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Saddleback Syndrome in the Common Lionfish *Pterois miles* (Scorpaeniformes: Scorpaenidae), Off Cyprus, Eastern Mediterranean Sea

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Abstract
Two abnormal specimens of the common lionfish *Pterois miles* (Bennett, 1828) (Scorpaeniformes: Scorpaenidae) were caught off the eastern and southeastern coasts of Cyprus, in the eastern Mediterranean Sea (Levantine Basin). Abnormalities (notches) in both specimens were observed in the dorsal fin. In one specimen (33 cm, total length and 565 g, gutted weight) three dorsal fin spines were absent (and the proximal pterygiophore of the 9th spine shorter or absent), while in the other specimen (40 cm, total length and 845 g, gutted weight) four fin-rays were missing. Globally, many other fish species are reported with this abnormality, known as the saddleback syndrome, whose origin could be congenital, pollutant-related, and physical. Given that *P. miles* is a Lessepsian migrant fish in the Mediterranean Sea, and an invasive species, a removal campaign began in Cyprus since 2017. In this campaign, scuba/free divers, and fishers, have been encouraged to remove it, mainly with pole spears or sling shots, to fight its population invasion. It is possible that this syndrome in *P. miles* is due to physical injuries related to failed spearfishing attempts rather than an either congenital or pollutant-related origin.

Keywords Lessepsian migration · Invasive species · Culling · Injury · Deformity

Introduction

The common lionfish *Pterois miles* (Bennett, 1828), native of the Indian Ocean and surrounding regions (Kulbicki et al. 2012), is a Lessepsian migrant of the Mediterranean Sea. The predatory nature of this scorpaenid, and its population increase, threaten the marine ecosystems where now represents a biological invasion of unexpected consequences in the region (Bariche et al. 2013; Kletou et al. 2016; Jimenez et al. 2016; Azzurro et al. 2017; Dimitriadis et al. 2020; Huseyinoglu et al. 2021). Various biological characteristics of *P. miles*, such as their growth, feeding and genetics, have been studied in the invaded region (Bariche et al. 2017; Dimitriou et al. 2019; Stern et al. 2019; Zannaki et al. 2019; Agostino et al. 2020; Savva et al. 2020). However, a morphological abnormality noticed in *P. miles* off Cyprus could be related to the saddleback syndrome. In general, a key characteristic associated and reported in various fish species with this syndrome is a notorious notch on the dorsal fin with fin spines being absent (Jawad and Ibrahim 2018).

Globally, the saddleback syndrome has been described in the red spotted grouper, *Epinephelus akaara* (Setiadi et al. 2006), the Mediterranean parrotfish, *Sparisoma cretense* (Koumoundouros 2008), the wild silver pomfret, *Pampus argenteus* (Jawad and Al-Mamry 2012), the white seabream, *Diplodus sargus* (Sfakianakis et al. 2003), the yellowfin bream, *Acanthopagrus australis* (Diggles 2013; Pollock 2015, 2020), and the wild black pomfret *Parastromateus niger* (Silambarasan et al. 2021). Also, this syndrome has been reported in a sibling of *P. miles*, the red lionfish, *Pterois*

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volitans (Aguilar-Perera and Quijano-Puerto 2018), and even in a freshwater fish, *Tilapia aurea* (Tave et al. 1983). This syndrome may have a congenital origin (Tave et al. 1983), pollutant-related origin (Bengtsson 1988; Browder et al. 1993), aquaculture affectation (Koumoundouros et al. 2001; Setiadi et al. 2006; Diggles 2013), or physical damage (Pollock 2015, 2020). The aim of this study was to describe, for the first time, the occurrence of the saddleback syndrome in *P. miles* off Cyprus, in the eastern Mediterranean Sea.

Materials and Methods

Konnos Bay (34°59′62’’N, 34°07′88’’E; Konnos hereafter), located in the eastern coast of Cyprus (Fig. 1), is a popular destination for water sports, including SCUBA and free diving, and is characterized by shallow to mid-deep rocky habitats of easy access from shore (erosional platforms and low cliffs), and seafloor with interspersed boulders, channels, ledges, crevices and patchy *Posidonia oceanica* seagrass meadows. Cape Kiti (34°49′21’’N, 33°38′24’’E; Kiti hereafter), located in the southeastern coast (Fig. 1) has an extensive and irregular rocky platform bordering the shallow areas, with abundant *P. oceanica* meadows. In deeper waters (> 20 m depth), platforms are interspersed with coarse sandy bottoms and isolated outcrops frequently visited by fishers and free divers.

