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Research article

The northernmost expansion and first record of lessepsian black-barred halfbeak, *Hemiramphus far* (Forsskål, 1775) in the Sea of Marmara, Türkiye

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Abstract: This study reports the northernmost expansion of the Black-barred halfbeak in the Mediterranean, which was previously reported around the Central part of the Aegean Sea coasts of Türkiye. On 29th of June 2024, one adult female individual was caught in the stationary uncovered pound nets located at Çardak, Sea of Marmara (SoM). The specimen has hydrated oocytes larger than 1.201 µm, and is detected as 2+ years old by sagittal otolith readings. The occurrence of that species in the SoM, characterized by less saline and colder waters, suggests that its range of expansion could further increase in the future. However, it should be confirmed with more records in the SoM, due to the complex two-layered structure.

Keywords: Lessepsian, distribution, Suez canal, halfbeak, Sea of Marmara

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Introduction

The Black-barred halfbeak, *Hemiramphus far* (Forsskål, 1775) is an Indo-Pacific origin fish species and is distributed from the Red Sea and East Africa to the Ryukyu Islands, Australia, and New Caledonia. Also, it is a Lessepsian-migrant fish species for the Mediterranean and migrated from the natal area to the Mediterranean Sea via the Suez Canal. The Hemirhamphidae family is represented by 8 genera and 61 species, whereas 10 species belong to the genus *Hemiramphus* worldwide (Collette, 2004).

The knowledge of its utilization and biology in the literature is scarce. It is consumed directly as a food or can be used as a raw material for some fish products or fish-derived by-products. It is stated as an economically important fish species in Bardawil Lagoon, Egypt (Mehanna et al., 2019) and Karachi coasts, Pakistan (Yousuf & Khurshid, 2008). Also, it was found that the gelatine obtained from its skin can be used as a coating agent for fish fillets more successfully than bovine commercial gelatin (Abdelhedi et al., 2019). Besides, it can be used as raw material for surimi around Thailand (Benjakul et al., 2001). It is usually distributed in shallow coastal waters (Fricke et al., 2011). It is mostly found in vegetative areas, sand flats (Kuiter & Tonozuka, 2001) and seagrass beds (Broad, 2003). It forms schools, swimming to the sea surface, and entering estuaries and lagoons for feeding and spawning (Collette, 1986; Collette, 1999). It is defined as omnivorous fish species that consume planktonic crustaceans, planktonic invertebrates, finfish, weeds, algae, fish eggs and larvae, and diatoms (Myers, 1991; Masuda & Allen, 1993; Al-Abdessalaam, 1995; Collette, 1999, Tabassum et al., 2017). Limited studies have been realized related to population biology (Mehanna et al., 2019; El Aiatt et al., 2024).

The reason why it has been most frequently mentioned in the literature in recent years is its spreading feature. *H. far* was stated as one of the earliest expanded Lessepsian fish species in the Mediterranean. It was first established on Israeli coasts (Steinitz, 1927) and Palestine (Gruvel, 1931), where the area is geographically closest to the Suez Canal. In the early 1950s, it expanded through northern parts such as Rodos Island (Tortonese, 1946), the southern Turkish coast (Kosswig, 1950), and Cyprus (Demetropoulos & Neocleous, 1969). Until the 2000s, it expanded and spread through Egypt (Ben-Tuvia, 1978; El Sayed, 1994), Libya (Shakman & Kinzelbach, 2006), Albania, the Adriatic Sea (Collette & Parin, 1986), and the southern coasts of Türkiye waters (Gücü et al., 1994; Torcu & Mater, 2000). Later, the geographical expansion of the species according to more northern and western parts became limited. It was observed from the Kuşadası Bay (Tzomos et al., 2010), Eski Foça coasts, the central part of the Aegean Sea (Akça & Bilecenoğlu, 2010), Lampedusa Island, the Strait of Sicily (Falautano et al., 2014), and Güllük Bay, the southeastern Aegean Sea (Akyol & Ertosluk, 2019) in the North and Collo Bay, the eastern Algeria (Kara et al., 2012) in the west. Most recently, Akyol and Tosunoğlu (2020) recorded *H. far* in the Gediz Delta, İzmir Bay, while Tiralongo et al. (2022) documented it in the Italian Ionian Sea.

