 2003; Bariche, 2010, 2012; Salameh *et al*., 2012; Tsadok *et al*., 2015; Gurlek *et al*., 2019). However, other pathways have been also proposed, such as aquarium release and shipping — taking also into account absence of records from the Mediterranean Egypt and isolated records held far from the Suez Canal (Golani *et al*., 2010; Evans *et al*., 2015, 2016; Erguden *et al*., 2016; Zenetos *et al*., 2016; Capapé *et al*., 2018; Saad *et al*., 2018; Giovos *et al*., 2020). Although also in the present case there are no certainties regarding a potential pathway of arrival, which may involve Lessepsian spreading, shipping, or aquarium release, or a combination of them, the vicinity between the Red Sea and the Egyptian areas where the records occurred suggests that all these species most likely entered unaided in the Mediterranean Sea via the Suez Canal. In addition, this may also have happened long time ago, with species remaining unnoticed in the area due to absence of targeted field studies, and thus the record of their presence in the Mediterranean Egypt may be presumably happening with a wide time lag — about 20 years for *H. intermedius* and 10 years for both *Pomacanthus* taxa, at least as based on their first records in the Mediterranean Sea. On the other hand, with regards the latter group of species (those of the genera *Kyphosus* and *Abudefduf*), their presence in the Mediterranean Egypt could be the result of a secondary introduction from populations already established in the nearby countries (Goren *et al*., 2016; Dragičević *et al*., 2021) or that may have reached the area through the Suez Canal, thus accounting for new alien introductions. Unfortunately, uncertainties in the identifications explained above prevent us to further discuss potential hypotheses.

Apart of that, the present paper confirms the importance of citizen science integrated with the use of social networks for the early detection and monitoring of alien and rare fish species in the Mediterranean Sea, especially in areas where targeted and/or in general field studies are scarce to absent. This is particularly true for the Mediterranean coast of Egypt, where the number of alien species occurring in the area is in all likelihood considerably underestimated and that has a pivotal role for the early detection of Lessepsian species. A close collaboration between researchers and sea users through social networks should be further improved and widened to species with no commercial interest or that are not consumed.

ACKNOWLEDGEMENTS

The authors express their gratitude to the fishermen: Ahmed Elbarawy, Frass Fathy, Mohamed Hussein, Mohamed khamis, Fathi Nagi Abou Nagi, who generously provided photos and data of the recorded species.

AUTHOR CONTRIBUTIONS

S. A. A. A. M. collected data, wrote and revised drafts of the paper. A. A. collected data, wrote and revised drafts of the paper. O. N. collected data, wrote and revised drafts of the paper. M. A. collected data, wrote and revised drafts of the paper. F. C. wrote and revised drafts of the paper. N. D. wrote and revised drafts of the paper. P. K. wrote and revised drafts of the paper. F. T. wrote first draft of the manuscript, prepared figure and revised drafts of the paper.

REFERENCES

Akel, E. H. Kh. (2017a). A first record of *Bathygobius cyclopterus* (Cuvier & Valenciennes, 1837) in the Mediterranean Sea. In: Stamouli *et al*. New Mediterranean Biodiversity Records. *Mediterranean Marine Science*, *18*, 534–556.

Akel, E. H. Kh. (2017b). A new record of the Blackspot seabream *Pagellus bogaraveo* (Brünnich, 1768) in the south-eastern Mediterranean Sea. In: Stamouli *et al*. New Mediterranean Biodiversity Records. *Mediterranean Marine Science*, *18*, 534–556.

Akel, E.H.Kh., & Rizkalla, S. I. (2017). Biometric characteristics of *Anthias anthias* from Damietta. In: Lipej *et al*. New Mediterranean Biodiversity Records. *Mediterranean Marine Science*, *18*, 179–201.

Al Mabruk, S. A. A., Rizgalla, J., Giovos, I., & Bariche, M. (2020). Social media reveals the first records of the invasive lionfish *Pterois miles* (Bennett, 1828) and parrotfish *Scarus ghobban* Forsskål, 1775 from Egypt (Mediterranean Sea). *BioInvasions Records*, *9*, 574–579.

