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One *Siganus* or two? On the occurrence of *Siganus luridus* and *Siganus rivulatus* in the Maltese Islands

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*Although both *Siganus luridus* and *Siganus rivulatus* have been reported from the Maltese Islands in the literature, and on internet sites and databases, there do not seem to be any specific records of *S. rivulatus* from these islands. In order to address the question whether both or only one of these alien siganids occur in the Maltese Islands, all records of siganids collected or photographed in Maltese waters were evaluated. Thirteen records comprising at least 33 specimens supported by photographs or specimens and 25 records of 48 individual rabbitfish identified in the field were all *S. luridus*. This suggests that *S. rivulatus* does not occur in Maltese waters.*

Keywords: rabbitfish, marbled spinefoot, dusky spinefoot, non-indigenous species, distribution, central Mediterranean

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INTRODUCTION

The two siganids *Siganus luridus* (Rüppel, 1829) and *Siganus rivulatus* Forsskål in Niebuhr, 1775 (rabbitfishes or spinefoots) are classic examples of successful lessepsian colonizers (Galil, 2007). These two fishes entered the Mediterranean from the Red Sea through the Suez Canal and colonized the Levantine coasts, where they established large populations (Harmelin-Vivien *et al.*, 2005), to the point that they are now commercially fished (EastMed, 2010 and references therein). Following a long period in which these fish did not extend beyond the eastern Mediterranean, both species gradually spread westwards, a trend which, given that both are thermophilic, has been interpreted as correlated with a gradual warming of Mediterranean surface waters (Francour *et al.*, 1994; Occhipinti-Ambrogi, 2007; Ben Rais Lasram *et al.*, 2008; CIESM, 2008; Lejeusne *et al.*, 2010), although it may also have been facilitated by recent hydrographic changes in the east Mediterranean basin related to the Eastern Mediterranean Transient and to climatic events, which are bound to have had an effect also on the central Mediterranean and the western basin (Gasparini *et al.*, 2007; Francour *et al.*, 2010).

Siganus rivulatus (marbled spinefoot) was first reported in the Mediterranean in 1924 from off the coast of Israel (Steinitz, 1927; Ben-Tuvia, 1964). It gradually colonized first the eastern part of the East Basin and then the central Mediterranean, from where it was first recorded from the Libyan coast in 1970 (Stirn, 1970) and then from that of Tunisia in 1974 (Ktari & Ktari, 1974). In 2004 it penetrated into the southern Adriatic (Dulčić & Pallaoro, 2004).

The first report of *Siganus luridus* (dusky spinefoot) in the Mediterranean was in 1956 (Ben-Tuvia, 1964) also from the Israeli coast. The pattern of spread of this species followed that of its congener; it reached the central Mediterranean in the late 1960s, with a number of reports from the coasts of Libya and Tunisia starting in 1969 (Stirn, 1970; Ktari-Chakroun & Bouhlal, 1971; Ktari & Ktari, 1974; Bradai *et al.*, 2004), and the island of Linosa in 2000 (Azzurro & Andaloro, 2004). Unlike its congener, *Siganus luridus* has not yet penetrated into the Adriatic; however, it has entered the southern Tyrrhenian Sea (recorded from northern Sicily in 2004: Castriota & Andaloro, 2005) and it reached one sector of the north-west Mediterranean, the Gulf of Lions, in 2008 (Daniel *et al.*, 2009).

Both species of *Siganus* have been reported from the Maltese Islands. In his catalogue of Maltese fishes, Lanfranco (1993) mentions *Siganus rivulatus* ('This species has entered the Mediterranean from the Red Sea, and is apparently spreading to this area') but he does not enumerate it as he does other fish that he records from Malta, the implication being that he includes this species because he thinks it might occur and not because he, or the sources he based his catalogue upon, have recorded it. On the other hand Sammut (2001) includes this species in his guide and comments that while rare, amateur fishermen occasionally find it entangled in their trammel nets. Malta is listed as one locality of occurrence for *Siganus rivulatus* in the *FishBase* (Froese & Pauly, 2011), *DAISIE* factsheet (*DAISIE* European Invasive Alien Species Gateway: <http://www.europe-aliens.org>) and the *IUCN Red List* (Fricke, 2010) entries for this species; however, all these records give Lanfranco (1993) as their source.

In the case of *Siganus luridus*, Castriota & Andaloro (2005) state that a Maltese diver communicated to them that this species had been observed by SCUBA divers in Maltese waters since the 1990s. *FishBase* lists records from 2002 and 2003 by the same diver (Alexander Buttigieg). *DAISIE* does not include Malta in its list of localities for *Siganus luridus*

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(Galil, 2006), while the *IUCN Red List* does not include an entry for this species. Neither Lanfranco (1993) nor Sammut (2001) include this species.

