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Synodus synodus (Actinopterygii, Aulopiformes, Synodontidae) in the coastal waters of Malta, central Mediterranean Sea

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Abstract

The occurrence of *Synodus synodus* (Linnaeus, 1758) in the central Mediterranean Sea is ascertained through integrated morphological and molecular analyses conducted on two specimens collected in April 2025 off the southwestern coast of Malta as well as through underwater photographic documentation from the same region. Morphological examination, including meristic counts and morphometric measurements, revealed diagnostic characters consistent with *S. synodus*, further confirmed by DNA barcoding of the mitochondrial COI gene. The presence of *S. synodus* in Maltese waters represents the first confirmed record for the area and is added to the sparse reports of the species in the Mediterranean Sea. The occurrence of other Synodontidae recently found in the basin is briefly discussed.

Keywords

diamond lizardfish, uncommon species, neonative species, morphological identification, DNA barcoding

Introduction

In the Mediterranean Sea, the family Synodontidae includes the native species *Synodus saurus* (Linnaeus, 1758), the native or, maybe, neonative (sensu Essl et al. 2019), *Synodus synodus* (Linnaeus, 1758) (see Kovačić et al. 2021), along with three non-indigenous species of Indo-Pacific/Red Sea origin: *Saurida lessepsianus* Russell, Golani et Tikochinski, 2015 (see Russell et al. 2015), *Saurida gracilis* (Quoy et Gaimard, 1824) (see Khamassi et al. 2022) and *Synodus randalli* Cressey, 1981 (see Turan and Doğdu 2023). The Atlantic lizardfish *S. saurus* is widely distributed in the basin, while *S. synodus*, known as the diamond lizardfish or redbarret lizardfish, exhibits a seemingly scattered and poorly documented presence. The lizardfish *S. synodus* is a subtropical species native to both the eastern and western Atlantic. Although *S. synodus* was reported for the Mediterranean ichthyofauna in Anderson et al. (1966a), the same authors (Anderson et al. 1966b) did not include the basin in its distribution range. The species was never listed among the fishes of the basin (cf. Sulak 1984; Bauchot 1987; Quignard and Tomasini 2000; Psomadakis et al. 2012; Froese and Pauly 2025), while it was added recently in the fish checklist provided by Kovačić et al. (2021), on the basis of four photographs from Bello Rincon, Almeria (Spain) published in Lloris (2015). The distribution of *S. synodus* in the Mediterranean appears not to be homogeneous, being to date unreported in several national fish checklists, except for the Egyptian Mediterranean waters (Akel and Karachle 2017). The species *Saurida lessepsianus*, previously recorded as "*Saurida grandisquamis* Günther, 1864", "*Saurida undosquamis* (Richardson, 1848)" or "*Saurida macrolepis* Tanaka, 1917", has successfully migrated from the Red Sea through the Suez Canal (Lessepsian migrant) into the Mediterranean. First recorded in Israeli waters (Ben-Tuvia 1953; Golani 2021), it is now widely distributed in the eastern part of the basin (Russell et al. 2015; Golani and Fricke 2018; Golani et al. 2021; Uyan et al. 2024). The gracile lizardfish, *Saurida gracilis*, was recorded for the first time in the Mediterranean from Tunisian waters (Khamassi et al. 2022). The second report of *S. gracilis* from Lebanon (Fatfat et al. 2025) appears a dubious one. The unequal length of the pelvic fin rays with the inner rays being significantly longer than the outermost rays, visible in Fatfat et al. (2025), are more likely attributable to a *Synodus* sp. (see Fischer and Bianchi 1984; Carpenter and Niem 1999). Moreover, the reddish color of the specimen identified as *S. gracilis* in Fatfat et al. (2025) is different from the mainly gray color with black blotches described for *S. gracilis* (see Fischer and Bianchi 1984; Khamassi et al. 2022). The most likely pathway of introduction of *S. gracilis* is through Lessepsian migration, although ship transport is not to be excluded (Khamassi et al. 2022). The Randall's lizardfish, *Synodus randalli*, was first recorded in the Mediterranean in 2023 at Iskenderun Bay, Turkey (Turan and Doğdu 2023), with additional records from southeastern Crete, Greece (Christidis and Kosoglou 2024) and in 2024 from Mersin Bay, Turkey (Erguden et al. 2024). As for other Indo-Pacific lizardfish, Lessepsian migration via the Suez Canal is considered to be a plausible introduction route for the recently recorded *S. randalli* (see Turan and Doğdu 2023).

Integrative taxonomy, which combines traditional morphological variation with other sources of data, such as molecular DNA-based variation (Padial et al. 2010), has greatly benefited from global initiatives like the Fish Barcode of Life (FISH-BOL; Ward et al. 2009). As part of the broader Barcode of Life initiative (BOL; http://www.barcodinglife.org), FISH-BOL offers an efficient and user-friendly taxonomic toolkit, including standardized protocols, primer pairs, and a web-based identification system of fish. The Barcode of Life Data System (BOLD; Ratnasingham and Hebert 2007) is commonly used for identifying putative species of unknown specimens or alien/vagrant ones (Deidun et al. 2024; Zava et al. 2024). These identifications are based on nucleotide sequence similarity with reference sequences from voucher specimens that have been morphologically verified.

In the present study, the occurrence in the central Mediterranean Sea of *S. synodus* is documented for the first time, based on two specimens collected in Maltese waters and supported by further underwater observations. Species identification was confirmed through a combination of detailed description of morphometric and meristic characters, corroborated by DNA barcoding.

Materials and methods

All records from Maltese waters reported in this study were gleaned through the Spot the Alien Fish citizen science campaign (campaigns.ocean.mt), which has been implemented within the Department of Geosciences of the University of Malta since 2016. On 13 April 2025, two specimens of an unidentified fish species (hereafter referred to as specimen A and specimen B) were caught by a professional fisher off Wied iz-Zurrieq, southwestern coast of the island of Malta (35.8188°N, 014.4544°E), at 20 m of depth, by means of a trammel net on sandy bottom in proximity to sparsely distributed rocks.

