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The seasonal variation in diet composition and feeding strategy of *Grammoplites suppositus* (Troschel, 1840) (Family: Platycephalidae) in relation to its sex and size

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The present study had investigated different aspects of feeding biology of *Grammoplites suppositus*. The *G. suppositus* was found to feed on crabs (26.85 %), zooplanktons (14.02 %), shrimps (18.78 %), fishes (10.83 %), gastropod (5.14 %), cephalopods (3.24 %) and miscellaneous (digested matter) food items (21.2 %). The number and occurrence of food items vary in relation to sex and size of investigated species, although the variation was insignificant ($P > 0.05$). However the changing environmental conditions during monsoon, pre and post-monsoon season significantly ($P < 0.05$) influence the feeding intensity of the observed fish. The highest percentages of empty stomach were recorded during SW monsoon and post-monsoon which may be due to increased spawning activity. The GaSI ranged between 2.48 to 7.63 whereas, HSI ranged between 1.06 to 3.98. The cannibalism was only observed during monsoon season. The females feed less actively and showed highest percentage of cannibalism than males.

[**Keywords**: Cannibalism, Monsoon, Qualitative, Sex, Size, Spawning]

Introduction

The *Grammoplites suppositus* is commonly known as spot fin flathead fish and is member of well known family of demersal fishes *i.e.* Platycephalidae. Due to demersal mode of life the body of Platycephalids is compressed and dorso-ventrally flattened hence termed as flathead fishes[1]. The flatheads are classified worldwide into 17 genera and 27 species[2] occupying the sandy and muddy substratum of tropical and subtropical waters[3]. The *G. suppositus* is characterized by brownish cylindrical body and distinguished with the presence of black blotch on first dorsal fin and small black dots on second dorsal fin. The species of family Platycephalidae are of great commercial importance and constitute the largest fishery resource of East Asia[4] and Australia[5]. Although flathead fishes do not shows significant contribution to the commercial fishery of the India, but still harvested in considerably high percentage[6]. Along Pakistan coast the total landing of Platycephalids ranged between 2 to 8 metric tons from 1998 to 2008(ref.7). The Platycephalids are largely consumed as food in different regions of the world because of their high nutritive value and excellent taste and are also known for some medicinal values[8]. The *G. suppositus* is among one of the important species of family Platycephalidae and is commercially exploited along the Arabian Gulf, Sri Lanka and Bay of Bengal[9,10].

The knowledge on food and feeding habits of fish plays important role in determining the population dynamics and ecological parameters *i.e.* trophic interaction, diet overlap and food spectrum[11]. Moreover the information of feeding habits of the fish allows the selection of suitable species for commercial culture[12]. The literature survey shows that diet composition and feeding habit of the different species of family Platycephalidae has been investigated earlier. These species involve *G. scaber* from Bay of Bengal[13], *Platycephalus maculipinna* from Cochin coast of India[3], *P. fuscus* from Persian Gulf[14], *Cociella crocodila* from Asian mangrove waters[15] and from Hoogly estuary India[16]. The trophodynamic aspects of feeding biology of *G. suppositus* have also been investigated from Southeast Arabian Sea[17]. The little or no information is available about diet composition as well as seasonal changes in feeding of *G. suppositus* in relation to sex and size; therefore the aim of present study is of great significance and the results can be further used in stock assessment, conservation and management of fishery resource as well as in aquaculture practices.