Since 2017, there is a mediatic campaign in Cyprus to remove *P. miles* encouraging fishers and public to catch and consume it in order to fight its population invasion (Jimenez et al. 2017, 2018; Kleitou et al. 2019; see also http://relionmed.eu/). In Konnos, on March 2019, a local, experienced free diver speared 53 lionfish, in less than two hours, with a slingshot (Hawaiian sling) at 25 m depth. Here, one fish specimen drew attention due to a deformity at the dorsal area, so it was provided to us for further examination. In Kiti, on August 2021, a fisher using trammel nets (26 mesh size) at 21 m depth, got three individuals. From this catch, a specimen also drew attention due to a dorsal deformity and it was provided to us for examination.

At the laboratory, both specimens were taxonomically identified following Schultz (1986). Morphometrics, such as total length (TL) in centimeters (cm) and wet, gutted weight (GW) in grams (g), were recorded. Deformities for each fish at the dorsal fins were measured (width, length and height; WxLxH, cm), and dorsal fin spines counted where possible. Under normal conditions, the *Pterois* genus is characterized by having XIII dorsal fin spines and 10 to 11 fin soft rays. In fact, *P. miles* has 13 spines and 10 soft rays in dorsal fin (DXIII-10), while *P. volitans* 13 spines and 11 soft rays (DXIII-11). Photographs and X-ray radiographies were taken not only for the abnormal specimens but also for a normal lionfish specimen for comparisons.

Although the presence of *P. volitans* in the eastern Mediterranean is debatable (Gürlek et al. 2016; Ayas et al. 2018; Turan et al. 2020; see Çinar et al. 2021), we proceeded with the genetic identification for the abnormal specimens described in our study. Thus, small pieces of fin tissue from both individuals were used for the DNA isolation. Total genomic DNA was extracted using DNeasy Blood and Tissue Kit (Qiagen, Hilden, Germany) following the proposed protocol. The concentration and purity of yielded DNA was assessed with NanoDrop 2000/200c (Thermo Fisher Scientific Inc., Waltham, MA, USA). In both cases, the concentration exceeded 15 ng/μL and the purity ratio (A260/A280nm absorption rate) was > 1.85. PCR products were

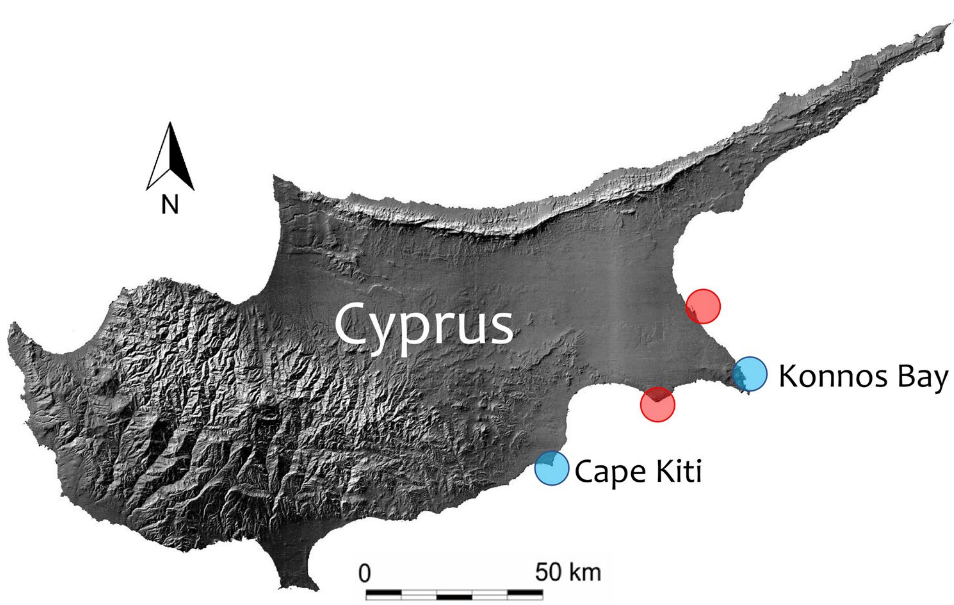

Fig. 1 Locations in Cyprus from which specimens of *Pterois miles* with the saddleback syndrome were caught by volunteers (blue circles) and also those reported by local fishers (red circles)