Morphometric measurements (0.1 mm accuracy) and meristic counts were conducted following Hubbs and Lagler (1958). The two specimens are currently preserved in ethanol within the collection of the Department of Geosciences at the University of Malta under the catalogue number OMRG_06_2025.

Subsequently, on 3 May 2025, another individual presenting similar external morphology was photographed in situ by a diver at Cirkewwa (35.9885°N, 014.3274°E), off the northwestern coast of Malta, at 20 m of depth, on the hard bottom covered with macroalgae.

Total genomic DNA was extracted from a muscle sample of approximately 20 mg, taken from each of the two specimens using a RBC Bioscience extraction kit, following the manufacturer's protocol. A fragment of the mitochondrial cytochrome c oxidase subunit I (*COI*) gene was amplified using the universal primers FishF2 and FishR2 (Ward et al. 2005). PCR reactions were carried out in a total volume of 25 µL containing: 2.5 µL gDNA template, 5 × PCR buffer, 2.5 mM of $MgCl_2$, 0.05 mM dNTPs, 0.1 µM of each primer and 0.25 U GoTaq G2 Flexi DNA polymerase (Promega). Amplification was performed in a TAdvanced Biometra thermocycler with an initial denaturation of 2 min at 95°C, followed by 35 cycles of 30 s at 94°C, 30 s at 54°C and 1 min at 72°C and a final extension of 7 min at 72°C. Amplification success was verified by 2% agarose gel electrophoresis. Positive amplicons were purified using EXOSAP and sequenced in both directions by an external provider (Macrogen Europe, Milan). The resulting consensus sequences were compared against publicly available sequences in the NCBI GenBank (https://www.ncbi.nlm.nih.gov) and BOLD (Barcode of Life Data System; http://www.barcodinglife.org, Ratnasingham and Hebert 2007) databases using BLASTn and the BOLD Identification Engine, respectively.

From the BOLD database, 35 public *COI* sequences of *Synodus synodus* were retrieved. A neighbor-joining (NJ) tree was then reconstructed in MEGA 11 (Tamura et al. 2021), using p-distance and 1000 bootstrap replicates. In addition, 11 *COI* sequences of other congeneric species retrieved from BOLD—*Synodus lacertinus* Gilbert, 1890; *Synodus doaki* Russell et Cressey, 1979; *Synodus indicus* (Day, 1873); *Synodus variegatus* (Lacepède, 1803); and *Synodus randalli*—were included as comparative outgroups. The *COI* sequences were submitted to GenBank (accession numbers PV904155 and PV904156) and to BOLD system (Process ID NIFM001-25 and NIFM002-25, respectively).

Results

The two individuals collected from the coastal waters of Malta, specimen A and specimen B, presented a total length (TL) of 300.2 mm and 166.3 mm and weighed 244.7 g and 38.6 g, respectively (Fig. 1A, B).

Description. Body elongate, cylindrical; short-based first dorsal fin; small adipose second dorsal fin; length of anal-fin base shorter than dorsal-fin base; forked caudal fin, lateral line extending to base of caudal fin; snout rounded from above, pointed from side; eye at about middle of upper jaw; innermost rays of pelvic fins longer than