Materials and Methods

The present study involves monthly sampling of 395 specimens (♀ = 270; ♂ = 125) of *G. suppositus* from commercial landing of Karachi Fish harbour during the study period of January to December 2018. The Karachi coast encounter the northern boundary of Arabian Sea, lying between latitude of 24°53' N and longitude 67°00'E[18]. There are more than 65 commercial fish landing centers along the Pakistan coast, among which Karachi Fish harbour is one of the largest fish landing centre. The most common type of gears used in commercial catch along Pakistan coast are gill nets used for pelagic and coastal fishery and trawlers used for capture of demersal fishery[19]. The specimens were brought in ice to the laboratory and stored at -20 °C till further investigation. The collected samples were of different size range and were measured nearest to 0.1 cm and weighed nearest to 0.1 gm accuracy. The stomach were carefully removed after dissecting the specimens, and weighted nearest to 0.1 g with the help of electronic balance (Camry EK3250). Visually stomach were classified as full or gorged, 3/4th filled, 1/2 filled, 1/3rd filled, 1/4th filled and empty on the basis of amount of food[20], and fishes are said to be heavily fed (full and 3/4th), moderately fed (1/2, 1/3rd) and poorly fed (1/4th and empty) on the basis of degree fullness of stomach[21]. The stomach contents were sorted, counted and identified to the possible taxon. The dietary importance and abundance of each prey item was determined by calculation of frequency of number (%N) and occurrence (%F)[22], frequency of weight (%W)[23], index of relative importance (%IRI)[24], and index of absolute importance (%Al)[25]. The seasonal variation in feeding intensity was assessed through gastro-somatic index (GaSI)[26], hepato-somatic index (HSI)[27], cumulative index (CV) and stomach fullness index (SFI)[28]. The statistical analysis involved univariate analysis (ANOVA) to test the significance of sex, size and size wise variation in feeding intensity of *G. suppositus*.

Results

The mouth of *G. suppositus* is elongated, with broad oral cavity and sharp series of teeth in both the jaws as an adaption of carnivore mode of feeding. The pharynx and oesophagus were short sized, but stomach was large, thick walled and extensible muscular structure to encapsulate the variety of prey items. The gut contents of G. *suppositus* have been categorized into seven taxonomic groups: fishes, shrimps, crabs, zooplankton, gastropods, cephalopods and miscellaneous (digested matter) food items. The analysis of percent composition of the food contents shows that among crustaceans, crabs constitute 26.85 %, zooplankton 14.02 % and shrimps 18.78 % of total food consumption. The fishes were also important food source constituting 10.83 %, gastropod 5.14 %, cephalopods 3.24 % and miscellaneous (digested matter) constitute 21.2 % of the total food consumption (Fig. 1).

Food in relation to sex of fish

The sex wise variation in diet composition was determined by analyzing gut contents of both males and females of *G. suppositus.* The result showed a dominance of shrimp *Penaeus indicus* (%F = 15.98, %W = 14.61, %IRI = 15.86 and %Al = 10.83) and isopods (%N = 12.67) in gut contents of male fishes. Whereas, in females there was a dominance of copepods (%N = 17.72), *Cynoglossus* sp. (%W = 13.57 and %Al = 10.76), and *Acetes* sp. (%F = 18.26 and %IRI = 21.30) (Table 1). Although diet composition of both sexes showed variation in terms of number and occurrence of different prey items, but this variation was insignificant (ANOVA, F = 0.052, $P > 0.05$) when tested with one way ANOVA.

Food in relation to size of fish

The collected specimens of *G. suppositus* were of different size range and were divided into three groups; 15-25 cm, 26-35 cm and 36-45 cm. In specimens of 15-25 cm most dominant food items were crabs *Portunus pelagicus* (%N = 13.83 and %Al = 14.88), *P. sanguinolentus* (%W = 15.57 and %IRI = 27.20) and *Acetes* sp. (%F = 16.02). In 26-35 cm sized fishes, predominat food items were copepods (%F = 17.86 and %Al = 12.09), shrimp *P. indicus* (%W = 14.06 and %IRI = 29.08) and *Lucifer* (%N = 16.87). Similarly in fishes of 36-45 cm most dominant food items were copepods (%N = 15.32 %IRI =

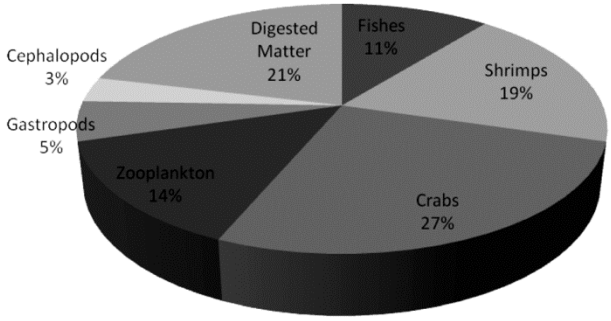

Fig. 1 — Percent composition of food items of *G. suppositus*

19.13), shrimp *Parapenaeopsis stylifera* (%F = 16.73 and %Al = 14.58) and miscellaneous (digested matter) food items (%W = 15.48) (Table 2). The variation in diet composition of three size groups was tested through one way ANOVA and found to be insignificant ANOVA, F = 0.036, $P > 0.05$).

