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Feeding Habits of the Gilthead Sea Bream (*Sparus aurata*, Linnaeus, 1758) in Ain El-Ghazala Lagoon, Eastern Libya

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ABSTRACT

The feeding habits of *Sparus aurata* (family: Sparidae) were studied using 350 specimens collected monthly from Ain El-Ghazala Lagoon between September 2024 and August 2025. The investigation focused on seasonal changes in diet composition and examined the relationship between food items and fish size. Results indicated that *S. aurata* consumed a wide variety of prey, mainly crustaceans (41.5%), mollusks (23.3%), polychaetes (18.1%), bony fish (8.1%), foraminifers (5.9%), and algae (3.1%). Crustaceans, mollusks, polychaetes, and bony fish were the dominant food groups throughout the year and were found in all size classes. As the fish grew, the proportions of crustaceans, polychaetes, bony fish, and algae increased, whereas mollusks and foraminifers decreased in larger individuals. Feeding intensity varied seasonally, reaching its peak during spring and early winter and declining in mid-winter and summer. These variations are likely influenced by environmental conditions, prey availability, and the reproductive cycle of the species.

INTRODUCTION

Sparid fishes are commonly distributed in tropical and temperate coastal waters, particularly in shallow habitats such as bays and inlets. The family Sparidae comprises about 41 species belonging to 22 genera **(Bauchot & Smith, 1983)**. Along the Libyan coast, fourteen species have been identified, including *Sparus aurata*, *Diplodus vulgaris*, and *Pagrus pagrus* **(Al-Hassan & El-Silini, 1999)**.

The gilthead sea bream (*Sparus aurata*) is a highly valued sparid species, renowned for its desirable flesh quality, making it one of the most important commercial fish in the Atlantic and Mediterranean regions **(Bauchot & Hureau, 1990)**. Despite its wide distribution, populations of this species have been reported as endangered in certain localities **(Figueiredo *et al.*, 2002)**.

Feeding studies on several sparid species have shown that most of them are generalist and opportunistic feeders. In the Central Adriatic, for instance, *Lithognathus* *mormyrus* feeds mainly on mollusks, echinoderms, polychaetes, and crustaceans **(Froglia, 1977; Jardas, 1996)**. Similarly, *Pagrus pagrus*, occurring along the eastern Libyan coast, consumes various prey items including sea grasses and foraminifera **(Ali, 2008)**. In Ain El-Ghazala Lagoon, Libya, *Diplodus vulgaris* feeds predominantly on crustaceans, polychaetes, and algae **(El-Maremie *et al.*, 2015)**, while *Diplodus noct* in the Gulf of Suez preys on fish remains, crustaceans, and algae **(El-Mor & El-Maremie, 2008)**.

The feeding ecology of *S. aurata* has been investigated in several Mediterranean regions such as the Bay of Cadiz **(Suau & Lopez, 1976)**, the Gulf of Lion **(Rosecchi, 1987)**, and the Mellah Lagoon in Algeria **(Chaoui *et al*., 2005)**. These studies indicate that the species behaves as a flexible and opportunistic feeder, adjusting its diet to the availability of prey in each area.

Although sparid fishes are of great economic importance, limited morphological and ecological information is available about them, particularly along the eastern Libyan coast **(Laith, 2003)**. Knowledge about the feeding ecology of *S. aurata* in this region remains scarce, despite its potential role in maintaining local trophic balance. Therefore, the present study represents the first comprehensive assessment of the feeding ecology of *Sparus aurata* in Ain El-Ghazala Lagoon, eastern Libya. The main objectives are to identify trophic relationships between *S. aurata* and other components of the ecosystem, enhance understanding of ecological processes within this habitat, and provide baseline information useful for improving local aquaculture management.

MATERIALS AND METHODS

Study area and sampling

Ain El-Ghazala Lagoon (32°55'N, 22°10'E) encompasses approximately 50km² of shallow coastal habitat along Libya's northeastern Mediterranean coast (Fig. 1). Between September 2024 and August 2025, a total of 350 *S. aurata* specimens were monthly collected using gill nets (45- 55mm stretched mesh) and trammel nets (65- 75mm inner panel) deployed at the lagoon's primary fishing grounds.

Stomach content analysis

Each specimen's total length (TL) was measured to the nearest 0.1cm and dissected the digestive tract. Stomachs were preserved in 10% buffered formalin and later transferred to 70% ethanol for storage. We assessed stomach fullness using the six-point scale established by **Pillay (1952)**, categorizing contents as: empty, trace, ¼ full, ½ full, ¾ full, or full.