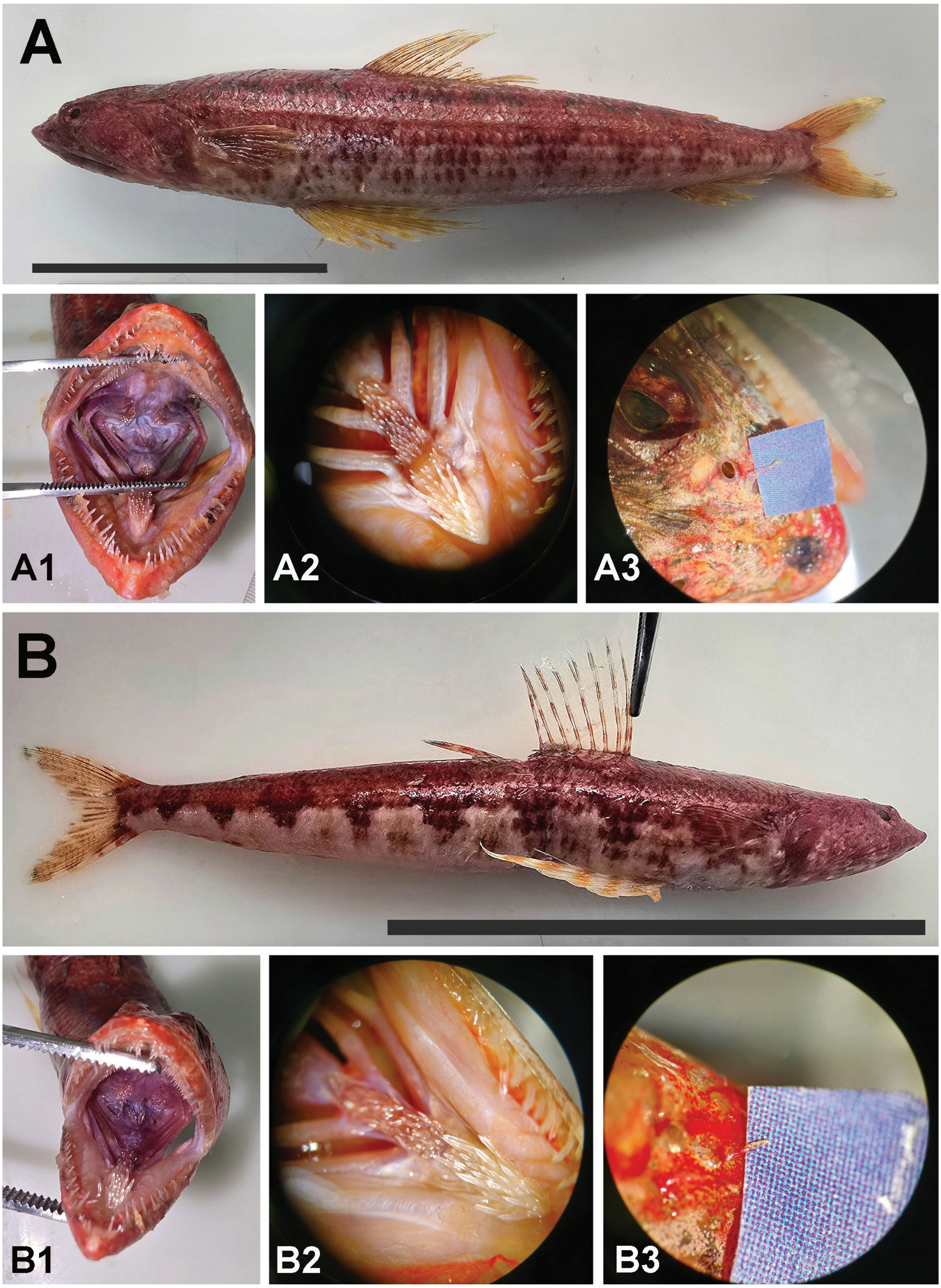

Figure 1. The two specimens of *Synodus synodus* collected from the coastal waters of Malta on April 2025 (**A**, **B**: whole specimens, scale bar = 10 cm; **A1**, **B1**: dentition; **A2**, **B2**: lingual teeth; **A3**, **B3**: left nostrils, showing the flap of the anterior nostril).

outermost; pectoral fin not reaching line from pelvic-fin origin to dorsal-fin origin, shorter than one-half length of pelvic fin (Fig. 1A, B); cheek fully scaled in five rows; lanceolate teeth on jaws alternatively long and short; mouth oblique; in each side of roof of mouth, single band of lanceolate palatine teeth arranged in various rows, longer teeth in inner rows, anterior teeth largest (Fig. 1A1, B1); lingual teeth well-developed, those on free end of tongue largest and about 50 in specimen A (Fig. 1A2) and about 25 in specimen B (Fig. 1B2); anterior nostril on each side bearing long flap extending well beyond margin of nares when depressed anteriorly in specimen A (Fig. 1A3), relatively shorter in specimen B (Fig. 1B3). Dorsal fin rays 13 (specimen A), 13 (specimen B damaged); anal fin rays 8; pelvic fin rays 8; pectoral fins rays 12; caudal fin rays 19; pored Lateral line (LL) scales 59 in specimen A, at least 56 in specimen B (damaged); four scale rows above LL to dorsal fin; predorsal scales 18. Absolute measurements of specimen A and specimen B, expressed also as percent of standard length (SL), are presented in Table 1. Proportions in specimen A and B respectively: Head length (HL) 4.1 and 4.1 in SL; inter-orbital space 7.6 and 8.5, eye diameter 5.2 and 5.1, both in HL; eye diameter 0.8 and 0.9 in snout; anal fin base 1.8 and 1.7 in dorsal fin base, pectoral fin length 2.4 and 2.3 in pelvic fin length. Color in thawed specimens: body reddish on back, pale ventrally, with at least seven irregular more or less darker bands across upper part of body, with narrow ventral extensions; dark brown patches longitudinally along upper part of body sides; fins yellowish with transverse dark bands (Fig. 1A, B); lips barred with dark, eye marked with red, distinctive dark blotch at tip of snout in both specimens (Fig. 1A3). Color in life (Fig. 2): four red-brown large bands across back between dorsal origin and caudal fin base alternated with orange bands; sparse sky-blue shades; black spot on upper surface of tip of snout.

Both specimens collected from Malta were morphologically identified as *Synodus synodus*, congruent with the descriptions given by Norman (1935), Fowler (1936), Anderson et al. (1966a, 1966b), Fischer et al. (1981), Sulak (1984), Lavett Smith (1997) and Russell (2002, 2016). In particular, the four scales rows above LL, the general color of the body and the small dark spot near the tip of the snout were helpful in the initial steps for identification. The four red brown bands across the back between the dorsal origin and the caudal fin base and the dark spot on the tip of snout of the live specimen in Fig. 2 corresponded to the livery of *S. synodus* described in Fowler (1936), Anderson et al. (1966a, 1966b) and Sulak (1984).

Figure 2. Underwater photograph of *Synodus synodus* taken at Cirkewwa, Malta, in May 2025. (Photo by E. Cuschieri).

Table 1. Morphometric measurements of two specimens of *Synodus synodus* from Malta and their proportions as % of SL.

Measurement	Specimen A		Specimen B	
	[mm]	[% SL]	[mm]	[% SL]
Total length	300.2		166.1	
Fork length	277.3		154.2	
Standard length	260.0		146.1	
Body depth	44.0	16.9	20.1	13.7
Head length	62.8	24.2	35.5	24.3
Snout	10.0	3.8	6.0	4.1
Eye diameter	12.0	4.6	7.0	4.8
Inter-orbital space	8.3	3.2	4.2	2.9
Snout to dorsal origin	116.0	44.6	56.0	38.4
Snout to adipose origin	217.0	83.5	118.1	80.8
Snout to anal origin	209.3	80.5	115.0	78.8
Snout to pelvic insertion	85.3	32.8	48.2	33.0
Snout to pectoral insertion	68.0	26.2	37.5	25.7
First dorsal-ray length	24.0	9.2	15.8	10.8
Longest dorsal-ray length	35.0	13.5	18.5	12.7
Pectoral fin length	27.6	10.6	14.3	9.8
Pelvic fin length	66.1	25.4	32.4	22.2
Pelvic fin base length	8.7	3.3	4.8	3.3
Upper jaw length	46.3	17.8	24.2	16.6
Caudal peduncle depth	14.3	5.5	7.9	5.4
Dorsal fin base	44.0	16.9	22.2	15.1
Anal fin base	24.0	9.2	13.0	8.9
Longest pectoral ray	29.1	11.2	15.2	10.4
Longest pelvic ray	62.0	23.8	32.4	22.2

Genetics. The mitochondrial COI sequences obtained from specimens A and B were 616 bp in length. BLASTn searches in the NCBI GenBank database and the BOLD Identification Engine revealed a maximum identity of 95.40% with reference sequences of *S. synodus* from the western Atlantic. In the reconstruction of the NJ tree (Fig. 3), our sequences did not cluster with the western Atlantic *S. synodus* sequences but formed a separate, well-supported cluster with 99% bootstrap support.

