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Analysis of food and feeding habits of *Gerres longirostris* in the Red Sea coast of Jeddah, Saudi Arabia

Md. Afsar Sumon[1], Mohamed Gabr[1&2*], Mamdoh Al-Harbi[1]

1-Marine Biology Department, Faculty of Marine Science, King Abdulaziz University, P.O. Box 80207, Jeddah 21589 Saudi Arabia.
2- National Institute of Oceanography and Fisheries, Suez, Egypt.

[*] **Corresponding Author: mgabr@kau.edu.sa**

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ABSTRACT

To expose the food and feeding habits of Strongspine silver-biddy *Gerres longirostris*, gut contents from specimens caught along the Red Sea coast of Jeddah were collected from August 2019 to July 2020 (ranging in size from 15.3 cm to 29.1 cm total length). Of the Stomach analyzed, 147 were empty (VI%=36.5) and food items were found in 259 of them. Results showed that *Gerres longirostris* mainly feeds on small mollusks and crustaceans and it is an omnivore and moderate to a poor bottom feeder. The study revealed a strong correlation between feeding intensity (fullness and vacuity index), relative condition factor and gonado-somatic index. Feeding intensity was the highest between August and February and the lowest from March to July. The maximum value of the Fullness index (FI%) was in Autumn (1.72) and lowest in Summer (0.58). The highest value of the Vacuity index (VI%) was in spring (61.96) and lowest in autumn (23). The highest GSI value was observed in Summer (4.04) with the lowest FI (0.58%) and opposite results in Autumn (FI, 1.72 and GSI, 0.81). Values of relative condition factor (K_n) showed an increasing trend with the value of GSI from lowest in Autumn to highest in Summer. The dominant food item in the diet of *G. longirostris* was bivalves by weight (63.67%), number (49.97%), occurrence (37.2%), index of preponderance (69.4%) and index of relative importance (75.4%). The results of this study would thus help in the development of a strategy for conservation and management of the natural stocks of *G. longirostris* in the Red sea, Saudi Arabia.

INTRODUCTION

Red sea has about 2,000 km long coast and is the main water resource of Saudi Arabia (Bird, 2010). The capture fisheries and aquaculture sectors provide to the food security of the kingdom populations (FAO, 2020). Sustainable fisheries management is crucial for the most biologically diverse reef communities. Information on food and feeding habits of fish can play a vital role for effective management and conservation of fisheries in an aquatic ecosystem.

Strongspine silver-biddy *Gerres longirostris* is broadly inhabiting throughout the Indo-Pacific regions, it prefers sandy and silty grounds and are mostly found among sea grass beds and coral reefs (Randall, 1995; Sommer *et al*., 1996; Iwatsuki *et al*., 2001; Gell and Whittington, 2002). Its presence was reported from western and southern coast of the Arabian Gulf (Carpenter *et al*., 1997; Hosny *et al.*, 2003; Grandcourt *et al.*, 2006; Hosny and Al-jaber, 2017). *G. longirostris* dwells in a group or single (Lieske and Myers, 1994) and mostly consume benthic invertebrates, comprising small mollusks and crustaceans (Randall, 1995). For other species of gerreids, Rao (1968) found bivalves, gastropods, decapods, amphipods, detritus, plants matter, diatoms, copepods, sands in the stomach contents of *G. oyena* and *G. filamentosus* and noted that bivalves (Index of preponderance, 63.7%) are the most consumed food by *G. oyena*. Al-Ghais and Varadharajulu (2019) studied on six commercially important fishes including *Gerres longirostris* from the Arabian Gulf where their abundance is limited. The results showed that the good quantity of protein is present in all six different commercially important species, so they can be safely used in food to supplement of required protein.

Unfortunately, information regarding the food and feeding habits of Strongspine silver-biddy is limited, despite their importance as valuable food fish and ample source of fisheries in the Jeddah coast of the Red Sea. Therefore, the dearth of knowledge about the food and feeding of this species; *G. longirostris* hinders its proper management. Thus, the present study aims to describe the food and feeding habits of *G. longirostris* in the Jeddah Red Sea coast since it performs a key role in Jeddah fisheries and food chain in the marine ecosystem.

