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Unexpected massive enmeshments of the Sharpchin barracudina *Paralepis coregonoides* Risso, 1820 in mesopelagic sediment traps in the Levantine Basin, SE Mediterranean Sea

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Abstract

This study reports exceptional penetrations of the Sharpchin Barracudina *Paralepis coregonoides* into pelagic, open-sea sediment traps in the Levant Basin of the SE Mediterranean Sea. This first substantiated record of the species at the Levant Basin has been observed in two sediment traps at 180 and 280 m depth, 50 km offshore the coast of Israel. Over one year of deployment (November 2016 till November 2017), 483 adult individuals have been repeatedly entrapped inside the automatic sediment traps that were covered with a 25 mm baffler mesh for the first half year and then replaced with a smaller 10 mm mesh for the second half. This undesirable catch of such an elusive and understudied species enabled us to revise its distribution, abundance and genetic divergence. The continuous entrapment throughout the year of sexually mature individuals has confirmed that this species is common to the SE Mediterranean. In order to avoid unwanted entrapments that disrupt biogeochemical sediment studies, the installation of small mesh size nets on the conventional sediment trap openings must be considered in the pelagic zone of the SE Mediterranean, and probably elsewhere.

Keywords: Paralepididae; Mesopelagic fishes; Mediterranean Sea; Genetic divergence; Mooring Station.

Introduction

The ocean mesopelagic zone covers the majority of earth's volume and is characterized by a strong hydrostatic pressure, diminished light and high inorganic nutrient concentrations which makes it an appealing region for biogeochemical studies (Robinson *et al.,* 2010; Sutton *et al.,* 2017). Among the variety of methodologies that are being employed worldwide, the use of sediment traps greatly contributes to the documentation and understanding of the carbon pump and cycling within the mesopelagic water column (Armstrong *et al.,* 2002; Peterson *et al.,* 2005; Trull *et al.,* 2008). However, while sediment traps are considered as an ideal tool to gather biogeochemical data, the fluency of the process may be occasionally interrupted by various incidental forces.

Mesopelagic fishes are highly abundant in oceanic waters with an estimated biomass of ten billion metric tons (St John *et al.,* 2016), with many of them that perform diel vertical migration (Gjøsaeter & Kawaguchi, 1980; Klevjer *et al.,* 2012; Olivar *et al.,* 2012), thus actively transporting carbon throughout the water layers (Wang *et al.,* 2019). Within this populated ecosystem, resides the fish family of barracudinas (Paralepididae) that contains almost 60 known circum-global species (Fricke *et al.,* 2018). Barracudinas inhabit a wide gradient of the water column, from the surface down to 1,000 m, from the continental slope to mid-ocean areas (Harry, 1953), and in spite of their wide distribution and species richness, the biology and distribution of this family remain largely understudied, with the last comprehensive study made by Harry (1953).

The Mediterranean Sea contains six species of barracudinas, five of them are reported to inhabit the easternmost basin, the Levant Basin (Whitehead *et al.,* 1984; Golani, 2005).

In this study, we document a rare and prolonged annual accidental catch, between November 2016 to November 2017, of 483 adult individuals of the rare Sharpchin barracudina *Paralepis coregonoides* Risso, 1820, in two sediment traps at depths of 180 and 280 m, 50 km offshore the northern coast of Israel at the Levant Basin. Although this catch has impeded the original objectives of the biogeochemical study, it constituted the first confirmed observation of the species in the eastern Mediterranean and granted a unique opportunity to obtain novel knowledge regarding the abundance and distribution of this elusive mesopelagic species.

Material and Methods

A multidisciplinary research enterprise to investigate various oceanographic processes has been established on board the 'DeepLev' mooring station in the Levant Basin. The mooring was deployed in November 2016 approximately 50 km west of Haifa, Israel, at 1500 m depth (Lat/Lon: 32.993°N, 34.493°E; Fig. 1B). On board the station, three time-series sediment traps (McLane PARFLUX Mark78H-21) with $0.5m^2$ opening with a honeycomb structure and a 25 mm baffler mesh has been positioned at depths of 180, 280 and 1300 m. Each trap was designed to collect sinking particles for six months and included 21 collection bottles filled with 500 ml of 5% buffered formaldehyde. Each bottle had an automatic duration of 11-12 days to be available for samplings. After six months, in May 2017, the traps were recovered, emptied and deployed again with a smaller 1 cm mesh size until November 2017. In total, the sediment traps have spent a year underwater, collecting data from 33 collecting bottles at each depth. In addition, water temperature has been recorded every 10 minutes in 300 m depth, in adjacent to the deeper sediment trap.