Allen, G. R., Steene, R., & Allen, M. (1998). *A guide to angelfishes and butterflyfishes*. Odyssey Publishing, Tropical Reef Research, Perth, 250 pp.

Ambrose-Oji, B., van der Jagt, A.P.N., & O'Neil, S. (2014). *Citizen science: Social Media as a supporting tool*. Edinburgh, Forest Research.

Azzurro, E., Peña-Rivas, L., Lloris, D., & Bariche, M. (2013). First documented occurrence of *Kyphosus incisor* in the Mediterranean Sea. *Marine Biodiversity Records*, *6*, e98.

Azzurro, E., & Tiralongo, F. (2020). First record of the mottled spinefoot *Siganus fuscescens* (Houttuyn, 1782) in Mediterranean waters: a Facebook based detection. *Mediterranean Marine Science*, *21*, 448–451.

Bariche, M., & Azzurro, E. (2016). Enhancing early detection through social networks: a Facebook experiment. *Rapp. Comm. Int. Médit.*, *41*, 413.

Bariche, M. (2010). First record of the angelfish *Pomacanthus maculosus* (Teleostei: Pomacanthidae) in the Mediterranean. *Aqua, International Journal of Ichthyology*, *16*, 31–33.

Bariche, M. (2012). Recent evidence on the presence of *Heniochus intermedius* (Teleostei: Chaetodontidae) and *Platycephalus indicus* (Teleostei: Platycephalidae) in the Mediterranean Sea. *BioInvasions Records*, *1*, 53–57.

Bianchi, C.N., & Morri, C. (2000). Marine biodiversity of the Mediterranean Sea: situation, problems and prospects for future research. *Marine Pollution Bulletin*, *40*, 367–376.

Canning-Clode, J., & Carlton, J.T. (2017). Refining and expanding global climate change scenarios in the sea: Poleward creep complexities, range termini, and setbacks. *Diversity and Distribution*, *23*, 463–473.

Capapè, C., Ali, M., Ali, A., & Esmail, A. (2018). Second Mediterranean record of Emperor angelfish, *Pomacanthus imperator* (Osteichthyes: Pomacanthidae), and first record from Syrian coast. *Cahiers de Biologie Marine*, *59*, 395–397.

Coll, M., Piroddi, C., Steenbeek, J., Kashner, K., Lasram, F. B. R., … Voultisiadou, E. (2010). The biodiversity of the Mediterranean Sea: Estimates, patterns, and threats. *PloS One*, *5*, e11842.

Crocetta, F., Macali, A., Furfaro, G., Cooke, S., Villani, G., & Valdés, A. (2013). Alien molluscan species established along the Italian shores: an update, with discussion on some Mediterranean "alien species" categories. *ZooKeys*, *277*, 91–108.

Dragičević, B., Fricke, R., Ben Soussi, J. B., Ugarković, P., Dulčić, J., & Azzurro, E. (2021). On the occurrence of *Abudefduf* spp. (Pisce: Pomacentridae) in the Mediterranean Sea: a critical review with new records. *BioInvasions Records*, *10*, 188–199.

Erguden, M., Çekiç, M., Erguden, S. A., & Turan, C. (2016). Occurrence of *Heniochus intermedius* Steindachner, 1893 in Iskenderun Bay, Turkey. *Journal of Applied Ichthyology*, *32*, 375–376.

Essl, F., Bacher, S., Genovesi, P., Hulme, P. E., Jeschke, J.M., Katsanevakis, ... Richardson, D. M. (2018). Which taxa are alien? Criteria, Applications, and Uncertainties. *BioScience*, *68*, 496–509.

Evans, J., Tonna, R., & Schembri, P. (2015). Portent or accident? Two new records of thermophilic fish from the central Mediterranean. *BioInvasions Records*, *4*, 299–304.

Evans, J., Zammit, E., & Schembri, P.J. (2016). First record of the yellowbar angelfish *Pomacanthus maculosus* (Forsskål, 1775) in the central Mediterranean (Maltese Islands). *Journal of Applied Ichthyology*, *32*, 1226–1228.

Francour, P., & Mouine, N. (2008). First record of *Kyphosus spectator* (Kyphosidae) along French Mediterranean coast. *Cybium*, *32*, 275–276.