MATERIALS AND METHODS

- **Fish sampling and laboratory analysis**

Fresh specimens of *G. longirostris* were collected monthly during the period from August 2019 to July 2020, from artisanal fishermen using gillnets to catch this species, together with other coral reef fishes in Jeddah fisheries, where they can take less than one hour from the fishing ground to the landing site. Total length, and weight of each specimen was measured to the nearest 0.1 cm and 0.1 g respectively. Specimens were dissected and their stomachs and only female gonads were taken out kept in 10% formalin for further analysis. Stomach condition was categorized according to the quantity of foodstuff present in the gut as gorged, full, 3/4th full, 1/2 full, 1/4th full, trace and empty. The weight and volume of stomach contents was measured and cut opened for documenting degree of fullness of stomachs. Food items in the stomachs were placed in a petri-dish and segregated to study the food composition. Prey items were identified visually and by using microscope. The photograph of prey items was taken under microscope using digital camera connecting to the computer.

- **Data Analysis**

To reveal the food and feeding habits of *Gerres longirostris*, occurrence and volumetric displacement methods were used for qualitative and quantitative analysis, respectively. Prey items were identified in generic level. Stomach content in advanced state of digestion were categorized as digested and semi-digested. The volume displacement method used by Pillay (1952) was applied, volume of each prey item was measured with a measuring jar. The index of pre-ponderance method followed by Natarajan and Jhingran (1961) was used which is a combination of occurrence (qualitative method) and volume (quantitative method) of food contents for grading the different food items. The index of pre-ponderance (I) was calculated using the following equation:

$$\mathbf{I = (V_i\, O_i / \Sigma\, V_i\, O_i) \times 100}$$

Where, V_i is volume percentage and O_i, the percentage of occurrence indices of each prey items.

The Frequency of occurrence method (Dewan and Shaha, 1979) was calculated using the following equation:

$$\mathbf{Fi\% = (ni / NT) \times 100}$$

Where, Fi is Frequency of occurrence; ni, number of samples containing type of prey items and NT, total number of stomachs with food in sample.

Changes of feeding intensity was assessed followed by Hyslop (1980) using the following equations:

Fullness index (FI%), FI = Weight of stomach content / weight of fish) × 100

Vacuity index (VI%), VI = (The no. of empty stomachs / total no. of the analyzed stomachs) ×100. Diet composition was analyzed by the following indexes:

Numerical percentage (N%), N = (No. of food items / total no. of all food items × 100)

Weight Percentage (W%), W = (Weight of food items / total weight of all food items × 100).

To assess the importance of each prey items in stomach contents, index of relative importance (IRI) formula (Pinkas *et al.* 1971), as used by Okan *et al*. (2016), was applied as follows:

$$\mathbf{IRI = (N\% + W\%) \times Fi\ \%}$$

The percentage of IRI of each food item has been expressed by following equation:

$$\mathbf{IRI\% = (IRI / \Sigma\ IRI) \times 100}$$

The Gonado-Somatic Index (GSI) was computed as:

$$\mathbf{GSI = (W_G / TW\text{-}W_G) \times 100}$$

Where, W_G is the gonad weight in gram, T_W is the total fish weight in gm

The length -weight relationship was described by using the power equation: $\mathbf{W = a\ L^b}$, where W denotes Weight; L, Length; a and b are constants.

The relative condition factor (K_n) was calculated by using the equation: $\mathbf{K_n = W / a\ L^b}$

.

RESULTS AND DISCUSSION

This study reports, for the first time, the qualitative and quantitative data of food and feeding habits of *G. longirostris* in Jeddah coast of the Red Sea. Food and feeding habits of *G. Longirostris* were studied based on the inspection of stomach contents of 406 individuals.

- **Food composition:**

Stomach content analyses revealed that food composition of *G. Longirostris* comprised mainly two groups: mollusks, and crustaceans. Bivalves, gastropods, decapods, amphipods, fish scale, eggs, plants matter, algae, sand grains, semi-digested and digested foods were observed in the diet composition of *G. Longirostris* in the present study (Figure 1). Bivalves constituted major portion of all the prey items. Among the crustaceans, crabs are the major portion in the diet whereas bivalves, chitons and snails represent major portions among all mollusks. Similar findings of food composition of different *Gerres* species and present study are summarized in Table 1.