Material and Methods

On June 29th, 2024, a single specimen of *H. far* was caught in the stationary uncovered pound nets (Dalian) located at Çardak, Sea of Marmara (40°22′40″ N, 26°42′20″ E) (Figure 1A). The Dalian was located on the beach off the entrance to Çardak Lagoon (Figure 1B) and primarily caught species such as Sand Steenbras, Bogue, Gilthead Seabream, Salema, etc. The Black-barred Halfbeak was accidentally caught among the Sand Steenbras harvest from the dalian. The specimen was identified according to Collette (1986; 1999; 2004).

The morphometric measurements were performed to the nearest 0.01 millimeter (mm) using a measuring board. The total length measurements were realized from the tip of the upper jaw to the end of the caudal fin according to Collette (1999). The sexual maturity stage of female individual was determined with Holden and Raitt's (1974) five-staged maturity scale. Otoliths were removed, and otolith length and width were measured Q-Capture pro digital imaging system and weighted with a 3-digit precision scale. Age was estimated by interpreting the annual growth rings of the otolith according to Iglesias and Dery's (1981) method with the effort of three independent researchers.

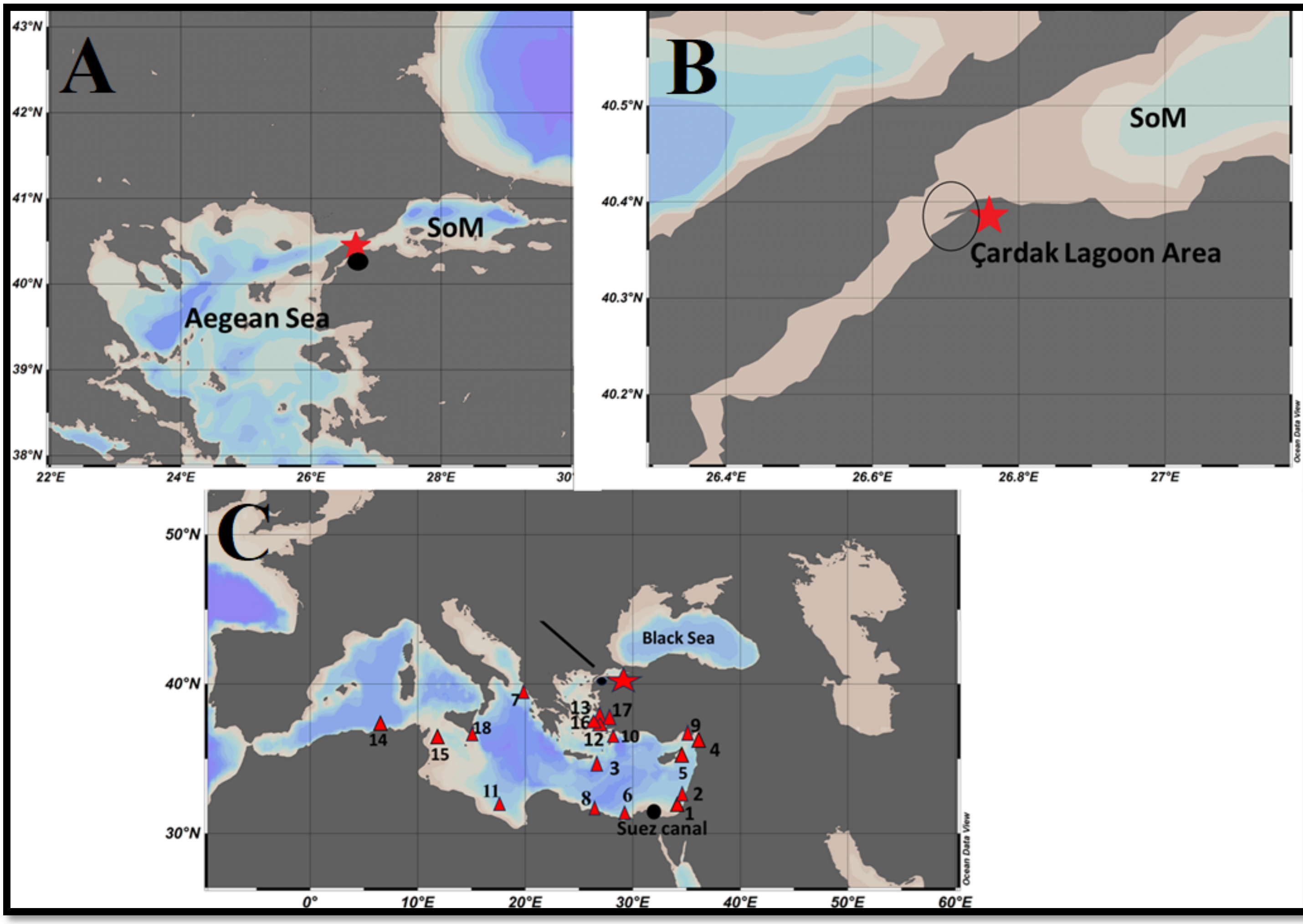

Figure 1. General view of Aegean Sea and the Sea of Marmara (SoM) (A); The northernmost expansion point of *Hemiramphus far*, Çardak Lagoon area (B); Migration route of *H. far* (C) *(Star: The present record); (1: Steinitz, 1927; 2: Gruvel, 1931; 3: Tortonese, 1946; 4: Kosswig, 1950; 5: Demetropoulos & Neocleous, 1969; 6: Ben-Tuvia, 1978; 7: Collette & Parin, 1986; 8: El Sayed, 1994; 9: Gücü et al., 1994; 10: Torcu & Mater, 2000; 11: Shakman & Kinzelbach, 2006; 12: Tzomos et al., 2010; 13: Akça & Bilecenoğlu, 2010; 14: Kara et al., 2012; 15: Falautano et al., 2014; 16: Akyol & Ertosluk, 2019; 17: Akyol & Tosunoglu; 18: Tiralongo et al, 2022.*

Results

Body elongated and laterally compressed. The most typical feature of the specimen is the prolonged lower jaw, and the short upper jaw (Figure 2A). Besides, four independent melanophores are situated laterally from each side of the body. The upper jaw length was measured as 58 mm. Anus is situated about 2/3 of the total length. The species has a short head with 18% of the total length, whereas it has big eyes which constitute 23% of the head length. Morphometric measurements and meristic counts of the individual are shown in Table 1.

