ISSN: 0001-5113 AADRAY	ACTA ADRIAT., 63 (1): 83 - 92, 2022	ORIGINAL SCIENTIFIC PAPER

On the presence of *Synagrops japonicus* (Acropomatiformes: Synagropidae) in the Mediterranean Sea

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A specimen of Synagrops japonicus *was collected in the north-western Mediterranean during an exploratory cruise using bottom trawl nets, aimed at the evaluation of possible consequences of lost-at-sea drums containing toxic materials. The discovery of this specimen follows the first record that occurred in the same area 28 years previously, fished by a bottom trawler in the waters of Portofino (Genoa, Italy) in 1987. The morphometric and meristic details of the new specimen are provided. The presence of this individual in the north-western portion of the Mediterranean is likely related to an accidental transport of larvae via ballast water by ships coming from outside the Mediterranean basin.*

Key words: black mouth splitfin; ballast waters; alien species; Ligurian trawl

INTRODUCTION

Synagrops japonicus (Döderlein, 1883) belongs to the family Synagropidae Smith, 1961 (*sensu* VAN DER LAAN *et al*., 2021) and is mainly distributed in the Indo-Pacific Ocean. In the Indo-West and Central Pacific areas, it has been found from East Africa, Madagascar, and Réunion (Western Mascarenes), east to the Hawaiian and Gilbert islands, north to southern Japan, and south to western Australia and New Caledonia (HEEMSTRA, 1984; HEEMSTRA, 1986; PAXTON *et al.*, 2006; HEEMSTRA, 2016); finally, in 1987, the species was also reported for the Mediterranean by ORSI-RELINI (1990) and confirmed by GOLANI *et al.* (2002).

Previously known as *Melanostoma japonicum* Döderlein, 1883 in STEINDACHNER &

DÖDERLEIN (1883) (FRICKE *et al.*, 2021), the species has been studied and reported by various authors such as CARPENTER (1999), NAKABO (2002), PAXTON *et al.* (2006), RANDALL (2007), FRICKE *et al.* (2011), LARSON *et al.* (2013), and SHINOHARA *et al.* (2014). It appears that some researchers have wrongly identified the species as *Acropoma japonicum Günther, 1859*. These are two distinct species of splitfin that belong to two different families, Synagropidae and Acropomatidae Gill, 1893 (FRICKE *et al.*, 2021). *Acropoma japonicum* (the glowbelly) is characterised by a pink body, the ventral surface bright in the night, silver, and thickly covered with dark dots (GHEDOTTI *et al.*, 2018); the anal fin has three slender spines and seven soft rays. The main morphological and meristic features that distinguish *S. japonicus* from the other species belonging to Acropomatidae and Synagropotidae families are: a clear separation between dorsal fins; the pectoral fins not reaching the anus; anal fin with two slender spines and seven-eight soft rays; canines in jaws; lateral-line scales 28 or 33; a distinct longitudinal ridge on lateral surface of maxilla; body uniformly blackish, a bit paler on the belly, lower end of the pre-operculum a pale blue colour with ridge smooth (MEJIA *et al*., 2001; HATOOKA, 2013; HEEMSTRA, 2016; SCHWARZHANS & PROKOFIEV, 2017).

Synagrops japonicus (the blackmouth splitfin) is a benthopelagic species that usually occurs in the area of the continental slope between 50 and 1000 meters of depth, in warm-temperate waters (HEEMSTRA, 1986; 2016); it can reach 35 cm maximum length, but more commonly is found up to 30 cm (MASUDA *et al.*, 1984); the larvae are planktonic, the post larvae possess two flat spines at the opercle rear edge, and the peritoneum is covered with melanophores; at this level of development the pelvic fins may be absent or very reduced (OKIYAMA, 1993). This fish has the peculiar features of a benthopelagic species, displaying relatively large eyes which are dark grey in colour, tending to black. It has sensory organs mainly distributed on the skin covering the head where numerous mucous dimples are visible. The swim bladder, anteriorly bifurcated, is directly in contact with the skull. This peculiarity, which is considered linked to sound reception, is also present in many species of Gadiformes (HEEMSTRA, 1984; PAXTON *et al*., 1989; ORSI-RELINI, 1990; HOESE *et al.*, 2006). Little is known about the feeding habits of *S. japonicus* and what we know is based only on ten samples analysed and sampled in the Sea of Japan, suggesting a preference for bony fishes of the genera *Diaphus*, *Hilsa*, *Lestidium*, *Nemichthys*, etc., but also echinoderms, cephalopods, molluscs, and crustaceans such as *Euphasia pacifica* (YAMAMURA *et al.*, 1998). *Synagrops japonicus* in the Sea of Japan constitutes in turn a prey item for some fish such as *Congriscus megastoma* (KUDO *et al.*, 2006) and *Macroramphosodes uradoi* (NAKAE & SASAKI, 2002); furthermore, *S. japonicus* was found in the stomach contents of pantropical spotted dolphins, *Stenella attenuata* (Gray, 1846), off the eastern coast of Taiwan (WANG *et al*., 2003). *Synagrops japonicus* is a relatively abundant species in the areas mentioned above and occurs as bycatch in trawl fisheries. It is listed as Least Concern (IWAMOTO, 2015).