Discussion

The description, meristic counts, morphometric proportions and color of the fish specimens from Malta hereby reported agreed with those for *Synodus synodus* as described in the literature, while the identification was validated through molecular analysis. Nevertheless, a discrepancy concerning the length of the pectoral fin was observed between the published descriptions and the attributes of our specimens: “tip of pectoral fin extending well

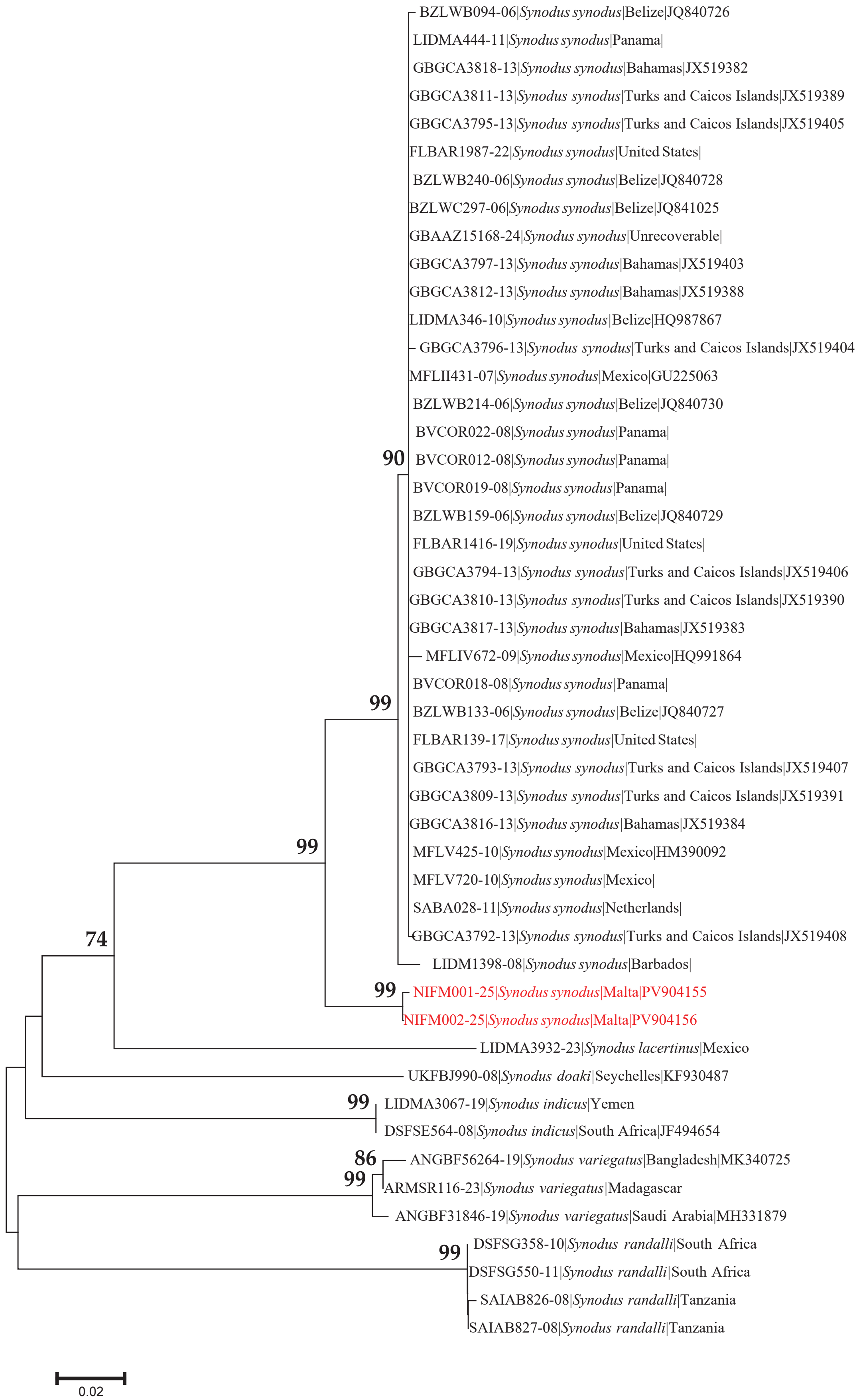

Figure 3. Neighbor-Joining (NJ) tree of mitochondrial Cytochrome c Oxidase Subunit I (COI) sequences showing the Maltese specimens (GenBank: PV904155–PV904156; BOLD: NIFM001-25, NIFM002-25) in relation to 35 publicly available *Synodus synodus* and 11 additional sequences of congeneric species. Bootstrap values (>50%) from 1000 replicates are shown at the nodes.

beyond base of pelvic fin" (Anderson at al., 1966a, 1966b; Fischer et al. 1981; Russell 2002), "pectoral fin extending to or very slightly beyond base of pelvic" (Norman 1935), "pectoral fin extending to or slightly beyond dorsal fin insertion" (Sulak 1984). In both the specimens from Malta, the pectoral fin hardly reaches the base of the pelvic fin, but it does not extend to the insertion of the dorsal fin.