Sciberras & Schembri (2007) attempted to evaluate all records of non-indigenous species reported from Maltese waters in order to set a baseline for future work. In the case of the siganids, they were able to confirm the occurrence of *Siganus luridus* based on the reliable records of Azzurro *et al.* (2007); however, they were not able to authenticate *Siganus rivulatus* as they could find no specific records of this species but only the general entry in Sammut (2001). These authors noted that while Sammut (2001) includes *Siganus rivulatus*, he does not mention *Siganus luridus* at all, giving rise to the suspicion that the records of *Siganus rivulatus* may actually refer to *Siganus luridus*; for this reason, Sciberras & Schembri (2007) regarded the occurrence of *Siganus rivulatus* in Malta as unconfirmed.

This is an intriguing possibility, especially since *Siganus rivulatus* is not only included in semi-popular (Lanfranco, 1993) and popular (Sammut, 2001) guides to Maltese fish and in websites for sports fishers and marine enthusiasts (e.g. 'Fish found in Malta': <http://renotonna.yolasite.com/>), but it even has a Maltese name *Qawsalla* (Barbara, 1961), which *Siganus luridus* does not. In order to address the question of whether both or only one of the alien siganids occur in the Maltese Islands, we searched for and evaluated all records of siganids collected or photographed in Maltese waters and we report upon our results here.

MATERIALS AND METHODS

The material studied consisted of collected specimens that were examined personally, fish observed and identified *in situ* by the authors and photographs of landed or living specimens submitted to the authors by fishers, divers and other sea users. Those fish that could be identified with certainty based on actual specimens or on photographs were termed authenticated records. In the case of photographs, the main character used to

distinguish between the two species was the shape of the tail (forked in *Siganus rivulatus* and straight or slightly concave in *Siganus luridus*) since this character was usually clearly visible in most images; other characters, such as the anterior nostril having a long flap covering the posterior nostril when depressed in *Siganus luridus* (only reaching approximately halfway to orifice of posterior nostril in *Siganus rivulatus*), were also used when it was possible to see these in the images. Other records of fish observed personally and identified by the authors, but which are not supported by actual specimens or by images, were considered as unauthenticated.

Where we were able to trace the person responsible for a website showing siganids purportedly from Malta, we questioned the person concerned as to the provenance of any images published on the site.

RESULTS

Using our criteria, we were able to authenticate 13 records comprising at least 33 specimens as *Siganus luridus* but none as *Siganus rivulatus* (Table 1). The earliest of the authenticated records (an image posted on *FishBase*) dated from 2002. All fish for which depth and habitat data were available came from shallow rocky bottoms with photophilic algae.

In addition, we have 25 unauthenticated records of 48 individual rabbitfish which were all identified as *Siganus luridus* (Table 2), and no records at all that may be ascribed to *Siganus rivulatus*.

Interviews with the persons responsible for Maltese websites that feature images of *Siganus rivulatus* revealed that none of the images of this species posted were actually taken in Maltese waters.

DISCUSSION

Whereas there is no doubt whatsoever that *Siganus luridus* is well established in Malta and is becoming more common, to the point that it has started being offered for sale at local

Table 1. Authenticated records of *Siganus* spp. from the Maltese Islands.

Date	Locality	Species and number	Basis of record	Notes
August 2002	Malta (no locality given)	<i>S. luridus</i> 1	Photograph (Alex Buttigieg)	Photograph published on <i>FishBase</i>
5 September 2005	Wied iz-Zurrieq	<i>S. luridus</i> 7	Video (Shaun Arrigo)	3–4 m depth; rocky seabed with photophilic algae
October 2006	Ras il-Qammieh	<i>S. luridus</i> 6	Specimens (John Camilleri)	7 m; rocky seabed with photophilic algae
12 June 2007	Cospicua	<i>S. luridus</i> 1 (adult)	Photograph	On sale at the Cospicua fish market
3 August 2007	Malta (no locality provided)	<i>S. luridus</i> 1 photographed 1 reported	Photograph (Adrian Theuma)	Another four of the same species reported encountered since 2003
27 December 2007	Ghar Lapsi	<i>S. luridus</i> 1	Photograph (Norman Ghigo)	3 m; rocky seabed with photophilic algae
22 February 2009	Marsaxlokk	<i>S. luridus</i> 7	Photograph (Edwin Zammit)	On sale at fish market
15 March 2010	Qbajjar, Gozo	<i>S. luridus</i> 3	Photograph (Arnold Sciberras)	1.5–2 m depth
9 August 2010	Wied iz-Zurrieq	<i>S. luridus</i> 2	Photograph (Sonia Silvio)	6 m; rocky seabed with photophilic algae
19 May 2011	Wied iz-Zurrieq	<i>S. luridus</i> 1	Photograph	3–4 m depth; rocky seabed with photophilic algae
July 2011	Mouth of Grand Harbour	<i>S. luridus</i> 1 seen, at least 7 reported	Specimen (Reno Tonna)	5 m; rocky seabed with photophilic algae; juveniles present
29 July 2011	Xlendi, Gozo	<i>S. luridus</i> 1	Photograph (Monica Farrugia)	Caught by angler
28 August 2011	Delimara	<i>S. luridus</i> 1 (juvenile)	Photograph	5 m; rocky seabed with photophilic algae

Table 2. Unauthenticated records of *Siganus* spp. from the Maltese Islands. All specimens were identified as *Siganus luridus*.