MATERIALS AND METHODS

During the night of 17/12/2011, following a storm that raged in the north-western area of the Mediterranean, the Eurocargo "Venezia" of the Grimaldi Lines heading for the port of Genoa lost part of the load that was stowed on the ship's deck consisting of drums containing exhausted catalysts (Fig. 1). The lost drums sank to depths between 400 and 500 meters. Considering the dangerousness of the load, the recovery of the drums and a survey for assessing the potential impact on the fish community was carried out. The survey was aimed at establishing the degree of toxicity caused to the fishes and to see whether the phenomenon of biomagnification, over time, had occurred in the local food web. For sampling fish, a trawler of the Livorno fleet with a commercial bottom trawl net operating with a codend with 50 mm mesh-size opening was used.

The monitoring procedures have followed the MEDITS international trawl surveys project protocol established for tows carried out below

Fig. 1. Place where the cargo carrier 'Venezia' of the Grimaldi lines lost its load of drums, and where the individual of Synagrops japonicus *was captured in August 2015*

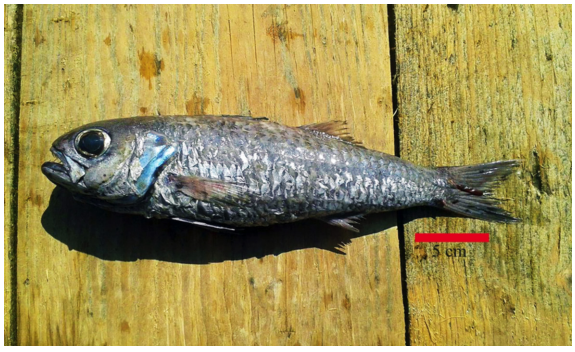

Fig. 2. Specimen of Synagrops japonicus *caught during the tow. At the end of the caudal peduncle, on the left side of the beginning of the caudal fin the copepod* Peniculus *cf.* fistula*. The blue colour of the operculum is clearly visible. Scale bar: 5 cm*

200 m depth for a time span of one hour (AA. VV., 2013; AA.VV., 2015). For four consecutive years, from January 2012 to August 2015, two tows of one hour each were carried out every three months at ca. 400 meters of depth (Fig. 1). During these fishing campaigns, a "new" fish unknown for the Mediterranean fauna was collected. In order to identify this species, various taxonomic references were used (HEEMSTRA, 1984, 1986, 2016; MEJIA *et al*., 2001; SCHWARZHANS & PROKOFIEV, 2017.

RESULTS

In four years of monitoring, 34 hauls in total were carried out and 13 different fish species were collected. During these fishing campaigns, in August 2015, a specimen of blackmouth splitfin was caught and is now stored in 75% alcohol with the P536 code in the collections of the Natural History Museum of the University of Pisa (Table 1; Fig. 2). The specimen was a maturing adult female of 306 mm in total length (TL) and 395.5 g in weight. According to the MEDITS scale (RELINI, 2015), the stage of maturity was determined by macroscopic analysis through the ovaric tunica, which was not yet translucent. The ovary was pinkish yellow in colour with a granular appearance and occupied approximately 2/3 of the body cavity. The eggs were visible by the naked eye. No eggs were expelled under light pressure. All the metrics were collected, and some meristic features were registered. These data were then compared to those of the specimen studied and described by ORSI-RELINI (1990) for an individual of the same species captured in the Portofino waters (Genoa) in 1987 and preserved in formaldehyde (Table 2).