After uploading on deck, the entire content of the sediment bottles was labelled and kept either at freezing temperature (-20°C) or preserved in 70% ethanol. In the lab, all samples were identified, counted and evaluated by the degree of the tissue degradation. Intact, well preserved individuals were later used for morphological and biological analyses, while individuals that less absorbed the DNA-degrading formalin were taken for genetic analyses. Finally, all intact fish individuals were deposited in the fish collection of the Steinhardt Museum of Natural History at Tel Aviv University under the catalogue vouchers SMNHTAU P. 15903-05.

At the lab, fish individuals were weighted and measured to the nearest 0.1g and 1 mm. In addition, a subsample of 50 individuals from both depths, comprising 10% of total individuals, have been dissected to determine maturity stage and gut contents. Considering the monoecious biology of the species (Whitehead *et al.,* 1984), the maturity stage was determined by the sex showing the more dominant gonads, according to the classification given in MEDITS handbook v. 9 (2017).

640-688bp fragment of the mitochondrial cytochrome oxidase subunit 1(COI) was amplified from three individuals using the primer Fish F1, and following the protocol of Ward *et al.,* (2005). The contiguous sequences have been uploaded to BOLD platform under the accession vouchers BIM566-18–BIM568-18. Genetic comparisons were computed with previously published sequences using MEGA, v.7 (Kumar *et al.,* 2016) under the Kimura-2-parameter (K2P) corrected distance (Kimura, 1980).

Results

During the first sampling period between November 2016 to May 2017, a total of 114 and 201 adult specimens of *P. coregonoides*, identified after Whitehead *et al.,* (1984), were entrapped in the 180 m and 280 m sediment traps, respectively (Fig. 1A, C). Despite changing to a smaller mesh size of 1 cm at the entrance of the traps before the second deployment, additional 102 and 66 individuals were caught in the two depths, respectively. The deepest sediment trap at 1300 m deep, however, remained empty of fish during both deployments.

The fish penetrated through the upper 25 mm mesh size and ended up in the collection bottles (Vol = 0.5L), with a maximum of 42 individuals in a single bottle. The number of caught individuals per collecting bottle varied throughout the year, with the highest numbers in late winter-early spring and autumn (December-May, 9.375±11.09 individuals versus the warmer months June-November, 5.38±7.47, Fig. 2).

The fish lengths ranged between 115-139 mm in to-

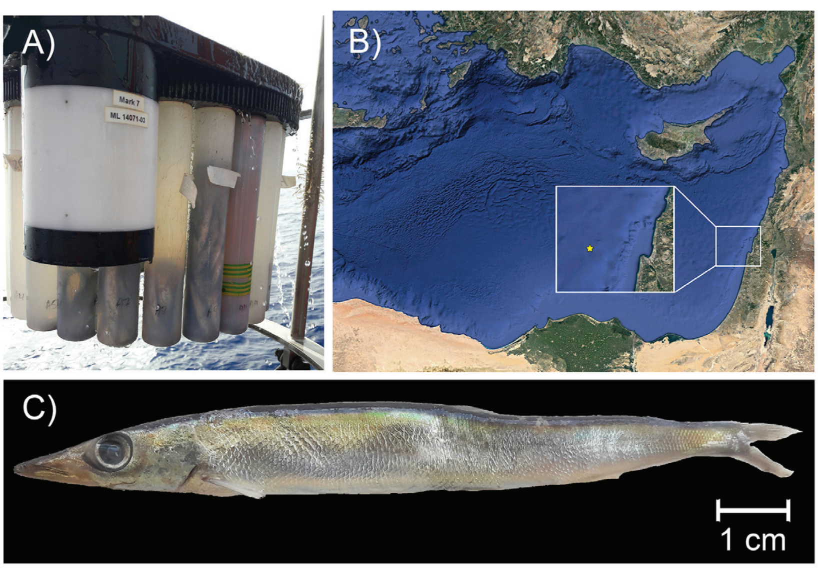

Fig. 1: A) The collecting sediment bottles with the entrapped specimens of *P. coregonoides*; B) Levant Basin, SE Mediterranean, indicating the site of the sediment traps at DeepLev station, 50 km offshore Haifa (yellow star); C) *Paralepis coregonoides* Risso, 1820, 18.04.2017.