Stomach content analysis was conducted using the points method **(Hyslop, 1980),** whereby each prey category was assigned a volumetric score proportional to its relative occurrence within each stomach. Prey items were identified to the lowest possible taxonomic level, primarily major groups, with the aid of regional identification keys **(Jardas, 1996)**.

Statistical analysis

Specimens were grouped into 1.9cm size classes to examine ontogenetic dietary patterns. Dietary composition differences among size classes and seasons were evaluated using permutational multivariate analysis of variance (PERMANOVA) with 9999 permutations. Similarity percentages analysis (SIMPER) identified prey categories contributing most to observed differences. All analyses were conducted in PRIMER v7 with PERMANOVA+ add-on.

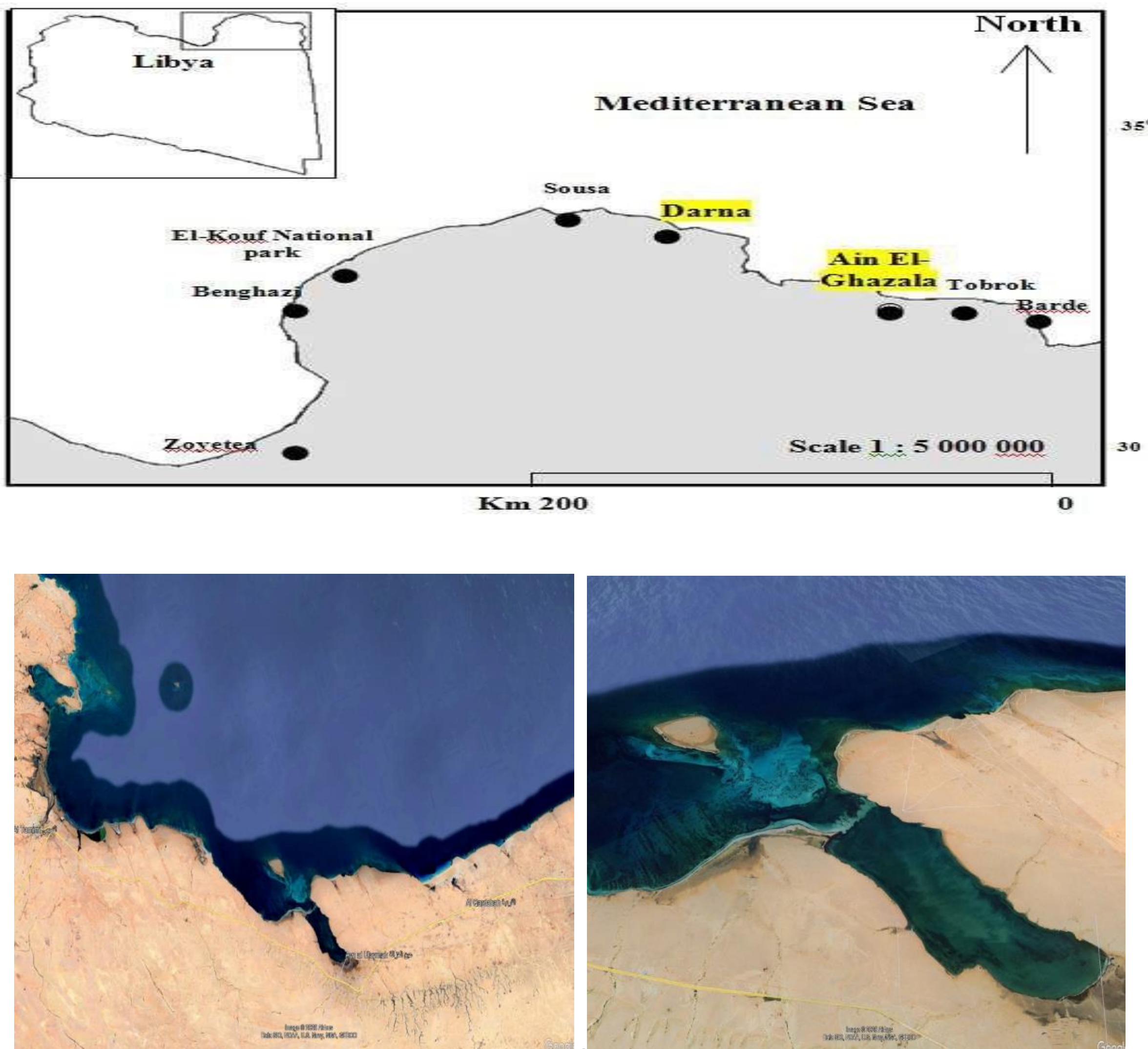

Fig. 1. Ain El-Ghazala Lagoon in eastern Libyan coast

RESULTS AND DISCUSSION

Annual diet composition

Crustaceans formed the dominant dietary component across all specimens (41.5%), primarily comprising small decapods and amphipods. Mollusks (23.3%) included both gastropod and bivalve species, while polychaetes (18.1%) represented various benthic families. Secondary components included bony fish (8.1%), foraminifera (5.9%), and algal matter (3.1%) (Fig. 2).

The remaining portion of the diet consisted of minor components: bony fish (8.1%), including species such as *Atherina boyeri*, *Liza auratus*, *Liza ramada*, *Diplodus sargus*, *Sardinella aurita*, and *Siganus rivulatus*; foraminifera (5.9%); and algae (3.1%), primarily represented by the genera *Ulva*, *Enteromorpha*, *Codium*, *Cladophora*, and *Chaetomorpha*.

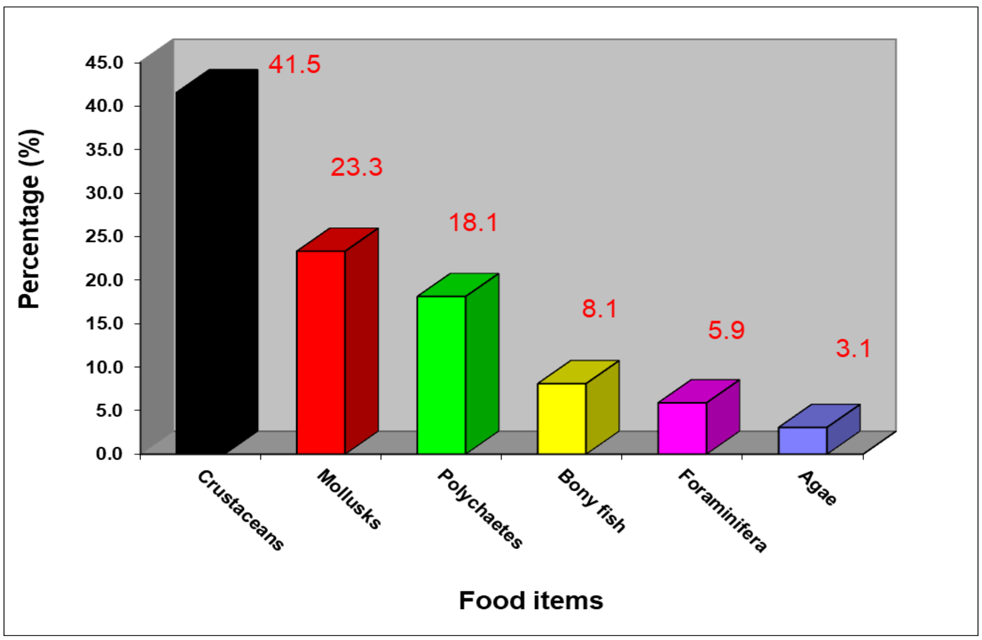

Fig. 2. The diet composition of *Sparus aurata* from Ain El-Ghazala Lagoon, eastern Libya during the period from September 2024 till August 2025

Monthly variations in diet composition