Table 1. Comparison of Prey items in different *Gerres* species living in different habitats.

Rao (1968) **(Pulicat lake, India)**		**Badrudeen and Mahadevan (1996)** **(Palk Bay and Gulf of Mannar, India)**	**Abu El-Nasr (2015)** **(Hurghada Red Sea, Egypt)**	**Present study (Red sea, Jeddah fisheries, Saudi Arabia)**
G. Oyena	*G. filamentosus*	*G. macracanthus*	*G. filamentosus*	*G. longirostris*
Bivalves Detritus Amphipods Gastropods Polychaetes Plant matter Decapod Crustacea Isopods Sand Copepods Cypris of cirripedes Diatoms	Copepods Diatoms Nauplii Cypris of cirripedes Bivalves Gastropods Amphipods Detritus Polychaetes Plant matter Sand Decapod Crustacea Isopods	Polychaetes Prawns Copepods Amphipods Bivalves Crabs Echuiroids Diatoms Detritus Fish scale Sand grains Digested matter Others	Ostracoda Isopoda Amphipoda Decapoda Brachyura Gastropoda pelecypoda Polychaetes Planktonic organismis Fish egg and scales marine larvae Foraminifera Algae & sea weeds Digested food	Bivalves Gastropods Decapods Amphipods Fish scales Eggs Sand grains Semi-digested Digested foods Plants matter Algae detritus