Food in relation to season

The seasonal variation in diet composition of *G. suppositus* was also studied. The degree of fullness of stomach showed active feeding during pre-monsoon, whereas poor feeding was observed during post- monsoon and SW monsoon. In pre-monsoon season there was dominance of crab *P. pelagicus* (%F = 16.75, %W = 14.19, and %Al = 12.07) and isopods (%N = 19.58 and %IRI = 20.53). In SW monsoon there was dominance of miscellaneous (digested matter) food items (%W = 15.85, %IRI = 14.98 and %Al = 10.75), *Lucifer* (%F = 17.83) and copepods (%N = 18.24). In post-monsoon there was dominance of shrimp *Penaeus indicus* (%F = 18.64 and %Al = 17.65), miscellaneous (digested matter) food items (%W = 17.26 and %IRI = 25.24) and copepods (%N = 13.85). Whereas in NE monsoon predominant food items observed were crab *P. pelagicus* (%W = 10.55 and %lRI = 13.92), isopods (%N = 11.94 and %Al = 10.12) and semi-digested fish parts (%F = 12.65) (Table 3). The significant variation (ANOVA, F = 5.12, $P < 0.05$) in feeding intensity of *G. suppositus* was observed during monsoon, pre and post-monsoon seasons.

Cumulative index (CV) and stomach fullness index

The stomach fullness and emptiness index provide measure of feeding intensity of fish. The mean value observed for stomach emptiness (CV) was 51.34 % and of fullness index (SFI) was 48.66 %. The females (51.31 %) showed comparatively higher percentage of empty stomachs than males (46.93 %). The medium sized fishes of 26-35 cm showed lower percentage of empty stomachs (39.89 %) in comparison to small sized fishes of 15-25 cm (67.56 %) and large sized fishes of 31-45 cm (46.58 %). Due to peak spawning activity, the highest percentages of empty stomachs were recorded during SW (59.34 %) and post-monsoon (53.21 %) seasons (Fig. 2).

Table 1 — Estimation of diet composition and feeding intensity of *G. suppositus* in relation to sex

	Male					Female				
	%F	%N	%W	%IRI	%Al	%F	%N	%W	%IRI	%Al
Fish										
Cynoglosus sp.	3.96	3.15	4.31	2.61	3.81	2.91	1.87	13.57	1.23	10.76
Nemipterus sp.	4.16	5.28	7.24	7.33	7.83	2.58	5.07	5.95	4.45	4.53
Trichiurus sp.	5.19	4.89	5.86	5.04	5.31	3.32	2.58	4.86	2.16	3.59
Grammoplites suppositus	0.71	3.16	0.67	0.42	1.51	3.39	3.79	3.81	2.42	3.66
Unidentified fishes	10.82	12.55	9.48	8.08	9.18	15.8	12.80	9.69	19.86	10.55
Fish parts	9.72	8.27	11	14.95	9.65	6.04	6.69	7.21	11.53	9.48
Crustaceans										
Shrimp										
Penaeus indicus	15.98	5.31	14.61	15.86	10.83	5.26	3.48	3.21	2.23	3.98
Penaeus stylifera	5.76	4.62	2.95	2.89	4.44	3.21	3.64	4.21	2.52	3.69
Crabs										
Portunus pelagicus	9.65	8.63	4.72	7.51	7.67	4.97	4.23	3.67	2.79	4.29
Portunus sanguinolentus	6.31	4.26	3.28	4.23	5.25	5.83	3.62	11.85	7.47	7.67
Zooplankton										
Acetes sp.	7.38	7.78	5.5	7.47	6.89	18.3	12.55	5.97	21.30	10.20
Isopods	3.38	12.67	4.31	8.64	6.79	4.63	4.28	3.61	3.91	4.98
Decapod larvae	5.81	4.47	3.45	3.16	4.58	2.63	5.67	2.81	2.52	3.70
Copepods	4.18	5.21	3.71	3.50	4.37	5.59	17.72	2.56	2.25	4.14
Molluscs										
Gastropods										
Tibia sp.	2.36	3.47	2.21	1.49	2.68	3.22	1.07	1.79	0.70	2.03
Cerathium sp.	1.75	2.38	2.19	1.04	2.11	2.18	2.52	1.69	0.88	2.13
Cephlopods										
Octopus sp.	1.23	0.89	3.74	0.68	1.95	0.79	0.96	3.75	0.59	1.83
Digested matter	1.65	3.01	10.8	5.09	5.16	9.38	7.46	9.79	11.20	8.88