Our specimen has the lower jaw, with distinct concavity on each side of the symphysis, has 5 canines at the front of the jaw. It also displays a triangular patch of villiform teeth on the vomer and a band of similar teeth on each palatine. Both specimens collected in the north-west Mediterranean exhibit similar features except the gill rakers on the 1st inferior arch (12 + 1 vs. 13 + 4 in the present specimen) and the number of the scales along the lateral line (27 vs. 34 in the present work). These slight inconsistencies are probably due to the poor preservation status of the first specimen described by ORSI-RELINI

Table 1. Geographical reference points of the tow where the specimen of Synagrops japonicus *was collected*

Tow	**Time**	**Latitude**	**Longitude**	**Depth (m)**
Start	2:20 pm	43°34.51 ′N	09°47.06 ′W	391
Intermediate point	2:45 pm	43°33.62 ′N	09°46.53 ′W	410
End	3:40 pm	43°30.33 ′N	09°45.54 ′W	420

Table 2. Comparison between the morphometric and meristic features of the two Mediterranean specimens of Synagrops japonicus *and other references regarding the genus only*

Measurements and counts	Present work	Orsi Relini, 1990	Schwarzhns & Prokofiev, 2017	FISHBASE Masuda et al, 1984	Present work as % SL	Orsi Relini 1990 as % SL
Sex	Female	Female				
Maturity	2 C (Medits protocol)					
Measurements						
Total length	306.0 mm	300.0 mm				
Fork length	290.0 mm					
Standard length	264.0 mm	250.0 mm				
Total Weight	395.5 g					
Pelvic Fin	46.4 mm				17.6	
Pectoral Fin	57.9 mm				21.9	
Body depth	65.4 mm	65.0 mm			24.8	26.0
Caudal peduncle	23.8 mm				9.0	
Head length	81.0 mm				30.7	
Anal Fin	37.0 mm				14.0	
Base Anal Fin	35.0 mm				13.3	
Base 1st dorsal fin	46.0 mm				17.4	
Base 2nd dorsal fin	31.6 mm				12	
Eye high	20.0 mm				7.6	
Eye width	23.1 mm	22.0 mm			8.8	8.8
Orbital to preopercle	22.2 mm				8.4	
Upper jaw length	33.2 mm				12.2	
Predorsal length	81.8 mm				31	
Head width	40.7 mm	42.0 mm			15.4	16.8
Head height	67.0 mm	65.0 mm			25.4	26.0
Gape width	34.9 mm				13.2	
Snout length	20.5 mm	20.0 mm			7.8	8.0
Interorbital	24.5 mm	23.0 mm			9.3	9.2
Premaxillary	35.5 mm	35.0 mm			13,4	14.0
1st dorsal base length	7.8 mm				3.0	
1st dorsal height	7.8 mm				3.0	
Dorsal caudal margin	32.5 mm				12.3	
Preventral caudal margin	10.1 mm				3.8	
Counts						
N. caudal rays	22					
N. pectoral rays	16	16				
N. pelvic rays	I + 5	I + 5	I+?			
N. anal rays	II + 7	II + 7	II + 7	II+7		
N. 1st dorsal rays	IX	IX	IX	IX		

N. 2nd dorsal rays	I + 9	I + 9	I + 9	I + 9		
Gill rakers (1st inferior arch)	13 + 4	12 + 1				
N. scales on Lateral Line	34 (33)	27?				
N. Vertebrae				25		

(1990) and they do not constitute significant structural differences. The two samples are both females of ~ 300 mm in TL, but the specimen described by ORSI-RELINI (1990), due to its preservation in formaldehyde, did not allow proper specification of some characteristics of the fish: the colour had lost the shades that this species usually shows. The specimen of the present contribution, freshly analysed, showed the body surface covered with relatively large, dark grey, cycloid scales, while the operculum, especially the outer part as well as the upper internal part of the jaw, was heavily silvered (Fig. 2).

The sagitta is small sized and fairly regular, square in shape with a pointed side, and the inner surface bears the typical sensory groove (*sulcus acusticus*). Its length (9.5 mm) is consistent with the size given by RIVATON & BOURRET (1999), even if the outlines of the sagitta described by these authors matched with those observed in their smaller individuals of ~ 10 cm in TL. Furthermore, the otolith shows the groove (cauda) typical of the genus *Synagrops* (SCHWARZHANS & PROKOFIEV, 2017) (Fig. 3).