The monthly variations in the diet composition of the studied species show clear seasonal fluctuations in the consumption of different food items. The food items, crustaceans, mollusks, polychaetes and bony fish, occurred in all year round (Table 1). Crustaceans were the dominant food component throughout the study period, with the highest mean percentage (41.5%), indicating their major role in the feeding ecology of the species. Mollusks and polychaetes represented the second and third most important food groups (23.3% and 18.1%, respectively), suggesting that the species is a benthic feeder that primarily relies on invertebrates living on or within the sediment. A noticeable decline in crustacean consumption occurred during March and April, coinciding with an increase in algae and foraminifera, which may reflect seasonal changes in food availability or habitat conditions. The proportion of bony fish in the diet remained relatively low (8.1%), indicating opportunistic predation or scavenging behavior rather than a specialized piscivorous habit. The absence of food (marked as "A") during January, February, May, June, July, and August may indicate a period of low feeding activity, possibly due to reproductive behavior, unfavorable environmental conditions, or reduced prey abundance during these months. PERMANOVA revealed significant seasonal variation in diet composition (Pseudo-F= 4.82, P= 0.001). Crustacean consumption decreased markedly during March-April (Table 1), a period characterized by a concurrent increase in the intake of foraminifera and algae. Algal matter was absent from the diets between January-February and May-August, while foraminifera were not recorded in August. According to SIMPER analysis, crustaceans, mollusks, and polychaetes were the primary contributors, collectively accounting for more than 70% of the observed seasonal dietary dissimilarity.