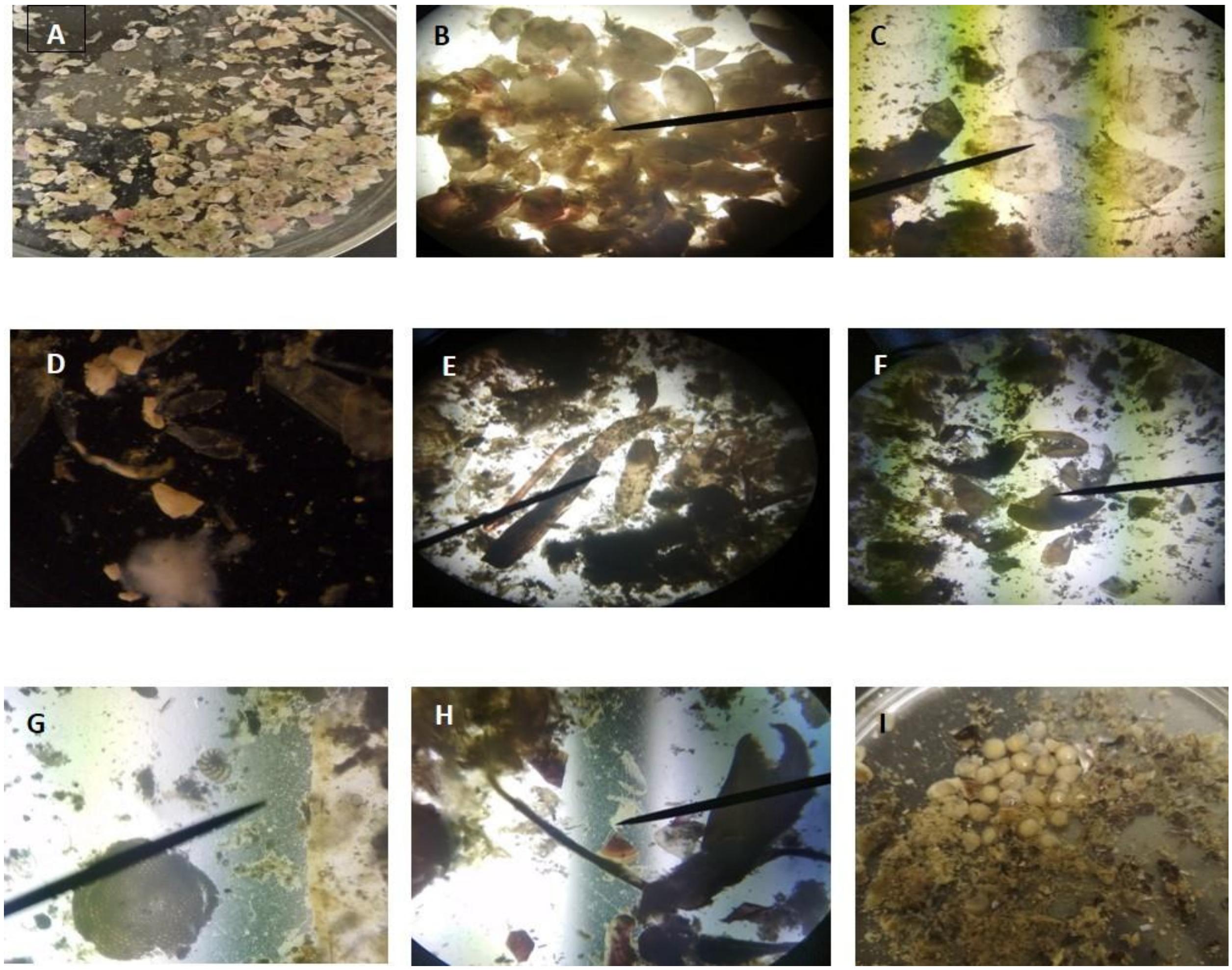

Figure 1. Diet contents in the stomachs of G. *longirostris* caught along the Jeddah Red Sea coast. (A & B) Bivalves (C) Fish Scale (D) Sand (E) Plants matter (F) Decapods (G) Gastropods (H) Amphipods (I) Eggs

- **Feeding intensity, gonado-somatic index, and relative condition factor**

Quantitative analysis of stomach contents of 406 specimens (pooled sexes) were carried out for understanding feeding intensity of *G. Longirostris* (Table 2). The fullness index and the vacuity index were used to know the feeding intensity of this fish. The higher percentage of moderate feeding intensity was observed from September to November and poor feeding intensity in December and August. Gorged stomach was noted in only May (2.12%). High occurrence of moderate and poorly fed fishes was observed in most of the months. These findings may indicate the absence of regular periodicity in the feeding intensity in different seasons. Nair (1979) stated that the absence of seasonal intense feeding activity was observed when poorly and moderate fed fishes predominate in most months. Highest percentage of prey items was noticed in October with lowest empty stomachs (19.05%) (Table 2).

Table. 2 Monthly variations in the feeding intensity of *G. Longirostris*

Months	Active feeding		Moderate feeding		Poor feeding		Empty
	Gorged	Full	¾ full	½ full	¼ full	Trace	
Aug	-	3.33	13.33	16.66	10	36.67	20
Sep	-	2.27	18.18	22.73	6.82	25	29.55
Oct	-	4.76	23.81	28.57	14.29	9.52	19.05
Nov	-	4	28	24	16	4	24
Dec	-	5.41	8.11	13.51	18.92	32.43	21.62
Jan	-	7.5	5	10	12.5	17.5	47.5
Feb	-	17.86	14.28	3.57	14.28	10.71	39.29
March	-	-	-	11.43	5.71	-	82.86
April	-	6.90	-	3.45	10.34	20.69	58.62
May	2.12	-	4.26	2.12	8.51	6.38	76.59
June	-	-	2	-	6	10	82
July	-	25	5	10	20	5	35