284 Galil, B., Marchini, A., Occhipinti-Ambrogi, A., & Ojaveer, H. (2017). The enlargement of the Suez
285 Canal–Erythraean introductions and management challenges. *Management of Biological*
286 *Invasions*, *8*, 141–152.
287 Giovos, I., Kleitou, P., Poursanidis, D., Batjakas, I., Bernardi, G., ... Katsanevakis, S. (2019). Citizen-
288 science for monitoring marine invasions and stimulating public engagement: a case project
289 from the eastern Mediterranean. *Biological Invasions*, *21*, 3707–3721.
290 Giovos, I., Tiralongo, F., Langeneck, J., Kaminas, A., Kleitou, P., Crocetta, F., & Doumpas. N.
291 (2020). First record of the Atlantic spadefish *Chaetodipterus faber* (Broussonet, 1782) in the
292 Mediterranean Sea: a new aquarium release in the basin? *BioInvasions Records*, *9*, 89–95.
293 Gökoglu, M., Bodur, T., & Kaya, Y. (2003). First record of the Red Sea bannerfish (*Heniochus*
294 *intermedius* Steindachner, 1893) from the Mediterranean Sea. *Israel Journal of Zoology*, *49*,
295 324–325.
296 Golani, D., Salameh, P., & Sonin, O. (2010). First record of the Emperor angelfish, *Pomacanthus*
297 *imperator* (Teleostei: Pomacanthidae) and the second record of the spotbase burrfish
298 *Cyclichthys spilostylus* (Teleostei: Diodontidae) in the Mediterranean. *Aquatic Invasions*, *5*,
299 S41–S43.
300 Goren, M., Galil, B. S., Gevili, R., & Stern, N. (2016). First record of the Brassy Chub *Kyphosus*
301 *vaigiensis* (Quoy & Gaimard, 1825) in the Eastern Mediterranean (Osteichthyes: Perciformes:
302 Kyphosidae). *Zoology in the Middle East*, *62*, 1–4.
303 Gurlek, M., Erguden, D., Atay, B., & Turan, C. (2019). First record of *Pomacanthus imperator*
304 (Bloch, 1787) from Turkish marine waters. *Natural and Engineering Sciences*, *4*, 231–236.
305 Halim, Y., & Rizkalla, S. (2011). Aliens in Egyptian Mediterranean waters. A check-list of Erythrean
306 fish with new records. *Mediterranean Marine Science*, *12*, 479–490.
307 Katsanevakis, S., Coll, M., Piroddi, C., Steenbeek, C., Lasram, F. B. R., Zenetos, A., & Cardoso,
308 A.C. (2014a). Invading the Mediterranean Sea: biodiversity patterns shaped by human
309 activities. Frontiers in Marine Science, *1*, 32.
310 Katsanevakis, S., Wallentinus, I., Zenetos, A., Leppäkoski, E., Çinar, M. E., Oztürk, B., Grabowski,
311 M., Golani, D., & Cardoso, A.C. (2014b). Impacts of marine invasive alien species on
312 ecosystem services and biodiversity: a pan-European review. *Aquatic Invasions*, *9*, 319–423.
313 Kiparissis, S., Loukovitis, D., & Batargias, C. (2012). First record of the Bermuda sea chub *Kyphosus*
314 *saltatrix* (Pisces: Kyphosidae) in Greek waters. *Marine Biodiversity Records*, *5*, e11.
315 Kiyaga, V. B., Mavruk, S., Özyurt, C. E., Akamca, E., & Coskun, C. (2019). Range extension of
316 *Kyphosus vaigiensis* (Quoy & Gaimard, 1825) in the northeastern Mediterranean, Iskenderun
317 Bay, Turkey. *Turkish Journal of Zoology*, *43*, 644–649.