Overall, the results demonstrate that the species exhibits an omnivorous feeding pattern with a strong preference for benthic invertebrates, particularly crustaceans, and shows seasonal flexibility in diet composition according to prey availability.

Table 1. Monthly variations in diet composition of 350 *Sparus aurata*, in Ain El-Ghazala Lagoon, Eastern Libya during the period from September 2024 till August 2025

Month	No.	Food items					
		Crustaceans	**Mollusks**	**Polychaetes**	**Bony fish**	**Foraminifera**	**Algae**
Sep. (2024)	**12**	**29.2**	**24.3**	**26.1**	**8.9**	**4.1**	**7.4**
Oct.	**22**	**24.5**	**27.7**	**15.7**	**11.9**	**3.2**	**17.1**
Nov.	**24**	**48.9**	**20.8**	**15.5**	**7.9**	**5.9**	**1.1**
Dec.	**25**	**42.8**	**22.9**	**19.9**	**2.4**	**6.4**	**5.6**
Jan. (2025)	**47**	**48.9**	**33.6**	**13.3**	**3.1**	**1.2**	**A**
Feb.	**47**	**44.9**	**26.8**	**17.8**	**6.6**	**3.9**	**A**
Mar.	**48**	**41.5**	**15.9**	**14.5**	**9.9**	**11.8**	**6.5**
Apr.	**48**	**45.9**	**13.3**	**15.7**	**10.1**	**14.1**	**0.9**
May	**26**	**42.8**	**23.8**	**16.2**	**10.5**	**6.8**	**A**
Jun.	**23**	**44.8**	**26.9**	**12.5**	**12.5**	**3.4**	**A**
Jul.	**15**	**40.7**	**22.7**	**18.4**	**9.1**	**9.2**	**A**
Aug.	**13**	**43.2**	**20.3**	**32.1**	**4.5**	**A**	**A**
%	**350**	**41.5**	**23.3**	**18.1**	**8.1**	**5.9**	**3.1**

Remarks: Data expressed as percentage; (A) No food in month occurred.

Feeding habit in relation to fish size

Table 2. The diet composition of different size classes of 350 *Sparus aurata* , in Ain El-Ghazala Lagoon, Eastern Libya during the period from September 2024 till August 2025

Size group (cm)	No.	Food items					
		Crustaceans	Mollusks	Polychaetes	Bony fish	Foraminifera	Algae
14.5-16.4	25	20.4	37.1	13.1	5.6	13.1	10.8
16.5-18.4	22	20.7	36.9	15.4	6.1	9.8	11.1
18.5-20.4	25	22.5	36.6	22.6	6.9	5.3	6.1
20.5-22.4	28	25.1	35.4	18.9	9.9	3.8	6.9
22.5-24.4	21	27.3	25.1	26.1	10.1	4.4	7.1
24.5-26.4	36	29.1	15.7	20.9	16.8	7.9	9.6
26.5-28.4	31	38.1	9.1	21.5	16.9	4.7	9.7
28.5-30.4	32	42.1	7.1	22.4	18.7	B	9.8
30.5-32.4	30	42.4	6.7	22.1	18.8	B	9.9
32.5-34.4	55	43.1	3.4	23.6	18.9	B	11.1
34.5-36.4	45	44.2	1.1	23.9	19.1	B	11.8

Remarks: Data expressed as percentage; (B) No food in size class occurred.