The relationships between feeding intensity, gonado-somatic index and relative condition factor was described in Figure 2. The length-weight relationship of *G. longirostris* in the Red Sea coast of Jeddah fisheries was highly significant with r^2 value of 0.98 with power equation: $W = 0.012\ L^{3.015}$. The maximum fullness index (FI%) was documented in autumn (1.72), followed by winter (1.23), spring (0.87), and the lowest FI was in summer (0.58). The highest value of Vacuity index (VI%) was in summer (71.79) followed by spring (61.96), winter (32.35) and lowest in autumn (23) (Fig. 2A). The study showed that feeding intensity was highly correlated to gonado-somatic index. Many mature gonads were observed from March to June with higher percentages of empty stomachs. The highest GSI value was recorded in summer (4.04) with lowest FI (0.58%) and opposite results was found in autumn (GSI, 0.81 and FI, 1.72) (Fig. 2B). The value of VI increased with GSI from lowest in autumn (VI, 23% and GSI, 0.813) to peak in Summer (VI, 71.79% and GSI, 4.04) (Fig. 2C). The value of relative condition factor (K_n) also elevated with the value of GSI from lowest in autumn to highest in summer (Fig. 2D). Studies on relative condition factor of *G. longirostris* disclosed that the changes in 'K_n' values can be attributed to gonado-somatic index as well as feeding intensity. The results revealed a strong positive correlation between GSI and both VI (0.988) and K_n (0.998), and a strong negative correlation between GSI and FI (-0.914). Hosney and Al-jaber (2017) reported that the reproductive cycle of *G. longirostris* was in late spring-early summer (May-June) and Grandcourt *et al.* (2006) reported it between April and August in the Arabian Gulf. Thus, the spawning period of this species coincided with the feeding intensity. Some research outcomes indicated that changes in the feeding intensity is closely related to the water temperature and reproduction activity and these are known main factors influencing the rate of feeding in fishes (Weatherley & Gill 1987, Okan *et al.*, 2016; Hosney and Al-jaber, 2017; Grandcourt *et al.*, 2006). Neelakantan and Pai (1985) and Narejo *et al.* (2002) stated that variations of condition factor of fishes are closely related to their reproductive cycle.