318 Kobori, H., Dickinson, J. L., Washitani, I., Sakurai, R., Amano, T., Komatsu, N., ... & Miller-
319 Rushing, A. J. (2016). Citizen science: a new approach to advance ecology, education, and
320 conservation. *Ecological Research*, *31*, 1–19.
321 Kremen, C., Merenlender, A. M., & Murphy, D. D. (1994). Ecological monitoring: a vital need for
322 integrated conservation and development programs in the tropics. *Conservation Biology*, *8*,
323 388–397.
324 Liberatore, A., Bowkett, E., MacLeod, C.J., Spurr, E., & Longnecker, N. (2018). Social media as a
325 platform for a citizen science community of practice. *Citizen Science: Theory and Practice*, *3*,
326 3.
327 Ligas, A., Sartor, P., Sbrana, M., & De Ranieri, S. (2011). A new record of *Kyphosus saltatrix* (Pisces:
328 Kyphosidae) along the Italian coasts (north-western Mediterranean). *Marine Biodiversity*
329 *Records*, *4*, e6.
330 Manley, P. N., Zielinski, W. J., Schlesinger, M. D., & Mori, S. R. (2004). Evaluation of a multiple-
331 species approach to monitoring species at the ecoregional scale. *Ecological Applications*, *14*,
332 296–310.
333 Mannino, A. M., Balistreri, P., Iaciofano, D., Galil, B. S., & Lo Brutto, S. (2015). An additional
334 record of *Kyphosus vaigiensis* (Quoy & Gainard, 1825) (Osteichthyes, Kyphosidae) from Sicily
335 clarifies the confused situation of the Mediterranean kyphosids. *Zootaxa*, *3963*, 45–54.
336 Mavruk, S., & Avsar, D. (2007). Non-native fishes in the Mediterranean from the Red Sea, by way
337 of the Suez Canal. *Reviews in Fish Biology and Fisheries*, *18*, 251–262.
338 Michailidis, N., & Roussou, M. (2017). First record of the brassy chub *Kyphosus vaigiensis* (Quoy &
339 Gaimard, 1825) from Cyprus. In: Gerovasileiou, V., *et al*. New Mediterranean Biodiversity
340 Records. *Mediterranean Marine Science*, *18*, 355–384.
341 Moussa, R., Kapiris, K., & Argyro, Z. (2016). Brachyuran diversity along the Mediterranean Egypt,
342 with the addition of a new introduced species. *Cahiers de Biologie Marine*, *57*, 43–49.
343 Moussa, R., & Zenetos, A. (2015). Looking for aliens: two unrecorded alien species well-established
344 along the coast of Alexandria (Egypt). In: Zenetos *et al*. New Mediterranean Biodiversity
345 Records. *Mediterranean Marine Science*, *16*, 266–284.
346 Moussa, R., & Zenetos, A. (2016). Contribution to the alien Mollusca of Mediterranean Egypt. In:
347 Mytilineou *et al*. New Mediterranean Biodiversity Records. *Mediterranean Marine Science*,
348 *17*, 794–821.
349 Orsi-Relini, L., Costa, M. R., & Relini, M. (2010). First record of the yellow sea chub *Kyphosus*
350 *incisor* in the Mediterranean. *Marine Biodiversity Records*, *3*, e4.

Osca, D., Tanduo, V., Tiralongo, F., Giovos, I., Al Mabruk, S. A. A., Crocetta, F., & Rizgalla, J. (2020). The Indo-Pacific sergeant *Abudefduf vaigiensis* (Quoy & Gaimard, 1825) (Perciformes: Pomacentridae) in Libya, south-central Mediterranean Sea. *Journal of Marine Science and Engineering*, *8*, 14.

Pirkenseer, C. M. (2020). Alien species in southern Laconia, Kythira Islands and southern Messenia (Greece): new and additional records and updated record maps. *Journal of the Black Sea/Mediterranean Environment*, *26*, 145–175.

Psomadakis, P. N., Giustino, S., & Vacchi, M. (2012). Mediterranean fish biodiversity: an updated inventory with focus on the Ligurian and Tyrrhenian seas. *Zootaxa*, *3263*, 1–46.

Pyle, R. (2001). Chaetodontidae. Butterflyfishes. In: Carpener, K.E., Niam, V.H. (eds.). *FAO species identification guide for fishery purpose. The living marine resources of the Western Central Pacific*. Vol. 5: Bony fishes part 3 (Menidae to Pomacentridae). FAO, Rome, pp. 3224–3265.