The sex was determined as female, with a mature gonad (Figure 2B) containing hydrated ovaries (Figure 2D). The egg sizes were distributed between 0.396 µm and 2.216 µm, whereas hydrated oocytes were larger than 1.201 µm. Four varied egg-size groups were detected and assumed that this species is a multiple spawner. According to sagittal otolith annual increments, the age was determined as 2 years old (Figure 2C). The stomach was found empty without any item.

Discussion

The spread of aquatic invasive fish species is controlled by several biotic, abiotic and human-induced effects such as physico-chemical properties of seawater and species-based requirements, artifactual seaways, food wealth, biological and chemical pollution, ballast waters etc. (Poff et al., 2002; Rahel, 2007; Molnar et al., 2008; Kintisch, E., 2008). Between of them, the Suez Canal is the main determinant for the invasion of the marine species from the Red Sea to the Mediterranean Sea (Galil, 2008). In addition, the long-term heating of Earth's surface named as global warming, also forced and accelerated this passage. Lastly, the deepening of the Suez Canal up to 24 meters in 2010 exacerbated the invasion more critically (Galil et al., 2021, Galil, 2023). Invasive species caused changes in biodiversity by forcing them to relocate due to food competition. Also, caused changes in other communities such as seagrass beds, benthic organisms etc. (Verges et al., 2014). Thus, the knowledge on invasive fish species, their behaviour, biology, population and expansions become more critically for understanding biodiversity changes. The interactions between native and non-native fish species were discussed by Avşar (2023). It was stated that the non-native species mostly being winner of the habitat competition, and the native species are facing biomass loss and being forced to move deeper and colder areas by non-native species (Çiçek et al., 2004).