tal length, with an average of 128.7±5.7 mm, whereas their weight ranged between 3.6-5.1 g, with an average of 4.2±0.5 g. While the majority of the examined specimens were found to be sexually mature (88%), the sex ratio was found to be female-biased (F:M-35:15). However, no temporal correlation was found throughout the year, i.e., each collecting bottle contained a mix of both maturing specimens (Stage 2) and spawners (stage 3). Considering the rarity of this finding, this is the first modern documentation of the species' gonad maturity stages, that can be now viewed in Fig. 3A-B. Regarding gut content analysis, the majority of the dissected stomachs were found empty due to their time spent in the trap. Five stomachs (10%) contained digested fish remains with one partially-identifiable specimen of lanternfish myctophid sp.

640-688 bp of the *COI* gene were sequenced for three specimens of *P. coregonoides*, and assigned in BOLD platform within the Barcode Index Number (BIN) BOLD:AAA8782. A genetic divergence of 0.2-0.8% was observed between and within the three examined individuals of this study and previously published sequences. These comparisons were done between collected specimens from the middle Atlantic (Accessions UKFBI496-08 and MAECO507-09, submitted under *Paralepis brevirostris* (Parr, 1928)) and northeast Atlantic Ocean (Accession MAECO508-09). Considering the absence of available genetic information for congeneric *Paralepis* spp., the nearest genetic resemblance was observed with two other paralepidids *Lestidiops ringens* (Jordan & Gilbert, 1880) and *Arctozenus risso* (Bonaparte, 1840), with an average of 12% of nucleotide divergence.

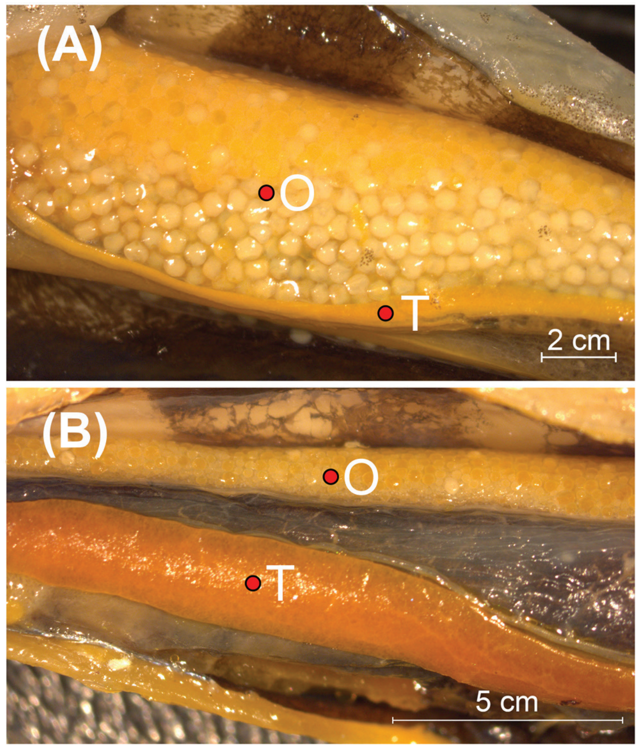

Fig. 3: Gonad maturity stages of *P. coregonoides*, under light stereoscope. O=female ovaries; T=Male testes. (A) Ovaries in spawning stage, testes in resting stage; (B) Ovaries in spent stage, testes in spawning stage.

Discussion

Offshore mooring stations can provide important knowledge on the remote oceanic habitat, which predominantly contributes to biogeochemical and oceanographic data. This study reports an unwanted, albeit unique, catch that enabled new insights on an elusive life history and distribution of a mesopelagic fish. Although *P. coregonoides* has been previously reported from the eastern Ionian Sea (Mytilineou *et al.,* 2005), and the Aegean and Libyan Seas (Papaconstantinou, 2014), this study consti-