purified with Qiaquick Purification Kit (Qiagen) and sent to Macrogen (Amsterdam, the Netherlands) for sequencing on both strands. The mitochondrial loci Cytochrome c oxidase subunit 1 (COI) and the Control region (CR) were targeted and successfully amplified using common PCR procedures. Primes used and PCR conditions were adopted from Dimitriou et al. (2019). Sequencing results were sent to us as chromatographs and inspected with CodonCode Aligner (v. 3.7.1; CodonCode Corp., USA). Basic Local Alignment Search Tool (BLAST) was applied aiming to identify genetically similar sequences available in NCBI GenBank. Multiple sequence alignments were performed with MAFFT v.7 (Katoh et al. 2002) and the resulted file was used to MrBayes v3.3.6 (Ronquist et al. 2012), where Bayesian inference was performed under the GTR model, as indicated by the jModelTest v.2.1.1 (Darriba et al. 2012). Specimens of another sibling, *P. mombase*, were included in our dataset to serve as an outgroup.

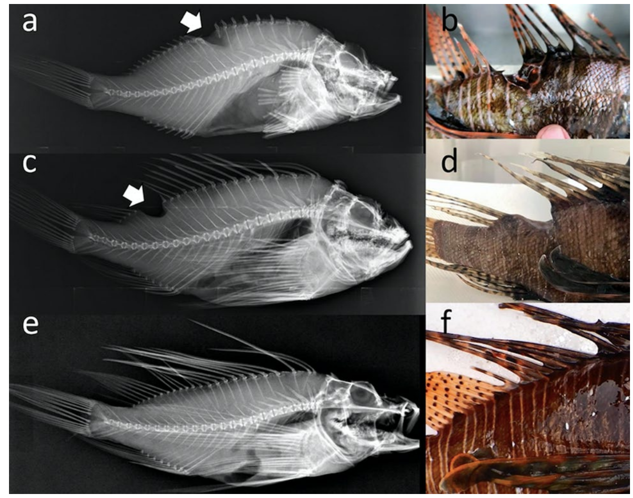

Fig. 2 Radiographic images and close up photographs of the deformities on the dorsal fins of *Pterois miles* specimens from Konnos (**a**, **b**) and Kiti (**c**, **d**), Cyprus. A normal (for reference) *P. miles* specimen (**e**, **f**)

Results and Discussion

The abnormal specimens were taxonomically identified as *Pterois miles* (Bennett, 1828). The specimen from Konnos (33 cm TL and 565 g GW) showed a deformity characterized as a notch or depression (1.7 W × 3.0 L × 1.4 H cm) at the posterior area of the dorsal fin and the specimen from Kiti (40 cm TL and 845 g GW) showed a similar deformity (2.0 W × 2.2 L × 2.5 H cm) at the posterior area of dorsal fin. However, based on the radiographic examination of the Konnos specimen, the proximal pterygiophore (basement of dorsal spine) of the 9th spine is shorter than the others and the two following spines (10th and 11th), along with their associated pterygiophores, were lost (Fig. 2a, b). The Kiti specimen showed the dorsal fin spines complete, but four soft rays were lacking (Fig. 2c, d).

Retrieved molecular sequences, from both abnormal specimens (A and B), for the targeted genes were identical to the already deposited sequences by Dimitriou et al. (2019) belonging to different *P. miles* haplogroups. A data set including publicly available sequences for *P. miles* and *P. volitans* was generated, and their GenBank accession numbers established (Fig. 3). Consequently, the abnormal specimens showing the saddleback syndrome in our work correspond to *P. miles*.

Worldwide, various fish species have been diagnosed with the saddleback syndrome (Jawad and Ibrahim 2018). In particular, *P. volitans*, off the northern Yucatan Peninsula, southern Gulf of Mexico, was diagnosed with this syndrome (Aguilar-Perera and Quijano-Puerto 2018). *P. volitans* is another invasive scorpaenid that threatens the marine ecosystem of the western Atlantic due to its voracity and abundance in mesophotic reefs (Andradi-Brown et al. 2017; Aguilar-Perera et al. 2017). However, it is possible this syndrome diagnosed in *P. volitans* could be a physical injury due to failed spear fishing by local fishers (Aguilar-Perera and Quijano-Puerto 2018). Since 2010, a mediatic campaign engaged local fishers in the Yucatan, Mexico, to remove it with spearguns to fight its population invasion (López-Gómez et al. 2014). The Parque Nacional Arrecife Alacranes, where this scorpaenid was caught, is located 130 km off the northern coast of the Yucatan Peninsula, Mexico. So, this area is far too distant from any potential source of pollution from the coast in the Gulf of Mexico.