Randall, J. E. (2007). *Reef and shore fishes of the Hawaiian Islands*. University of Hawaii Press, Honolulu, 546 pp.

Saad, A., Alkusairy, H., & Sabour, W. (2018). First record of the Emperor angelfish, *Pomacanthus imperator* (Actinopterygii: Pomacanthidae) in the Syrian coast (eastern Mediterranean). *Marine Biodiversity Records*, *11*, 16.

Salameh, P., Sonin, O., Edelist, D., & Golani, D. (2012). The first substantiated record of the yellowbar angelfish, *Pomacanthus maculosus* (Actinopterygii: Perciformes: Pomacanthidae) in the Mediterranean. *Acta Ichthyologica et Piscatoria*, *42*, 73–74.

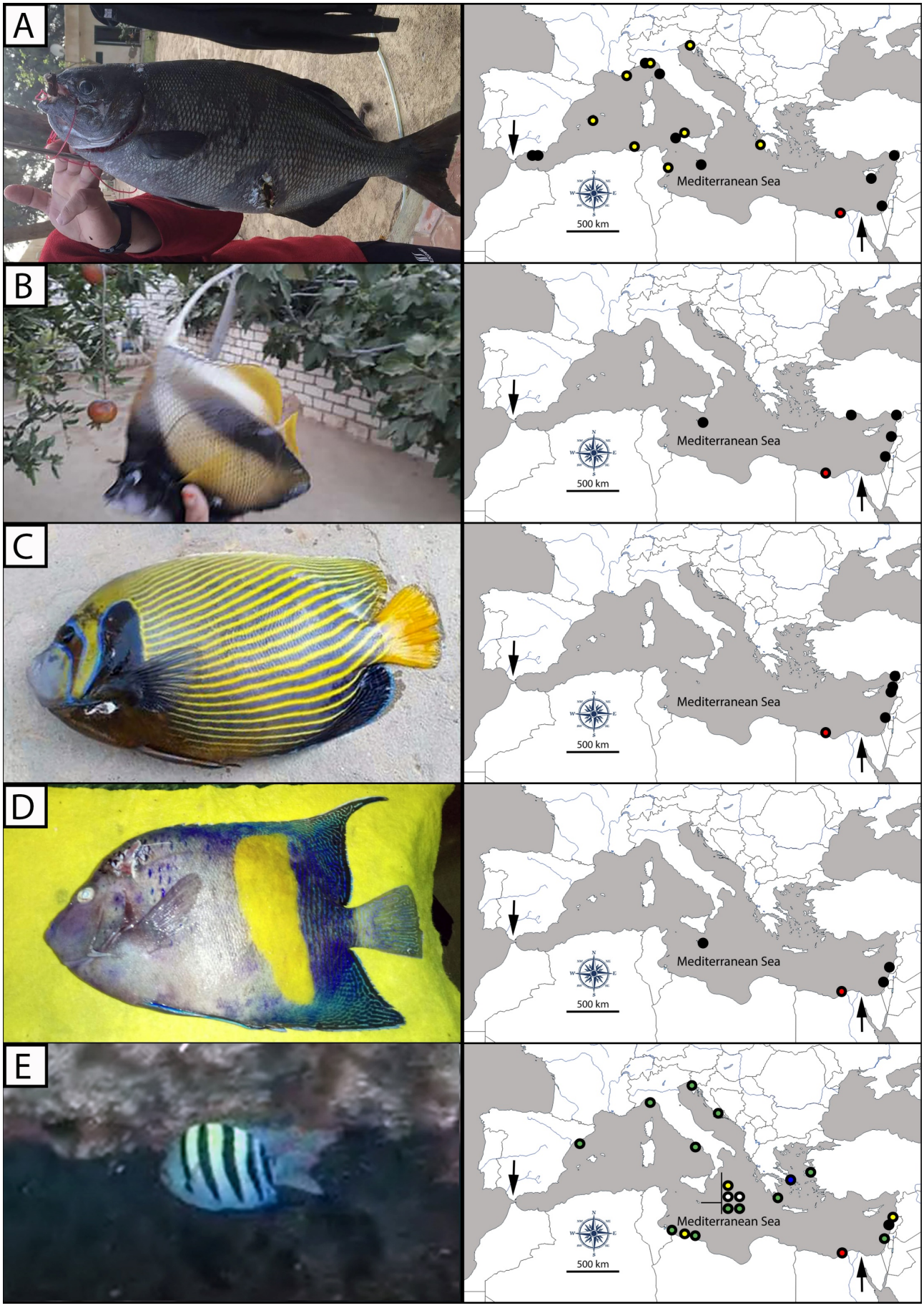
Tiralongo, F., Russo, F., & Colombo, M. (2019a). From scuba diving to social networks: a curious association between two small fish species, *Lepadogaster candolii* Risso, 1810 and *Parablennius rouxi* (Cocco, 1833), and *Muraena helena* (Linnaeus, 1758) coming from citizen science. *Regional Studies in Marine Science*, *29*, 100648.