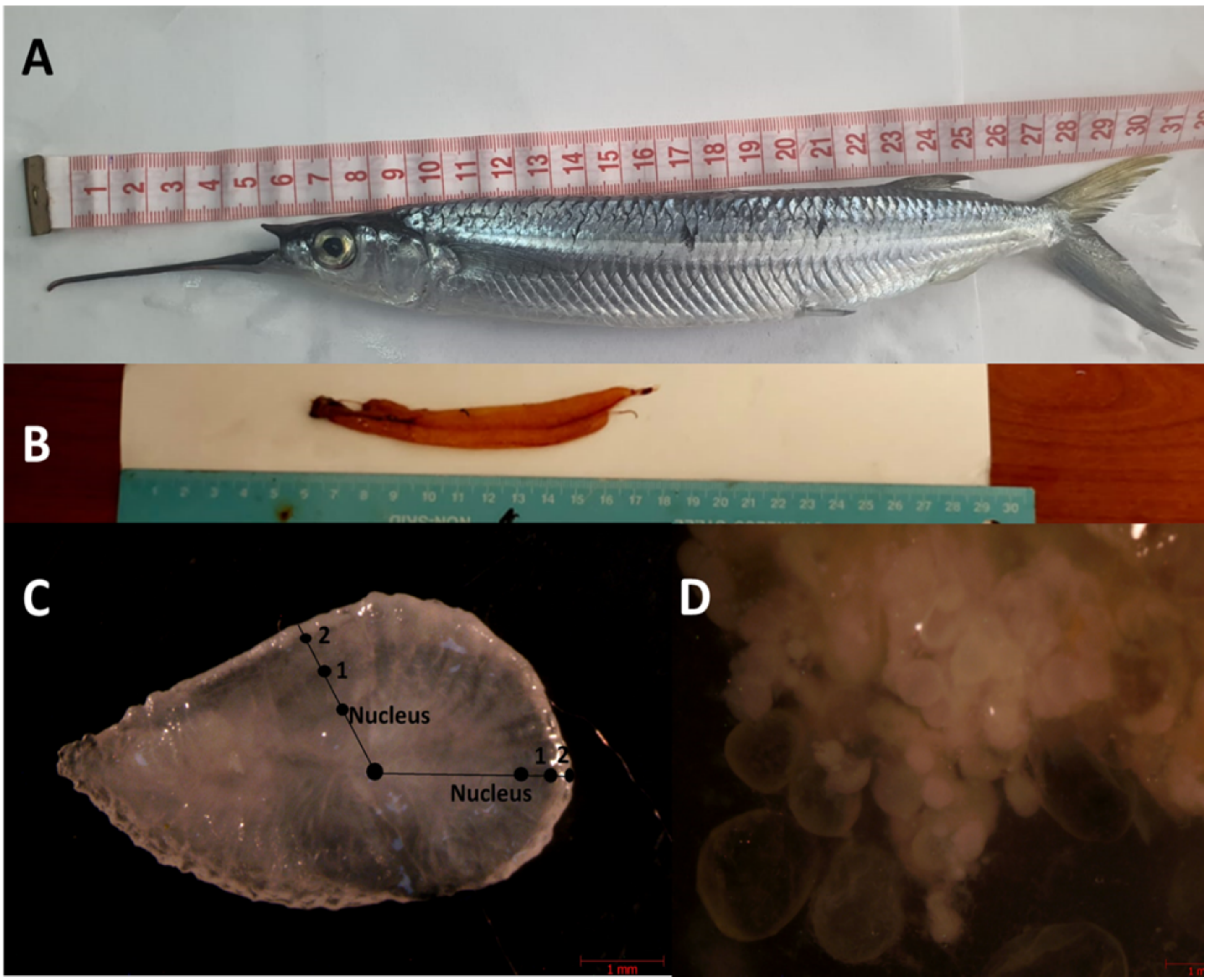

Figure 2. *Hemiramphus far* individual (A), Female mature gonad (B), Sagittal otolith (C), with Hydrated and developing oocytes (D).

Table 1. Morphometric measurements, otolith measurements, and meristic counts of the single specimen of *Hemiramphus far*.

Region	Sea of Marmara, Çardak Lagoon Area
Sex	Female
Morphometric measurements (mm)	
Total length (TL)	261
Standard length (SL)	218
Head length	48
Lower jaw length	58
Predorsal length	166
Preanal length	174
Prepectoral length	55
Prepelvic length	138
Max. Body depth	31
Eye diameter	11
Preorbital length	17
Meristic counts	
Dorsal fin rays	12
Anal fin rays	12
Pectoral fin rays	12
Caudal fin rays	21
Pelvic fin rays	6
Lateral line	55
Myomere	45
Weight (g)	
Total weight	97.7
Stomach weight	1.95
Gonad weight	5.73
Otolith Measurements(mm)	Right
Width	6.24
Height	3.54
Weight (g)	0.01

The Black-barred halfbeak was one of the earliest migrated lessepsian fish species, which was first identified in 1927 around Palestine coasts by Steinitzs (1927). As can be showed in Figure 1C, the migration route realised through the north and northeastern parts. Firstly, it was found in the Israeli and Palestinian coasts, then expanded through Cyprus, Crete and Levantine coasts of Türkiye chronologically. Later, the expansion enlarged slowly through the western and the northwest parts of the Mediterranean. The northernmost expansion of the species was recorded from the Aegean Sea lastly in the Eski Foça coastal area, the central part of the Aegean Sea (Akça & Bilecnoğlu, 2010) and Albanian coastal waters in the Adriatic (Collette & Parin, 1986). Several reports were realized from similar areas where previously reported. Also, species become commercial species in some areas, such as Bardawil Lagoon, Egypt (Mehanna et al., 2019). Whereas, no valid record was reported in the more northern parts of the Mediterranean over the past 15 years.