The total length of *Sparus aurata* population classified into 11 classes ranged from 14.5 to 36.4cm, with 1.9cm interval (Table 2). Prey size differed between large size individuals, which had ingested the large size prey, whereas the small sized fish ingested the small size prey. Crustaceans, mollusks, polychaetes, bony fish and algae were found in all length groups of *Sparus aurata*. Crustaceans, polychaetes, bony fish and algae increased as the fish size increased while mollusks and foraminifers decreased as the fish size increased. The analysis of diet composition across different size groups revealed clear ontogenetic (size-related) variations in feeding habits. Smaller individuals (14.5–18.4cm) consumed a wide variety of food items, with mollusks forming the dominant component (approximately 37%), followed by crustaceans and polychaetes. This pattern suggests that younger fish tend to feed more on soft-bodied and easily captured prey such as mollusks and polychaetes. As fish size increased (18.5– 24.4cm), the proportion of crustaceans in the diet gradually rose, while mollusks decreased, indicating a shift toward more mobile and energy-rich prey. Larger individuals (24.5– 36.4cm) showed a marked preference for crustaceans, which became the principal food item (ranging from 29.1% to 44.2%), followed by polychaetes and bony fish. This dietary shift reflects the development of stronger jaws and improved predatory capability with growth. The occurrence of bony fish in the diet increased progressively with size, reaching the highest values (about 19%) in the largest groups, suggesting partial piscivory at advanced stages. In contrast, mollusks became nearly absent in the largest fish, likely due to selective feeding behavior or difficulty in capturing slow-moving benthic prey. Foraminifera were present in smaller and medium-sized groups but completely absent (B) in larger size classes, implying that their ingestion is incidental or linked to sediment feeding at early stages. Similarly, algae were consistently present in low proportions across all groups, indicating their role as supplementary or accidental food. Overall, these findings indicate an ontogenetic dietary shift from a generalist and opportunistic feeding strategy in smaller individuals toward a more specialized carnivorous diet dominated by crustaceans and bony fish in larger individuals. This trend reflects ecological adaptation and trophic differentiation with growth. We observed pronounced dietary changes across size classes (PERMANOVA: Pseudo-F= 6.94, *P*= 0.001). Smaller individuals (14.5- 18.4cm TL) consumed predominantly mollusks (37.1%) and foraminifera (13.1%), with fewer crustaceans (20.4%) (Table 2). Larger fish (>24.5cm TL) shifted toward crustaceans (29.1- 44.2%) and bony fish (16.8- 19.1%), while mollusk consumption declined to 1.1% in the largest size class. Foraminifera disappeared from diets in fish >28.5cm TL.

Feeding intensity

Fishes with stomach half full, almost full and full of food ranked b% constituted 56.6% of all analyzed individual, whereas those with stomach that were empty or with traces of food and quarter full ranked a% represented 43.3 % of the total specimens (Table 3). The degree of stomach distension showed distinct seasonal variations, reflecting fluctuations in feeding activity throughout the study period. The average percentage of stomach fullness was 56.6%, while partially filled and empty stomachs accounted for 43.3%, indicating an overall moderate to high feeding intensity. During the autumn and early winter months (September–December 2024), feeding activity increased progressively, with the highest proportion of full stomachs recorded in December (82.1%). This suggests an abundance of food resources and favorable environmental conditions during this period, promoting active feeding. In contrast, a decline in feeding intensity was observed during late winter and early spring (January–March 2025), as evidenced by the higher percentages of empty and trace-filled stomachs (up to 63.9% partially filled or empty in March). This reduction may be linked to lower water temperatures, reduced prey availability, or reproductive activity, which often causes temporary feeding inhibition. Feeding activity increased again from April to June, peaking in April (88.6%), when the highest proportion of full stomachs was recorded. This suggests a recovery of feeding behavior following the winter period, possibly in response to increased prey abundance associated with rising temperatures and primary productivity. A noticeable decrease in feeding intensity occurred during the summer months (July–August), where a relatively high proportion of fish had partially full or empty stomachs. This pattern could be attributed to elevated water temperatures, which may reduce metabolic demand or affect prey distribution and behavior. Overall, the results indicate that feeding intensity in the studied species follows a seasonal cycle, with maximum feeding during spring and early winter, and reduced activity during mid-winter and summer. Such fluctuations are likely influenced by environmental conditions, food availability, and possibly reproductive cycles. Monthly feeding intensity varied significantly ($\chi^2 = 45.3$, $P < 0.001$). The highest proportions of full stomachs occurred in December (82.1%) and April (88.6%), while the lowest feeding activity was recorded in January (24.0% full stomachs) and July (40.0%) (Table 3). Overall, 56.6% of stomachs were half-full or more across the study period.