Tiralongo, F., Lillo, A. O., Tondo, E., Lo Martire, C., D'Agnese, R., …, Azzurro, E. (2019b). Monitoring uncommon and non-indigenous fishes in Italian waters: one year of results for the AlienFish project. *Regional Studies in Marine Science*, *28*, 100606.

Tiralongo, F., Crocetta, F., Riginella, E., Lillo, A.O., Tondo, E., … Azzurro, E. (2020). Snapshot of rare, exotic and ovewrlooked fish species in the Italian seas: A citizen science survey. *Journal of Sea Research*, *164*, 101930.

Tsadok, R., Shemesh, E., Popovich, Y., Sabag, Y., Golani, D., & Tcheronov, D. (2015). New record and occurrence of the Red Sea bannerfish, *Heniochus intermedius* (Actinopterygii: Perciformes: Chaetodontidae), in the Mediterranean Sea. *Acta Ichthyologica et Piscatoria*, *45*, 331–333.

385 Zenetos, A., Apostolopoulos, G., & Crocetta, F. (2016). Aquaria kept marine fish species possibly
386 released in the Mediterranean Sea: first confirmation of intentional release in the wild. *Acta*
387 *Ichthyologica et Piscatoria*, *46*, 255–262.
388 Zenetos, A., Çinar, M. E., Crocetta, F., Golani, D., Rosso, A., Servello, G., Shenkar, N., Turon, X.,
389 & Verlaque, M. (2017). Uncertainties and validation of alien species catalogues: The
390 Mediterranean as an example. *Estuarine, Coastal and Shelf Science*, *191*, 171–187.
391 Zenetos, A., & Miliou, A. (2020). *Abudefuf* cf. *saxatilis* in the Saronikos Gulf, Greece: Unaided
392 introduction or human aided transfer? *Annales, Series Historia Naturalis*, *30*, 227–230.



393

Figure 1. *Kyphosus* sp. and map with all Mediterranean records for *K. sectatrix* (yellow circles) and *K. vaigiensis* (black circles), after Ligas *et al*., 2011; Azzurro *et al*., 2013; Mannino *et al*., 2015; Goren *et al*., 2016; Michailidis & Rousou, 2017; Kiyaga *et al*., 2019 (**A**). *Heniochus intermedius* and map with all Mediterranean records (black circles), after Evans *et al*., 2015; Tsadok *et al*., 2015; Erguden *et al*., 2016 (**B**). *Pomacanthus imperator* and map with all Mediterranean records (black circles), after Capapé *et al*., 2018; Saad *et al*., 2018; Gurlek *et al*., 2019 (**C**). *Pomacanthus maculosus* and map with all Mediterranean records (black circles), after Salameh *et al*., 2012; Evans *et al*., 2016 (**D**). *Abudefduf* sp. and map with all Mediterranean records for *A. hoefleri* (white circles), *A. saxatilis* (black circles), *A. sexfasciatus* (blu circle), *A. vaigiensis* (yellow circles) and *Abudefduf* sp. (green circles), after Pirkenseer, 2020; Zenetos & Miliou, 2020; Dragičević *et al*., 2021 (**E**). New record from Egypt are marked with red circles for all taxa in each map.