In Australia, the saddleback syndrome in *A. australis* was first detected under aquaculture conditions (Diggles 2013), in which fish showed moderate to severe affectation by the syndrome. Similarly, other fish species under aquaculture conditions, exhibit this syndrome, such as *D. dentex* (Koumoundouros et al. 2001) and *E. akaara* (Setiadi et al. 2006). Jawad and Ibrahim (2018) present a list of various causes of the syndrome in fish species from the Arabian Gulf coast. A recent study contended that physical injury, due to net filaments cutting effects, as a plausible cause of this syndrome shown in *A. australis* (Pollock 2020) on the east coast of Australia.

In Cyprus, the saddleback syndrome in *P. miles* is probably also related to physical injuries. Here, local free-divers and fishers have been encouraged to catch it to fight its population invasion (Kleitou et al. 2019). Various fishing tournaments have been organized to remove it, as well as a mediatic campaign has been promoted to consume it since 2017 (Jimenez et al. 2018; see also http://relionmed.eu/). After many of these tournaments, underwater observations reports have remarked a similar deformity (saddleback) in the dorsal region of *P. miles* (Jimenez, unpublished data).

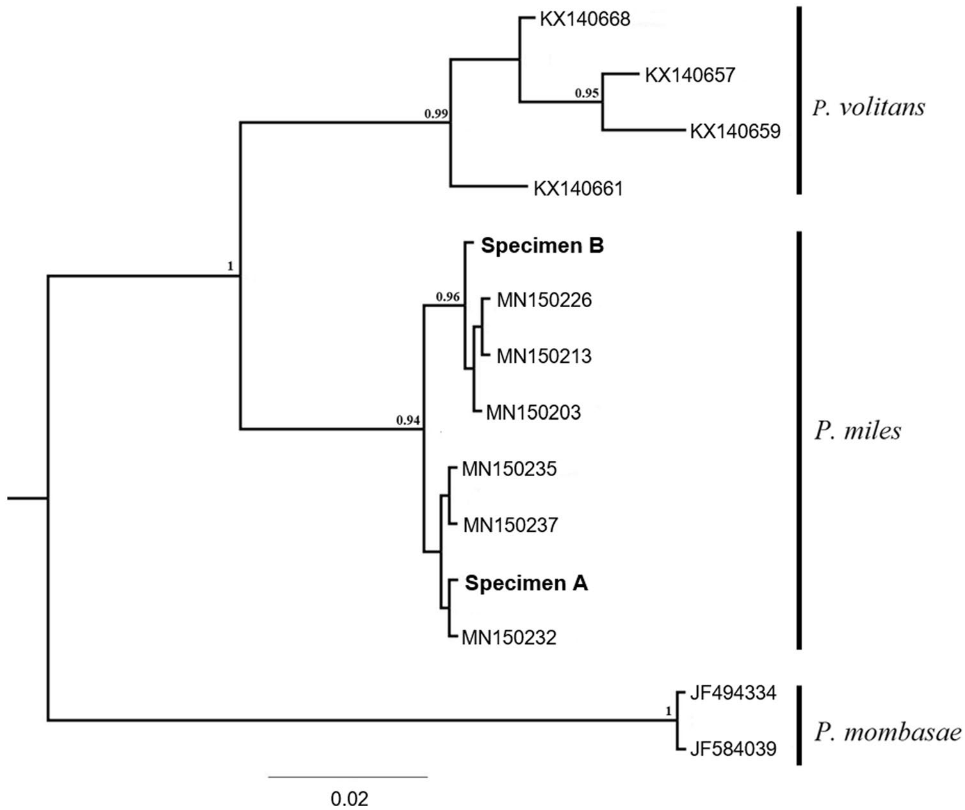

Fig. 3 Fifty percent majority-rule consensus tree of the Bayesian Inference analysis constructed using COI. Posterior probabilities (> 90) are given above nodes. Specimens A (Konnos) and B (Kiti) correspond to those collected *P. miles* in our study off Cyprus

It is possible that after, either a failed spearing or probably net filament cuts (e.g. Pollock 2020 like in *A. australis*), and if fish survive and wounds heal, the deformities would probably look like the ones described in our work and might be easily recognized by fishers. For example, after showing photographs of deformities to fishers from other coastal areas, where active culling and trammel net are common, they recalled catching either one or two lionfish showing similar deformities, such as those depicted in the photographs.

In our study, the incidence of deformities in *P. miles* noticed by fishers is low given that in a total lionfish catch of about 20 to 30 kg in a fishing trip, for example, such deformities are unheard (A. Petrou, unpublished data). This scenario in Cyprus calls to implement a program to identify if more specimens of *P. miles* have this syndrome, and also validate its relation to failed attempts to spear it compared to a congenital or pollutant-oriented origin.

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Declarations

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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