The diamond lizardfish *Synodus synodus* is a demersal subtropical species inhabiting depths of up to 144 m, although it is most frequently found in shallow sandy areas near rocky substrates. It can reach a TL of 45 cm, with individuals of approximately 20 cm TL being more common (Froese and Pauly 2025). The *S. synodus* specimens from the waters of Malta were collected from sandy shallow waters near rocks and their TL was included in the range known for the species. Like other synodontids, *S. synodus* is presumed to prey on small fishes and crustaceans (Fowler 1936; Fischer et al. 1981; Froese and Pauly 2025). The species is known from both sides of the Atlantic: along the western Atlantic coast from Uruguay to Canada, and along the eastern Atlantic from Senegal to northern Angola, including islands such as Madeira, the Canaries, Cape Verde, Ascension, and St. Helena (Sulak 1990; Russell 2016; Froese and Pauly 2025). Norman (1935) did not exclude the existence on the eastern side of the Atlantic of a subspecies distinct from that of the western side of the ocean. Sulak (1990) reported that eastern Atlantic individuals tend to be larger (up to approximate 30 cm SL) than their western counterparts (approximate 15 cm SL). According to Frable et al. (2013) and Russell (2016), populations of this species in the eastern Atlantic are genetically different from those of the western Atlantic. The species has been reported from the Mediterranean (Kovačić et al. 2021), but with scarce published information about its occurrence around the basin, except for Egyptian waters (Akel and Karachle 2017). In Mediterranean Egyptian waters it is occasionally captured and morphologically distinguished from other sympatric synodontids, such as *Saurida lessepsianus* and *Synodus saurus*, with recorded TL ranges for *Synodus synodus* of 16.7–23.6 cm (Abdallah 2002) and 13–19 cm (Akel 2020). It is interesting to note that in situ observations of *S. synodus* in the Mediterranean have been reported in the Global Biodiversity Information Facility (GBIF): in 2002 from Akrotirion Gatas/Cape Greco, southeastern Cyprus (Staatliches Museum für Naturkunde Stuttgart 2025), in 2008 from Santa Pola (Alicante), Spain (Conselleria de Medio Ambiente, Agua, Infraestructuras y Territorio. Generalitat Valenciana 2024) and Chania Gulf, Crete, Greece (Casassovici and Brosens 2022a), and in 2013 from Cape Palos (Cartagena), Spain (Casassovici and Brosens 2022b).

The molecular data supported the identification of the Maltese specimens as *Synodus synodus*. The 95.40% sequence similarity observed with western Atlantic records available in public repositories, likely reflecting the limited representation of Mediterranean and eastern Atlantic populations, is consistent with the previously documented genetic differentiation between western and eastern Atlantic populations (Frable et al. 2013; Russell 2016). However, public COI sequences from eastern Atlantic *S. synodus* are not currently available in BOLD to further corroborate the species assignment of our records.

The confirmed presence of *Synodus synodus* in Malta also prompts a cautious re-evaluation of recent records of the congeneric species *S. randalli* in the eastern Mediterranean. Specimens identified as *S. randalli* have been reported from Iskenderun and Mersin bays, Turkey (Turan and Doğdu 2023; Erguden et al. 2024) and Crete, Greece (Christidis and Kosoglou 2024). The species *S. randalli* is a benthopelagic western Indian Ocean tropical fish reported from the Red Sea to South Africa in depths from 140 m to 250 m that reaches a SL of 11 cm to 13 cm (Cressey 1981; Russell 2022; Froese and Pauly 2025). External features, coloration and meristics of the *S. synodus* specimens from Malta look similar to those of the specimens reported as *S. randalli* collected from Turkish and Greek waters. The *S. randalli* described from Turkey and Greece were caught at depths significantly lower than the range of water depths reported for *S. randalli* in Cressey (1981) and Russell (2022). The SL of the specimens from Iskenderun, Turkey (Turan and Doğdu 2023) and Crete, Greece (Christidis and Kosoglou 2024) greatly overcomes the maximum SL reported for *S. randalli* (see Russell 2022). Moreover, one of the distinctive characters for *S. randalli* is the pectoral fin reaching beyond a line from the base of pelvic fin to the origin of dorsal fin (Cressey 1981; Russell 2022; Froese and Pauly 2025); the pectoral fins of all specimens recorded as *S. randalli* in the Mediterranean do not reach beyond a line connecting the origin of the dorsal fin to the origin of the pelvic fin. Additionally, while in the original description of *S. randalli* by Cressey (1981) eight anal-fin rays were reported, this number was later revised to nine by Randall (2009) [a correction not reflected in Russell (2022)]. In all the Mediterranean *S. randalli*, eight anal-fin rays were counted. Finally, a dark blotch at the tip of the snout, a well-known diagnostic trait of *S. synodus* (see Fowler 1936; Anderson et al. 1966a, 1966b; Fischer et al. 1981; Sulak 1984; Lavett Smith 1997), can be observed in the picture of the specimen identified as *S. randalli* from Iskenderun (Turan and Doğdu 2023). Two or four dark markings on the snout can be found in some *Synodus* species from the west Indian Ocean and Hawaii (Waples and Randall 1988; Randall 2009; Russell 2022).

More broadly, the observed inconsistencies in morphology and meristic characters between these eastern Mediterranean records and the published descriptions of *S. randalli* suggest that their identity warrants further verification and direct comparison with *S. synodus*.