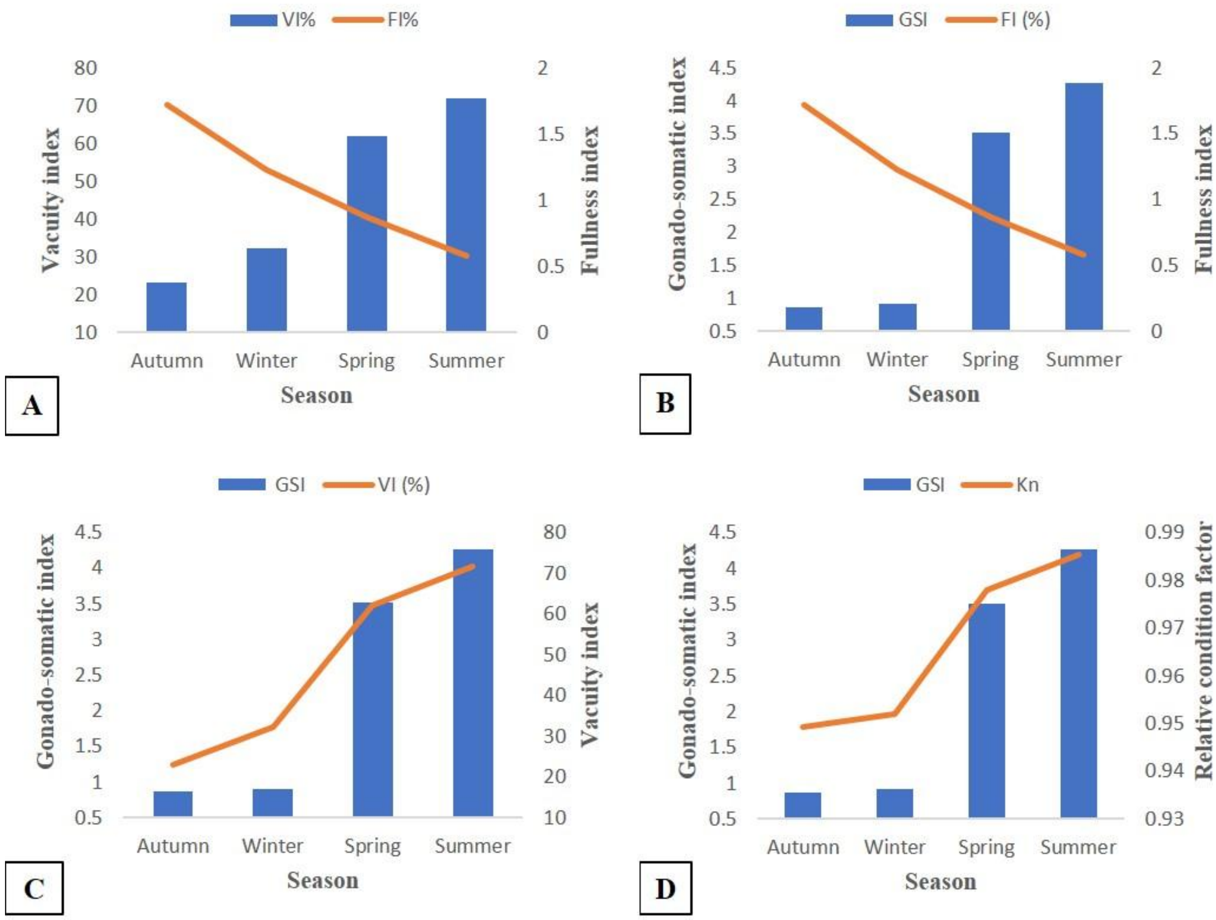

Fig. 2 Relationships between different indexes of *G. longirostris* according to seasons (A) FI vs VI (B) GSI vs FI (C) GSI vs VI and (D) GSI vs K_n. FI, Fullness index (%); VI, Vacuity index (%); GSI, Gonado-somatic index; K_n, Relative condition factor

- **Diet composition in relation to fish size**

Lengthwise prey preference of *G. longirostris* is demonstrated in Table 3. The diet of medium-sized (15.3-24.6 cm TL) *G. longirostris* comprised bivalves, gastropods, decapods, amphipods, fish scale, eggs, plants matter, algae, sand grains. The largest sized individuals consumed mainly mollusks and crustaceans. Bivalves varied from lowest of 10% in 24.7-27.7 cm length group to highest (27%) in 15.3-18.3 cm length group. Prey preference seems to be the same in all size groups, but the recorded percentages of diet composition decreases with the increase in fish size (Table 3). Mollusks (bivalves, gastropods), Crustaceans (decapods, amphipods) and Sand were frequently found in the diet of all length groups. The occurrence of sand grains in the diet of *G. longirostris* reveals that this fish are mainly bottom feeders. Moreover, Thomson (1966) indicated that the ingested sand particles are helpful in the grinding of food particles in the stomach.

Table 3. Diet composition (%) in relation to the length

Length group	Bivalves	Gastropods	Decapods	Amphi pods	Fish scales	Eggs	Sand grains	Semi-digested	Digested	Others
15.0-18.9	27	10.0	9.0	3.0	3.0	-	27.0	11.0	4.0	6.0
19.0-21.9	25	12.1	17.3	6.03	0.86	1.7	17.24	2.6	8.6	8.6
22.0-24.9	18.3	9.6	13.9	2.6	2.6	3.5	15.7	5.3	10.4	18.3
25.0-27.9	10	17.5	22.5	2.5	-	2.5	22.5	5.0	5.0	12.5
28.0-30.9	11.8	29.4	29.4	5.9	-	-	17.7	-	5.9	5.9

- **Index of Preponderance**

To assess the food proclivities of *G. longirostris*, the method of index of preponderance was applied and the results are tabulated in Table 4. It can be observed that there is well agreement between the method of index of preponderance and volumetric method. Index calculation of food items showed mollusks as the main prey item followed by crustaceans. Bivalves placed first (69.4%) and individually decapods (6.9%) were the second dominant prey. Gastropods (1.6%) represented another major food of *G. longirostris*. Rao (1986) stated similar results of bivalves (67.90%), gastropods (2.276%) in the diet of *G. oyena* species. Combined percentage of plants matter, algae and detritus contributed 7% of all the food items which is like the findings of Rao (1968) on *G. oyena* and *G. filamentosus* and Badrudeen and Mahadevan (1996) on *Gerres macracanthus*.

Feeding on amphipods, fish scales and eggs by *G. longirostris* was observed occasionally and it contributed 0.1%, 0.01% and 0.12% respectfully of all the food items. Digested matter ranked third with a contribution of 6.2%. The study found that sand grains was contributed 2.8% of all the food items of *G. longirostries* where Badrudeen and Mahadevan (1996) found that 6.8, 5.1 and 5% by volumetric percentages in different sizes on *Gerres macracanthus* in Palk bay. A large amount of food observed in broken condition. The index of preponderance of these broken semi-digested foods was 5.9%. Most of semi-digested foods were bivalves, gastropods, and plants matter.