Date	Locality	Number	Observer
12 July 2005	Delimara	3	M.A.F.
11 July 2007	Zurrieq	4	A.D.
09/14/23/25/28/29/30 June 2008	Delimara	3/1/3/1/1/2/5	M.A.F.
3 July 2008	Delimara	1	M.A.F.
21 July 2008	Delimara	4	M.A.F.
4 September 2008	Gnejna	1	M.A.F.
16 June 2009	Delimara	1	M.A.F.
22 July 2009	Delimara	1	M.A.F.
1 August 2009	Delimara	1	M.A.F.
13 August 2009	Ghar Lapsi	3	A.D.
16 July 2010	Delimara	2	M.A.F.
29 July 2010	Qawra Point	1	A.D.
7 September 2010	Zurrieq	1	A.D.
18 September 2010	Pembroke	1	M.A.F.
18 May 2011	Delimara	1	M.A.F.
22 July 2011	Delimara	1	M.A.F.
15 August 2011	Delimara	1	M.A.F.
23 August 2011	Wied iz-Zurrieq	4	M.A.F.
1 October 2011	Golden Bay	1 (juvenile)	M.A.F.
10 December 2011	Peter's Pool	4 (juvenile)	M.A.F.

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fish markets (see Table 1), we did not encounter any specimens of *Siganus rivulatus* at all and neither did we find any images of this species taken locally. In fact, all reports of this species from Malta appear to stem from its inclusion in the guide to Maltese fish by Lanfranco (1993). However, this author did not actually state that this species occurs, but that it 'is apparently spreading to this area'. Lanfranco (1993) also gives the Maltese name (*Qawsalla*) and cites Barbara (1961) for this. Barbara (1961) was an attempt by the Maltese governmental fisheries agency to standardize the names given to Mediterranean fish caught locally. It is clear from Barbara's introductory comments that he was giving the vernacular Maltese names to species known to occur in the central Mediterranean, without any regard as to whether these species actually formed part of the Maltese fauna or not.

There are therefore two possibilities. The first is that *Siganus rivulatus* used to occur in Maltese waters at the time that Barbara (1961) compiled his list of names and has since become extinct, or at least very rare indeed. The second is that Barbara (1961), followed by Lanfranco (1993), included this species in their respective works on the assumption that since it was spreading westwards from the eastern Mediterranean, it would eventually occur in Maltese waters. The second possibility is more likely.

This leaves Sammut (2001) as the only record of *Siganus rivulatus* from Malta. Given that this author states that the fish is occasionally caught in Maltese waters but that, in spite of our searches, we have not encountered the species, and because Sammut (2001) does not include *Siganus luridus* even though this fish was present in local waters at the time Sammut was writing (Alexander Buttigieg in personal communication to Castriota & Andaloro, 2005), it is likely that Sammut (2001) has confused the two species and was actually writing about *Siganus luridus* rather than *Siganus rivulatus*. Therefore, all evidence suggests that *Siganus rivulatus* has never been recorded from the Maltese Islands and does not occur, and Malta should be removed as a locality for

this species, especially from international databases which are widely consulted. Accuracy of occurrence data is especially important for localities such as Malta which is on or close to the boundary between the eastern and western Mediterranean biogeographical sectors (Bianchi, 2007), particularly if such data are used to formulate models of dispersal between the east and west basins.

One interesting question that arises from our results is why does *Siganus rivulatus* not occur given that it is present along central Mediterranean coasts, including those of Libya and Tunisia, less than 350 km from Malta. Both *Siganus luridus* and *Siganus rivulatus* are very fecund, potentially producing more than 250,000 eggs per spawning season (Bariche *et al.*, 2009) and with a surface planktonic larval period that may last up to four weeks (Woodland 1999); potentially therefore, surface currents may transport larvae for up to 1000 km (Azzurro *et al.*, 2006). Moreover, adult siganids may disperse by active swimming, perhaps in association with drifting weed (Azzurro *et al.*, 2006 and references therein). The potential for *Siganus rivulatus* to reach Malta, as was done by *Siganus luridus* therefore exists. A similar situation occurs in the Ionian Sea where *Siganus luridus* is abundant but where *Siganus rivulatus* has not established itself and has only very occasionally been recorded (Bardamaskos *et al.*, 2009). It has been suggested that niche overlap between these species in the different environment of the Ionian may result in *Siganus luridus* outcompeting *Siganus rivulatus* (Bardamaskos *et al.*, 2009). Similarly, Shakman (2008) has suggested that competition between the two siganids may account for his observations that *Siganus luridus* is more abundant in the Gulf of Sirte (also known as the Gulf of Sidra) and the western Libyan coast whereas *Siganus rivulatus* is more abundant along the eastern Libyan coast.

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