Gastro-somatic (GaSI) and Hepato-somatic index (HSI)

The GaSI ranged between 2.48 to 7.63 showing mean value of 5.05. Among three observed size groups, medium size fishes of 26-35 cm showed highest percentage (5.68) of gastro-somatic index. Seasonally highest value of GaSI was observed during pre-monsoon (7.02) followed by NE monsoon (6.44). The GaSI of males (5.18) was higher than females (4.93) due to high feeding intensity. The HSI was 1.06 to 3.98, showing mean value of 2.52. Whereas, the HSI values of females (2.87) was higher than males (2.16). The highest value of hepato-somatic index was found during the period of active feeding *i.e.* during pre-monsoon season (3.24; Fig. 3).

Cannibalism

In the present study various events of cannibalism were noted in *G. suppositus*. The fishes of all size groups were observed to feed on their own kind of individuals. There was lower percentage of cannibalistic fish in small fishes (%W = 2.2 and %IRI = 0.37) as compared to medium size (%W = 4.61 and %IRI = 2.61) and large sized fishes (%W = 4.28 and %IRI = 2.31). The cannibalism shows higher percentage during SW monsoon (%W = 10.35 and %IRI = 10.79) compared to NE monsoon (%W = 5.04 and %IRI = 1.90). Female fishes showed higher percentage of cannibalism (%IRI = 2.42) than males (%IRI = 0.42).

Discussion

The qualitative and quantitative analysis of gut content can be used to determine the variation in feeding biology of a fish[29]. The stomach content analysis of *G. suppositus* shows that it is a carnivore fish feeding on variety of food items like crustaceans, fishes and mollusc, showing strong preference toward crustaceans. Among crustaceans crabs like *P. pelagicus* and *P. sanguinolentus* showed higher percentage, followed by zooplankton (isopods, copepods, decapods larvae and *Lucifer* sp.) and shrimps (*P. indicus* and *P. stylifera*). The teleost fishes (10.83 %) also showed considerable percentage among gut contents of *G. suppositus* among which *Nemipterus* sp. and *Cynoglosus* sp. were most dominant. Similar to the present study, another study carried out along the southeast Arabian Sea reported

Table 2 — Estimation of diet composition and feeding intensity of *G. suppositus* in relation to size