The diamond lizardfish *S. synodus* could be an uncommon species in the Mediterranean waters or, alternatively, it has been to date under-recorded, due to its cryptic behavior or due to its similarity with other species of Synodontidae. Furthermore, empty niches already present or generated by over-fishing of local species as well as the warming of the Mediterranean waters in recent years (see von Schuckmann et al. 2024) could act as favorable factors for the reproduction, increase and spread of an existing population in the basin. The same hypothesized factors could also have created suitable environmental conditions for a successful wave of expansion of this subtropical species from the eastern Atlantic into the Mediterranean. It is noteworthy that at least 5 to 10 individuals similar to that we characterized and identified, have previously been caught by the same fisherman at the same location since January 2025, but these individuals were subsequently sold and not formally documented. The diamond lizardfish *S. synodus* could be therefore a neonative species (see Essl et al. 2019) that extended its range from the Atlantic into the Mediterranean, as other fish species recorded in the last decades in the basin (Evans et al. 2020). A number of these neonative species have been reported in the waters of the Malta–Sicily Channel (see Deidun et al. 2021).

Citizen science campaigns are increasingly shedding light on shifts in the dynamics of marine species distributions, with the efficacy of such campaigns increasing greatly when key stakeholders, including fishers, are engaged. A number of studies (e.g., Azzurro et al. 2019; Michail et al. 2024) have underscored the importance of close collaborations between fishers and scientists through the opportunities provided by citizen science, given the valuable local ecological knowledge (LEK) on the distribution of alien species held by fishers.

In conclusion, this study confirms the occurrence of *S. synodus* in the central Mediterranean and updates the known ichthyofauna of the Maltese Archipelago (Borg et al. 2023). It further underscores the necessity of combining classical morphological examination with molecular approaches to ensure accurate identification, particularly in taxonomically challenging groups. The limited number of records and specimens studied indicates the need for further research on its distribution in the Mediterranean basin.

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References

Abdallah M (2002) Length–weight relationship of fishes caught by trawl off Alexandria, Egypt. Naga 25(1): 19–20.

Akel ESHKh (2020) Fisheries status of the trawlers by-catch from Alexandria, Egypt. Egyptian Journal of Aquatic Biology and Fisheries 24(2): 83–106. https://doi.org/10.21608/ejabf.2020.78754

Akel ESHKh, Karachle PK (2017) The Marine Ichthyofauna of Egypt. Egyptian Journal of Aquatic Biology and Fisheries 21(3): 81–116. https://doi.org/10.21608/ejabf.2017.4130

Anderson WW, Gehringer JW, Berry FH (1966a) Field Guide to the Synodontidae (Lizardfishes) of the Western Atlantic Ocean. Fish and Wildlife Service, Bureau of Commercial Fisheries. Circular 245: 1–12.

Anderson WW, Gehringer JW, Berry FH (1966b) Family Synodontidae. In: Mead GW, Bigelow HB, Breder CM, Cohen DM, Merriman D, Olsen YH, Schroeder WC, Schultz LP, Tee-Van J (Eds) Fishes of the Western North Atlantic. Memoirs of the Sears Foundation for Marine Research 1(5): 30–102.

Azzurro E, Sbragaglia V, Cerri J, Bariche M, Bolognini L, Ben Souissi J, Busoni G, Coco S, Antoniadou C, Fanelli E, Ghanem R, Garrabou J, Gianni F, Grati F, Kolitari J, Letterio G, Lipej L, Mazzoldi C, Milone N, Pannacciulli F, Pešić A, Samuel-Rhoads Y, Saponari L, Tomanic J, Topçu NE, Vargiu G, Moschella P (2019) Climate change, biological invasions, and the shifting distribution of Mediterranean fishes: A large-scale survey based on local ecological knowledge. Global Change Biology 25: 2779–2792. https://doi.org/10.1111/gcb.14670

Bauchot M-L (1987) Poissons osseux. In: Fischer W, Bauchot M-L, Schneider M (Eds) Fiches FAO d'identification des espèces pour les besoins de la pêches. (Révision 1). Méditerranée et Mer Noire. Zone de pêche 37. Volume 2: Vertébrés. FAO, Rome, 891–1422.

Ben-Tuvia A (1953) New Erythrean fishes from the Mediterranean coast of Israel. Nature 172: 464–465. https://doi.org/10.1038/172464b0

Borg JA, Dandria D, Evans J, Knittweis L, Schembri PJ (2023) A critical checklist of the marine fishes of Malta and surrounding waters. Diversity 15: 225. https://doi.org/10.3390/d15020225

Carpenter KE, Niem VH [Eds] (1999) FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 3. Batoid fishes, chimaeras and bony fishes part 1 (Elopidae to Linophrynidae). FAO, Rome, 1397–2068.

Casassovici A, Brosens D (2022a) Diveboard—Scuba diving citizen science observations. Version 54.51. Diveboard. [Occurrence dataset] [Accessed on 23 June 2025]

Casassovici A, Brosens D (2022b) Diveboard—Scuba diving citizen science observations. Version 54.51. Diveboard. Occurrence dataset. [Accessed on 23 June 2025]

Christidis G, Kosoglou I (2024) First record of the non-indigenous Randall's lizardfish *Synodus randalli* Cressey, 1981 in Greece. In: Christidis G, Ammar IA, 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, Çağlar Oruç A, Peristeraki P, Renoult JP, Tanduo V, Tuney I, Yilmaz M, Žuljević A, Gerovasileiou V (Eds) New records of introduced species in the Mediterranean (August 2024). Mediterranean Marine Science 25(2): 453–479. https://doi.org/10.12681/mms.34474

Conselleria de Medio Ambiente, Agua, Infraestructuras y Territorio. Generalitat Valenciana (2024) Biodiversity data bank of Generalitat Valenciana. Occurrence dataset. [Accessed on 23 June 2025] https://doi.org/10.15468/b4yqdy

Cressey RF (1981) Revision of Indo–west Pacific lizardfishes of the genus *Synodus* (Pisces: Synodontidae). Smithsonian Contributions to Zoology 342: 1–53. https://doi.org/10.5479/si.00810282.342

Deidun A, Insacco G, Galdies J, Balistreri P, Zava B (2021) Tapping into hard-to-get information: The contribution of citizen science campaigns for updating knowledge on range-expanding, introduced and rare native marine species in the Malta-Sicily Channel. BioInvasions Records 10(2): 257–269. https://doi.org/10.3391/bir.2021.10.2.03