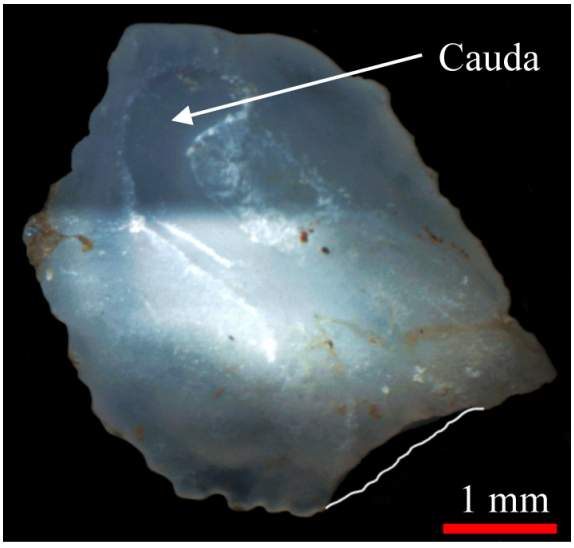

Fig. 3. Left otolith of the specimen. The typical curved groove (cauda) of the genus Synagrops *is clearly visible. The otolith shows a small break towards the rostrum at the bottom right; normal shape drawn with white line*

Unfortunately, the analysed specimen had an empty stomach and the few remains observed at the level of the intestine were completely digested.

It is worth noting the presence of the copepod *Peniculus* cf. *fistula* Nordmann, 1832 (Siphonostomatoida: Pennellidae) in the left side of the end of the peduncle (at the beginning of the tail; Fig. 2). This parasite has a worldwide distribution (ÖKTENER, 2008; WILLIAMS & WILLIAMS, 2009).

DISCUSSION

All species discussed above were classified as Acropomatidae until 2018; subsequently, based upon the fin formula and some other features, the genus *Synagrops* Günther, 1887 was assigned to the family Synagropidae, also known as splitfin ocean-basses (GOLANI *et al.*, 2002; SCHWARZHANS & PROKOFIEV, 2017; VAN DER LAAN *et al*. 2021). A review of the fishes of the basal percoid family has revealed that the genus *Synagrops* Günther, 1887 as currently understood is not a natural group. In fact, species with a serrated pelvic-fin spine have been placed into two different genera, the resurrected genus *Parascombrops* Alcock, 1889 that contains 13 species, and the new monospecific genus *Caraibops* PROKOFIEV & SCHWARZHANS, 2017. The genus *Synagrops* is now confined to two species only, *S. japonicus* (Döderlein, 1883) and *S. bellus* (GOODE & BEAN, 1896), mainly characterised by the apomorphic character of an otic capsule and a very specialised otolith morphology with a particular curved caudal groove (SCHWARZHANS & PROKOFIEV, 2017) (Fig.3). Moreover, *Synagrops* is also characterised by the absence of pelvic-fin spine serrations. Two other species without a serrated pelvic-fin spine originally

described in *Synagrops* have been removed: *Synagrops microlepis* Norman, 1935 has been assigned to the monotypic *Kaperangus* Prokofiev & Schwarzhans, 2017, while the second, *Synagrops pseudomicrolepis* Schultz, 1940, has been assigned to the genus *Verilus* Poey, 1860 (SCHWARZHANS & PROKOFIEV, 2017).

It is interesting to note that after ~ 28 years it was possible to confirm the presence of *S. japonicus* in the same area of the north-western Mediterranean. The two specimens showed similar morpho-biometric features compatible with the values reported in the literature (HEEMSTRA, 2016; SCHWARZHANS & PROKOFIEV, 2017; PSOMADAKIS *et al.*, 2019). ORSI-RELINI (1990) stated that no benthopelagic species migrating from the Red Sea through the Suez Canal had been recorded. If it had happened, this species would have been unable to cross the bathymetric Sicilian-Tunisian threshold. Additionally, *S. japonicus* does not occur in the Red Sea fish fauna (DOR, 1984; FROESE & PAULY, 2019), therefore it is unlikely that the species in question can be considered a Lessepsian migrant.

ORSI-RELINI (1990) also hypothesizes that *S. japonicus* can be considered, in a way, a relict species of the Tethys Sea. This derives from the historical analysis carried out on the presence of fossil specimens belonging to the "Acropomatidae" family found in the Eocene deposits of Bolca, Italy. If that were the case, this species should be very rare and its capture could have escaped the observation of researchers. We believe that this second hypothesis is questionable if not improbable. However, we can state that Italian research operating with scientific bottom trawl cruises has been active since the 1980s with specific programmes to regularly assess the fish resources of our seas, to depths of up to 800 meters, and the species has never been recorded from the area. This systematic investigation continues to the present day with great intensity, so the distribution of the blackmouth splitfin in the Mediterranean is probably not native (RELINI *et al.*, 2008; SPEDICATO *et al.*, 2019).