Table 4. Index of preponderance of various food items in *G. longirostris* caught along the Jeddah Red Sea coast

Food items	Occurrence	Occurrence percentage (Oi%)	Volume (V) (ml)	Volume percentage (Vi%)	OiVi	Index of preponderance
Bivalves	97	25.6	68.9	46.2	1182.7	69.4
Gastropods	34	8.9	4.6	3.1	27.6	1.6
Decapods	36	9.5	18.3	12.3	116.9	6.9
Amphipods	9	2.4	0.9	0.6	1.4	0.1
Fish scales	7	1.8	0.2	0.1	0.2	0.01
Eggs	7	1.8	1.6	1.1	2	0.12
Sand grains	60	15.8	4.51	3	47.4	2.8
Semi-digested	26	6.9	21.98	14.7	101.4	5.9
Digested foods	32	8.4	18.7	12.5	105	6.2
Others (plants, algae, detritus)	71	18.7	9.5	6.4	119.7	7

- **Diet composition by number, weight, occurrence, and index of relative importance**

Of the stomach content analyzed, 147 were empty (VI%=36.2) and food items were present in 259 of them (Table 5). A total of 1741 food items were identified from those 259 stomachs. The main food items of *G. longirostris* were bivalves. Bivalves were the dominant prey in diet by weight (63.67%), number (49.97%), and occurrence (37.2%). The second most consumed food type was decapods (N% 9.59, W% 19.28, and FO% 13.97). This is the first study so far on the index of relative importance of different food items in the stomach of *G. longirostris*. According to the IRI%, bivalves were the most important prey items (IRI% = 75.4), then decapods (IRI% = 7.11) and Gastropods (IRI% = 1.96). Sand grains (IRI% = 8.71) and others (plants, detritus, algae) (IRI% = 6) were also important food items for *G. longirostris*. Amphipods, fish scales and eggs were the least important food items where they collectively represented only 0.82% of the total index of relative importance (IRI). However, Abu El-Nasr, (2015) reported that crustacea were the most important prey items (IRI%, 34.44), then polycheates, mollusca, and bivalves, and also amphipods and fish scales and eggs represented the least important food items in the stomach contents of G. *filamentosus*.

Table 5. Diet composition of *G. longirostris* in Jeddah fisheries

Foods	n	N%	W	W%	O	Fi%	IRI	IRI%
Bivalves	870	49.97	64.29	63.67	97	37.2	4227.4	75.4
Decapods	167	9.59	19.48	19.28	36	13.79	398.3	7.11
Gastropods	94	5.39	3.06	3.03	34	13.03	109.7	1.96
Amphipods	71	4.08	1.66	1.64	9	3.45	19.7	0.35
Fish scales	38	2.18	0.30	0.29	7	2.68	6.62	0.12
Eggs	82	4.71	2.64	2.60	7	2.68	19.6	0.35
Sand grains	304	17.46	3.78	3.73	60	22.99	487.4	8.71
Others (plants matter, detritus, algae)	115	6.62	5.76	5.76	71	27.2	336.5	6
Total	1741	100	100.97	100			5605.2	100
No. of Stomach analyzed	406							
Full stomach	259	63.1%						
Empty stomach	147	36.2%						

CONCLUSION

The food and feeding habits of *G. longirostris* in Red sea Jeddah fisheries showed seasonal variations. From this study, it could be surmised that the diet of *G. longirostris* consists of two main groups, the Mollusks, and the crustaceans. This species was moderate to poor bottom feeders with identical food habits, subsisting on bivalves, decapods, detritus, amphipods, gastropods, plant matter, sand etc. The prey preferences are similar in most of the months. The study concluded that feeding intensity, relative condition factor is more related to gonado-somatic index. The present analysis of food and feeding habits of this fish would help in ecosystem modelling and its fisheries conservation, in addition to its prospective use for aquaculture.

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