Table 3. Monthly variations in the intensity of feeding of 350 *Sparus aurata* in Ain El-Ghazala Lagoon, Eastern Libya during the period from September 2024 till August 2025

Month	No.of fish	The degree of distension of the stomach							
		Empty	Trace	1/4	a %	1/2	¾	Full	b %
Sep. (2024)	12	24.0	28.0	A	52.0	24.0	24.0	A	48.0
Oct.	22	10.0	10.0	15.0	35.0	25.0	14.1	25.9	65.0
Nov.	24	23.2	A	A	23.2	15.4	15.4	46.1	76.9
Dec.	25	16.0	2.0	A	18.0	12.0	20.0	50.1	82.1
Jan. (2025)	47	6.0	30.1	39.9	76.0	13.9	10.1	A	24.0
Feb.	47	26.2	22.7	26.3	75.2	8.9	A	15.9	24.8
Mar.	48	26.0	21.1	16.8	63.9	16.0	2.0	18.0	36.0
Apr.	48	11.4	A	A	11.4	13.1	48.3	27.2	88.6
May	26	23.2	A	A	23.2	15.4	15.4	46.1	76.9
Jun.	23	13.9	10.1	A	24.0	6.0	30.1	39.9	76.0
Jul.	15	10.0	5.0	45.1	60.1	A	40.0	A	40.0
Aug.	13	10.0	4.0	44.0	58.0	20.0	22.0	A	42.0
Average					43.3				56.6

Remarks: Data expressed as percentage; (A) No food in month occurred.

DISCUSSION

Our findings reveal that *S. aurata* in Ain El-Ghazala Lagoon functions as an opportunistic omnivore, exhibiting both seasonal and ontogenetic trophic plasticity. The crustacean-dominated diet aligns with studies from Tunisian waters **(Kherraz *et al.*, 2020)**. However, it shows higher mollusk consumption than that reported for Adriatic populations **(Matic-Skoko *et al.*, 2014)**. This likely reflects the lagoon's particular benthic community structure, where crustaceans represent the most abundant and accessible prey.

The marked ontogenetic shift from mollusk/foraminifera-dominated to crustacean/fish-based diets mirrors patterns observed in Spanish Mediterranean populations **(Sánchez-Jerez *et al.*, 2002)**. This transition likely results from several factors: larger fish possess stronger pharyngeal teeth capable of crushing harder prey, enhanced swimming ability for capturing mobile prey, and greater energy demands that make energy-rich fish prey more profitable **(Ben Salem *et al.*, 2015)**. The disappearance of foraminifera from larger fish diets suggests their initial consumption was incidental during deposit feeding by juveniles.

The bimodal pattern in feeding intensity—with peaks in spring and early winter—corresponds with known periods of high secondary production in Mediterranean coastal systems. The summer decline coincides with the species' spawning period in the region, when energy allocation shifts toward reproduction **(Pita *et al.*, 2019)**. The mid-winter reduction may reflect decreased metabolic rates and prey availability during cooler periods. The seasonal dietary shifts, particularly the increased consumption of foraminifera and algae when crustaceans decline, demonstrate the species' capacity to exploit alternative food resources—a crucial adaptation in the lagoon's fluctuating environment.

CONCLUSION

This study establishes that *S. aurata* in Ain El-Ghazala Lagoon employs a flexible feeding strategy, consuming predominantly crustaceans while adjusting to seasonal prey availability and undergoing significant ontogenetic niche shifts. The species' trophic plasticity likely enhances its resilience in the dynamic lagoon ecosystem. These findings provide essential baseline data for managing this fishery resource and contribute to understanding how coastal fishes adapt to heterogeneous environments. Future research should quantify benthic prey availability to better resolve feeding preferences and examine how anthropogenic impacts affect trophic relationships in this vulnerable system.

Ethics approval

The animal studies adhered to the norms and criteria set out by ARRIVE (https://arriveguidelines.org/). The Faculty of Fish Resources at Suez University, Suez, Egypt, authorized all operations following the IACUC.

Author Statement

Karima Al-Mabrouk Momen[1]: Data curation, Project administration, Funding acquisition, Methodology, Software, Writing- original draft, Writing – review& editing.

Ahmed S. Abd El-Naby[2]: Data curation, Project administration, Funding acquisition, Methodology, Software, Writing- original draft, Writing – review& editing.

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