This record realized in the SoM is important in terms of expanding the invasion area where the northernmost geographical latitude. The SoM is a semi-enclosed basin, connecting the Aegean Sea and the Black Sea (Beşiktepe et al., 1994). Due to the SoM located between two distinct water masses, it constitutes a two-layered system separated by strong pycnocline and thermocline. Thus, the upper layer reflects colder and less saline Black Sea waters, which inflow from the southern Black Sea to the SoM and North Aegean Sea. Conversely, the lower layer reflects more temperate and saline Aegean Sea water, moving from the North Aegean Sea to the SoM. Hence, the SoM becomes a natural pathway and plays a biological corridor for lots of fish species. Previously, several Lessepsian migrant fish species were identified in the SoM. Some of these species were reported from the SoM for a long time, such as *Atherinomorus forskalii* (Rüppell, 1838), *Parexocoetus mento* (Valenciennes, 1847), *Equulites klunzingeri* (Steindachner, 1898), *Epinephelus fasciatus* (Forsskål, 1775) and *Hemiramphus marginatus* (Forsskål, 1775) by Tortonese (1948). Besides, misidentified record of *Lagocephalus spadiceus* (Richardson, 1845) was reported by Tunçer et al. (2008), which was corrected later as *Lagocephalus guentheri* Miranda Ribeiro, 1915, *Siganus rivulatus* Forsskål & Niebuhr, 1775 was detected by Artüz (2012), *Stephanolepis diaspros* Fraser-Brunner, 1940 was identified by Bilecenoğlu et al. (2013), *Alepes djedaba* (Forsskål, 1775) was identified by Artüz and Kubanç (2014), *Lagocephalus sceleratus* (Gmelin, 1789) was identified by Artüz and Kubanç (2015c), *Sargocentrum rubrum* (Forsskål, 1775) was reported by Artüz and Golani (2018), and *Upeneus moluccensis* (Bleeker, 1855) was detected by Artüz and Fricke (2018). The number of Lessepsian migrant species in the SoM has been detected as 12, which may be increased soon. Sea water temperature (Ben-Tuvia & Golani, 1995) and thermal tolerance of the fish species (Wootton, 1992) were stated as the main abiotic factors that affect the dispersal of Lessepsian migrants. The preferred temperature of *H. far* ranges between 24.7 and 29.3, with a mean of 28.5 °C (Froese, R., 2020). The coastal SST was measured as 24.8 °C in the study area on 25th June 2024. The SST of the study area at the time of the record coincided with the preferred range of the species. Tokat and Beşiktepe (2024) revealed that the surface waters of the SoM and the southern Black Sea warm faster than the Aegean Sea, with the examination of a 40-year STT data set. This may be the most critical explanation for why the invasion distances of the Lessepsian species have increased in the last years through the northernmost parts of the Mediterranean. Besides, as well as climate change, lots of complex and long-term processes can be effective in the expansion of the Lessepsian migrants. It has been stated that experimental studies on predation, competition, alteration of habitat, and interruption of food webs should be conducted to discover the mystery behind it (Arndt et al., 2018). Also, the present record around coastal areas near lagoons supported the distribution preference around estuaries, lagoons, and brackish seas (Mehanna et al., 2019). The preferences towards lagoons may be due to their preference for breeding grounds (Collette, 1986) and their preference for being in vegetative areas (Fischer et al., 1990).

It is not possible to draw general conclusions about the biology of a species from a single individual and must be supported by additional data. However, in species with scarce information on their biology, even limited information, such as otolith dimensions, otolith shape, age, stomach content, egg size, etc. obtained from a single individual can be useful in understanding and confirming their biology. The first Sexual maturity length, the high GSI value, and the hydrated oocytes of the present individual indicated that it could be during the reproductive period. Most of these reproductive characteristics coincide with the population of *H. far* in Bardawil Lagoon (Mehanna et al., 2019). It was reported that spawning occurred between May and July, and it can be thought that *H. far* might be spawned in the SoM and should be created stock in upcoming years if offspring can survive under the phsical-chemical parameters of the SoM. The egg diameters of Hemiramphidae family members ranged between 1.5 and 2.5 µm (Collette et al., 1984). Besides, the mean hydrated oocyte diameter is given as 1.6 µm for *Hemiramphus balao* and 2.4 µm for *Hemiramphus brasiliensis.* Whereas, no valid oocyte diameter was found for *H. far* in the literature. The diameter of hydrated oocytes was measured between 1.201 and 2.160 µm. Thus, the diameter range of hydrated oocytes in the present study should contribute to the literature.

As can be seen in Figure 2C, the age of the individual was determined as 2 years-old. According to otolith readings, the life span of the *H. far* was detected as 4 years in both males and females of Bardawil Lagoon stock which distributed at length between 16.7 and 30.5 cm TL (Mehanna et al., 2019). The age of *H. far* individual was detected as 2+ in the present study, which is seen as consistent with the range of the results of previous work. The empty stomach of the present individual may be related to the rapid digestion of algal feeding, which was previously identified for *H. far* (Collette, 1999).

With the changing environmental conditions of the seas, more non-indigenous species should be entering the new habitats such as the present study. From the new records to population biology, all aspects of these species should be monitored closely to understand the potential threats to the biodiversity of indigenous species.

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Ethical Approval

No need to ethical approval for this study.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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