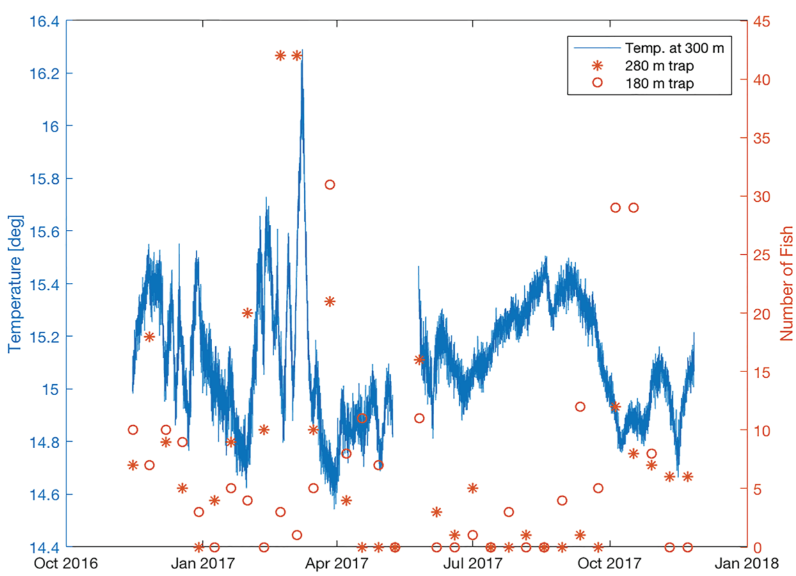

Fig. 2: Number of sampled individuals of *P. coregonoides* in each bottle of the two sediment trap systems, the DeepLev station at the SE Levantine basin. Corresponding water temperature (°C) measured in 300 m in blue line.

tutes the first substantiated record of this species from the eastern Levant Basin, taking into account only unidentified *Paralepis* sp. larva collected in 1969 in Israel (Lourie, 1972), and previous records. Moreover, to the best of our knowledge, this study documents the largest catch of adult specimens of *P. coregonoides* throughout its entire distribution. Together with the continuous findings of sexually mature individuals, this clearly indicates that this species is a common resident at the Levant Basin.

Acting as a fish aggregating device (Castro *et al.,* 2002; Dempster & Taquet, 2004), the sediment traps in our study have most likely attracted local residents of the mesopelagic habitat. However, considering size restriction and opening orientation of the traps, only vertical swimmers can ensure capture. Indeed, this unique habit of swimming characterizes species of barracudina (Whitehead *et al.,* 1984), which explains, together with their slender form, this mono-species entrapment events. We postulate that this unique swimming behavior contributes to their known tendency to efficiently avoid sampling nets, which is eventually reflected in a scarce and infrequent information available throughout their distribution, that is mainly based on documenting juvenile and adult specimens inside stomachs of large pelagic fishes (Potier *et al.,* 2007; Consoli *et al.,* 2008; Battaglia *et al.,* 2013). Moreover, the absence of juvenile individuals in the traps throughout the year may suggest they either lack vertical swimming abilities at this life stage or that they simply do not dwell in this layer of the pelagic water column.

Although this study only summarizes a single year, higher values in average catch per collecting bottle were shown during the colder months, though without correlation with 300 m water temperature measurements (Fig. 2). This result may coincide with the general trend in which temperate or cold water species avoid warm water, and perform vertical or horizontal migration when local conditions are inadequate (Stern *et al.,* 2018).

The shallow mitochondrial genetic divergence found between specimens from this study and previously published data from distant localities around the Atlantic Ocean (0.2-0.8%) signifies the pelagic lifestyle of this species and could possibly represent migration characteristics and/or efficient propagule dispersal that enables continual gene flow throughout its distribution.

Last, apart from this unplanned contribution to mesopelagic ichthyology, we consider this case as a ‘warning sign’ for future deployment of pelagic sediment traps. This general trend of uninvited “swimmers” in sediment traps has been previously debated, providing several recommendations on how to prevent, remove or consider the impact of the different life forms of these swimmers (Buesseler *et al*., 2007). In our case, the fish penetrations made it impossible to quantify and intelligibly analyze the sediment particles and their fluxes, and only after placing a 7mm stainless-steel mesh on the trap openings during the third deployment, were we able to prevent future additional fish entries.

Conflict of Interest: The authors declare that they have no conflict of interest.

Data linking: The genetic datasets generated during the current study are available in the Barcode of Life Data System (BOLD), with the accession codes – BIM566-18, BIM567-18 and BIM568-18.

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