Deidun A, Corsini-Foka M, Marrone A, Galdies J, Zava B, Crobe V, Tinti F (2024) Yet another non-indigenous fish from Maltese waters, central Mediterranean: A first record of *Lagocephalus guentheri* Miranda Ribeiro, 1915 (Tetraodontiformes, Tetraodontidae). BioInvasions Records 13: 777–786. https://doi.org/10.3391/bir.2024.13.3.16

Erguden D, Ayas D, Alagoz Erguden S (2024) Range expansion of *Synodus randalli* Cressey, 1981 in the Northeastern Mediterranean. Annales. Series Historia Naturalis: Anali za Istrske in Mediteranske Študije = Annali di Studi Istriani e Mediterranei = Annals of Istrian and Mediterranean Studies 34(1): 119–124. https://doi.org/10.19233/ASHN.2024.16

Essl F, Dullinger S, Genovesi P, Hulme PE, Jeschke JM, Katsanevakis S, Kühn I, Lenzner B, Pauchard A, Pyšek P, Rabitsch W, Richardson DM, Seebens H, Van Kleunen M, Van Der Putten WH, Vilà M, Bacher S (2019) A conceptual framework for range-expanding species that track human-induced environmental change. Bioscience 69(11): 908–919. https://doi.org/10.1093/biosci/biz101

Evans J, Arndt E, Schembri PJ (2020) Atlantic fishes in the Mediterranean: Using biological traits to assess the origin of newcomer fishes. Marine Ecology Progress Series 643: 133–143. https://doi.org/10.3354/meps13353

Fatfat S, Badreddine A, Fricke R (2025) Breaking boundaries: First record of *Saurida gracilis* (Quoy and Gaimard, 1824) (Teleostei: Synodontidae) in Lebanese waters highlights a new Lessepsian expansion. Journal of Fisheries and Livestock Production 13(1): e1000611.

Fischer W, Bianchi G [Eds] (1984) FAO species identification sheets for fishery purposes. Western Indian Ocean; (Fishing Area 51). FAO, Rome, Volume 4 [pages not numbered].

Fischer W, Bianchi G, Scott WB [Eds] (1981) FAO species identification sheets for fishery purposes. Eastern Central Atlantic; fishing areas 34, 47 (in part). Canada Funds-in-Trust. Ottawa, Department of Fisheries and Oceans Canada, by arrangement with the Food and Agriculture Organization of the United Nations, Volume 4. [pages not numbered]

Fowler HW (1936) The marine fishes of West Africa. Bulletin of the American Museum of Natural History 70: 1–1493.

Frable BW, Baldwin CC, Luther BM, Weigt LA (2013) A new species of western Atlantic lizardfish (Teleostei: Synodontidae: Synodus) and resurrection of *Synodus bondi* Fowler, 1939, as a valid species from the Caribbean with redescriptions of *S. bondi*, *S. foetens* (Linnaeus, 1766), and *S. intermedius* (Agassiz, 1829). Fish Bulletin 111(2): 122–146. https://doi.org/10.7755/FB.111.2.2

Froese R, Pauly D [Eds] (2025) FishBase. [Version 04/2025] http://www.fishbase.org

Golani D (2021) An updated checklist of the Mediterranean fishes of Israel, with illustrations of recently recorded species and delineation of Lessepsian migrants. Zootaxa 4956: 1–108. https://doi.org/10.11646/zootaxa.4956.1.1

Golani D, Fricke R (2018) Checklist of the Red Sea fishes with delineation of the Gulf of Suez, Gulf of Aqaba, endemism and Lessepsian migrants. Zootaxa 4509: 1–215. https://doi.org/10.11646/zootaxa.4509.1.1

Golani D, Azzurro E, Dulčić J, Massuti E, Orsi-Relini L (2021) Atlas of exotic fishes in the Mediterranean Sea, 2nd Edn. CIESM Publishers, Paris, 365 pp.

Hubbs EL, Lagler KF (1958) Fishes of the Great Lakes region. Bulletin of the Cranbrook Institute of Science 26: 1–213. https://doi.org/10.3998/mpub.12946839

Khamassi F, Ghanem R, Hassan B, Karray S, El Bour M, Ben Souissi J, Azzurro E (2022) First record of the Gracile lizardfish *Saurida gracilis* (Quoy and Gaimard, 1824) in Mediterranean waters. Mediterranean Marine Science 23(1): 25–29. https://doi.org/10.12681/mms.28173

Kovačić M, Lipej L, Dulčić J, Iglesias SP, Goren M (2021) Evidence-based checklist of the Mediterranean Sea fishes. Zootaxa 4998(1): 1–115. https://doi.org/10.11646/zootaxa.4998.1.1

Lavett Smith C (1997) National Audubon Society field guide to tropical marine fishes of the Caribbean, the Gulf of Mexico, Florida, the Bahamas, and Bermuda. Alfred A. Knopf, Inc., New York, 720 pp.

Lloris D (2015) Ictiofauna marina. Ediciones Omega, S.A, Barcelona, 674 pp.

Michail C, Tanduo V, Crocetta F, Giovos I, Litsiou S, Kleitou P (2024) Engagement of fishers in citizen science enhances the knowledge on alien decapods in Cyprus (eastern Mediterranean Sea). Aquatic Ecology 58(1): 107–116. https://doi.org/10.1007/s10452-023-10046-6

Norman JR (1935) 4. A revision of the lizard-fishes of the genera *Synodus*, *Trachinocephalus*, and *Saurida*. Proceedings of the Zoological Society of London 1: 99–135. https://doi.org/10.1111/j.1469-7998.1935.tb06233.x

Padial JM, Miralles A, De la Riva I, Vences M (2010) The integrative future of taxonomy. Frontiers in Zoology 7: 16. https://doi.org/10.1186/1742-9994-7-16

Psomadakis PN, Giustino S, Vacchi M (2012) Mediterranean fish biodiversity: An updated inventory with focus on the Ligurian and Tyrrhenian seas. Zootaxa 3263: 1–46. https://doi.org/10.11646/zootaxa.3263.1.1

Quignard JP, Tomasini JA (2000) Mediterranean fish biodiversity. Biologia Marina Mediterranea 7: 1–66.