CONCLUSIONS

We think it is more likely that the presence of two individuals of this species in the Mediterranean basin, in particular in the northernmost part of the western area, is due to the accidental transport of individuals, probably at larval stages, by ships arriving from external zones beyond the Mediterranean. Already ORSI-RELINI (2009) hypothesized a transport in ballast waters for this species. The larvae of this species are planktonic and it is logical to assume that their presence in the area could be related to the ballast water issue, already addressed by OCCHIPINTI-AMBROGI *et al.* (2011) and OCCHIPINTI-AMBROGI (2016). The species of subtropical origin has probably found some favourable environmental conditions in the Mediterranean basin.

HANNACHI *et al.* (2015) described the capture of 20 *S. japonicus* juvenile specimens in the Bay of Annaba (Algeria), correlating the presence of these specimens with the increased maritime traffic and the issue of the ballast water tanks. However, this information is not without some reservation. We believe that confirmation of the presence of the species in this area is required, as the specimens may have been misidentified as another species belonging to a bathyal apogonid fish of the genus *Epigonus* Rafinesque, 1810, possibly supported by a genetic analysis.

In conclusion, it is necessary to consider the question relating to the real geographical distribution of *S. japonicus*. HEEMSTRA (2016) considers the species present in the eastern Atlantic from Guinea to Angola; in the western Atlantic from Canada and Bermuda to southern Brazil, including the Gulf of Mexico and Caribbean. In an evaluation of the conservation status of the species, IWAMOTO (2015) considers it as present in the Atlantic, but expresses some doubts at the same time. In agreement with SINGH-RENTON *et al*. (2015) and SCHWARZHANS & PROKOFIEV (2017) in combination with Iwamoto's doubts, we believe that the presence of *S. japonicus* in the Atlantic has been confused with *S. bellus*. American colleagues we contacted confirmed that during their scientific campaigns *S. japonicus* was never found and that it does not appear

in the recent ichthyological lists of the American area (Singh-Renton, Arocha, *pers. comm*.). Therefore, the occurrence of the two species, *S. japonicus* in the Indo-Pacific and *S. bellus* in the Atlantic, need confirmation (Schwarzhans, *pers. comm*.).

ACKNOWLEDGMENTS

Heartfelt thanks go to Lidia Orsi-Relini, University of Genoa, Italy and to Anna Occhipinti, University of Pavia, Italy for their valuable suggestions. Thanks also to Elena Madeo, University of Calabria, Italy for the identification of the copepod species and for her critical suggestions; Alvaro Juan Abella for the critical reading of the text. A special thanks to Kent Carpenter, Old Dominion University Norfolk, Virginia as well as manager of IUCN Global Marine Species Assessment, USA for valuable suggestions; Susan Singh-Renton, CRFM Secretariat, Saint Vincent and the Grenadines; Freddy Arocha, Universidad de Oriente Cumaná, Venezuela; and Werner Schwarzhans, University of Copenhagen, Denmark for helping us to better define the species identification and geographical distribution of the genus *Synagrops* in the American Atlantic area and in the Indo-Pacific Ocean.

Finally, we are grateful to the referees for their critical and constructive reviews of the MS that resulted in a more comprehensive text.

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Received: 17 April 2021
Accepted: 25 February 2022

Zapis o prisutnosti *Synagrops japonicus* (Acropomatiformes: Synagropidae) u Sredozemnom moru

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SAŽETAK

Uzorak *Synagrops japonicus* sakupljen je u sjeverozapadnom Mediteranu tijekom istraživačkog krstarenja pridnenim povlačnim mrežama, s ciljem procjene mogućih posljedica izgubljenih u moru bubnjeva koje sadrže otrovne materijale. Otkriće ovog primjerka slijedi prvi zapis koji se dogodio na istom području prije 28 godina, a primjerak je bio ulovljen pridnenom koćaricom u vodama Portofina (Genova, Italija) 1987. godine.

Navedeni su morfometrijski i meristički detalji novog uzorka. Prisutnost ove jedinke u sjeverozapadnom dijelu Sredozemnog mora je vjerojatno povezana sa slučajnim transportom ličinki balastnom vodom u brodovima koji dolaze izvan mediteranskog bazena.

Ključne riječi: *Synagrops japonicus*; balastne vode; strane vrste; Ligurska koća