Randall JE (2009) Five new Indo–Pacific lizardfishes of the genus *Synodus* (Aulopiformes: Synodontidae). Zoological Studies (Taipei, Taiwan) 48(3): 402–417.

Ratnasingham S, Hebert PDN (2007) BOLD: The Barcode of Life Data System (www.barcodinglife.org). Molecular Ecology Notes 7: 355–364. https://doi.org/10.1111/j.1471-8286.2007.01678.x

Russell BC (2002) Synodontidae. Lizardfishes. In: Carpenter KE (Ed.) The living marine resources of the Western Central Atlantic. Volume 2: Bony fishes part 1 (Acipenseridae to Grammatidae). FAO Species Identification Guide for Fishery Purposes and American Society of Ichthyologists and Herpetologists Special Publication 5. FAO, Rome, 923–930.

Russell BC (2016) Synodontidae. Lizardfishes. In: Carpenter KE, De Angelis N (Eds) The living marine resources of the Eastern Central Atlantic. Volume 3: Bony fishes part 1 (Elopiformes to Scorpaeniformes). FAO Species Identification Guide for Fishery Purposes. FAO, Rome, 1824–1828.

Russell BC (2022) Family Synodontidae, Lizardfishes. In: Heemstra PC, Heemstra E, Ebert D, Holleman W, Randall JE (Eds) Coastal fishes of the western Indian Ocean. Volume 2. South African Institute for Aquatic Biodiversity, Makhanda, South Africa, 209–221.

Russell BC, Golani D, Tikochinski Y (2015) *Saurida lessepsianus* a new species of lizardfish (Pisces: Synodontidae) from the Red Sea and Mediterranean Sea, with a key to *Saurida* species in the Red Sea. Zootaxa 3956(4): 559–568. https://doi.org/10.11646/zootaxa.3956.4.7

Staatliches Museum für Naturkunde Stuttgart (2025) The Ichthyology Collection at the Naturkundemuseum Stuttgart. Occurrence dataset. [Accessed on 24 June 2025]

Sulak KJ (1984) Synodontidae. In: Whitehead PJP, Bauchot ML, Nielsen J, Tortonese E (Eds) Fishes of the North-eastern Atlantic and the Mediterranean. Volume 1. UNESCO, Paris, 405–411.

Sulak KJ (1990) Synodontidae. In: Quero JC, Hureau JC, Karrer C, Post A, Saldanha L (Eds) Check-list of the fishes of the eastern tropical Atlantic (CLOFETA). Volume 1. JNICT, Lisbon; SEI, Paris; UNESCO, Paris, 365–370.

Tamura K, Stecher G, Kumar S (2021) MEGA11: Molecular Evolutionary Genetics Analysis version 11. Molecular Biology and Evolution 38: 3022–3027. https://doi.org/10.1093/molbev/msab120

Turan C, Doğdu SA (2023) First record of the non-indigenous Randall's lizardfish *Synodus randalli* Cressey, 1981 in the Mediterranean Sea. In: Langeneck J, Bakiu R, Chalari N, Chatzigeorgiou G, Crocetta F, Doğdu SA, Durmishaj S, Galil SB, García-Charton JA, Gülşahin A, Hoffman R, Leone A, Lezzi M, Logrieco A, Mancini E, Minareci E, Petović S, Ricci P, Orenes-Salazar V, Sperone E, Spinelli A, Stern N, Tagar A, Tanduo V, Taşkin E, Tiralongo F, Trainito E, Turan C, Yapici S, Zafeiridis I, Zenetos A (Eds) New records of introduced species in the Mediterranean Sea (November 2023). Mediterranean Marine Science 24(3): 610–632. https://doi.org/10.12681/mms.35840

Uyan A, Turan C, Doğdu SA, Gürlek M, Yağlıoğlu D, Sönmez B (2024) Genetic and some bio-ecological characteristics of Lessepsian Lizardfish *Saurida lessepsianus* from the Northeastern Mediterranean Sea. Tethys Environmental Science 1(1): 1–16. https://doi.org/10.5281/zenodo.10878150

von Schuckmann K, Moreira L, Grıgoire M, Marcos M, Staneva J, Brasseur P, Garric G, Lionello P, Karstensen J, Neukermans G [Eds] (2024) 8th edition of the Copernicus Ocean State Report (OSR8). Copernicus Publications, State Planet, 4-osr8. https://doi.org/10.5194/sp-4-osr8

Waples RS, Randall JE (1988) A Revision of the Hawaiian lizardfishes of the genus *Synodus*, with descriptions of four new species! Pacific Science 42: 178–213.

Ward RD, Zemlak TS, Innes BH, Last PR, Hebert PDN (2005) DNA barcoding Australia's fish species. Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences 360: 1847–1857. https://doi.org/10.1098/rstb.2005.1716

Ward RD, Hanner R, Hebert PDN (2009) The campaign to DNA barcode all fishes, FISH-BOL. Journal of Fish Biology 74: 329–356. https://doi.org/10.1111/j.1095-8649.2008.02080.x

Zava B, Corsini-Foka M, Scannella D, Insacco G, Deidun A, Crobe V, Tinti F (2024) *Chilomycterus reticulatus* (Actinopterygii: Tetraodontiformes: Diodontidae) in the southern Sicilian waters, central Mediterranean Sea. Acta Ichthyologica et Piscatoria 54: 157–163. https://doi.org/10.3897/aiep.54.121303