Food category	15-25 cm					26-35 cm					36-45 cm				
	%F	%N	%W	%IRI	%Al	%F	%N	%W	%IRI	%Al	%F	%N	%W	%IRI	%Al
Fish															
Cynoglosus sp.	3.67	3.48	3.19	1.79	3.45	-	-	-	-	-	1.63	2.05	3.67	1.12	2.45
Nemipterus sp.	2.27	3.42	5.02	2.36	3.57	3.91	4.62	5.59	3.54	4.71	4.93	5.16	4.84	3.66	4.98
Trichiurus sp.	2.33	3.40	4.71	2.23	3.48	2.87	3.20	4.67	2.12	3.58	4.57	3.23	5.28	2.64	4.36
Grammoplites suppositus	0.67	1.09	2.2	0.37	1.32	4.39	3.81	4.61	2.61	4.27	3.67	3.56	4.28	2.31	3.84
Unidentified fishes	6.20	5.27	7.68	5.67	6.38	5.39	6.02	6.96	5.62	6.12	6.12	4.92	14.50	9.47	8.51
Fish parts	10.84	12.83	3.58	6.90	9.08	4.64	6.34	8.24	6.76	6.41	8.24	9.07	5.29	6.87	7.53
Crustaceans															
Shrimps															
Penaeus indicus	3.41	3.57	5.6	2.84	4.19	15.07	13.82	14.6	29.08	11.51	6.83	8.19	8.72	9.57	7.91
Penaeus stylifera	1.67	2.50	4.03	1.43	2.74	4.61	4.44	5.33	3.15	4.79	16.73	11.91	7.09	11.62	14.58
Crabs															
Portunus pelagicus	14.39	13.83	10.41	19.23	14.88	5.56	4.28	7.29	4.09	5.71	6.23	7.05	5.20	5.24	6.16
Portunus sanguinolentus	13.96	13.49	15.57	27.20	12.34	7.25	6.80	8.98	7.61	7.68	5.29	4.13	5.64	3.49	5.02
Zooplanktons															
Acetes sp.	16.02	7.21	5.71	6.95	9.65	3.87	2.60	4.68	1.91	3.72	-	-	-	-	-
Decapod larvae	4.21	3.87	2.18	1.54	3.42	8.42	4.08	4.36	1.79	5.62	6.77	5.82	3.80	3.53	5.46
Lucifer	3.67	4.26	2.68	1.83	3.54	5.49	16.87	7.09	11.56	10.82	3.81	4.62	4.06	2.76	4.16
Copepods	3.68	11.65	5.36	8.03	6.90	17.86	9.81	2.59	4.51	12.09	14.11	15.32	9.40	19.13	13.97
Molluscs															
Gastropods															
Tibia sp.	2.09	3.05	2.07	1.02	2.40	-	-	-	-	-	-	-	-	-	-
Cerathium sp.	1.67	1.14	1.35	0.39	1.39	0.49	1.38	0.86	0.19	0.91	1.31	0.34	1.11	0.21	0.92
Cephalods															
Octopus sp.	0.53	1.26	3.6	0.62	1.80	0.62	1.03	2.52	0.35	1.39	1.59	0.50	1.63	0.29	1.24
Digested matter	8.71	4.67	15.06	9.60	9.48	9.57	10.89	11.6	15.13	10.69	8.17	14.13	15.48	18.07	8.90

Table 3 — Estimation of diet composition and feeding intensity of *G. suppositus* in relation to season

Food category	Pre monsoon (Mar-Apr)					SW monsoon (May-Sep)					Post monsoon (Oct-Nov)					NE monsoon (Dec- Feb)				
	%F	%N	%W	%IRI	%AI	%F	%N	%W	%IRI	%AI	%F	%N	%W	%IRI	%AI	%F	%N	%W	%IRI	%AI
Fish																				
Cynoglosus sp.	7.73	7.63	10.8	11.38	8.71	3.89	2.93	3.59	1.86	3.47	4.53	5.68	5.94	4.29	5.38	4.78	5.68	7.51	6.83	5.99
Nemipterus sp.	3.07	3.92	4.98	2.86	3.99	4.28	3.39	4.21	2.39	3.96	3.75	4.21	5.29	2.92	4.42	6.44	4.78	9.21	7.27	6.81
Trichiurus sp.	4.86	5.36	6.45	4.99	5.56	4.29	5.87	6.16	5.22	5.44	6.02	5.92	8.28	6.17	6.74	5.67	6.14	8.03	7.91	6.61
Grammoplites suppositus	-	-	-	-	-	5.74	7.54	10.3	10.79	7.87	-	-	-	-	-	2.19	2.19	5.04	1.90	3.14
Unidentified fishes	6.5	5.94	6.15	5.45	6.20	4.87	5.78	3.93	3.56	4.86	7.21	9.47	11.64	13.16	9.44	7.46	7.59	6.68	8.37	7.24
Fish parts	10.5	7.74	5.81	7.03	8.02	12.17	11.97	7.25	12.76	10.46	9.52	10.8	6.87	9.40	9.07	12.65	6.54	7.35	8.45	8.18
Crustaceans																				
Shrimps																				
Penaeus indicus	2.69	3.61	3.85	2.10	3.38	3.86	4.27	5.56	3.56	4.56	18.64	5.63	10.67	13.66	17.65	7.46	8.63	4.66	6.86	6.92
Penaeus stylifera	4.53	3.59	5.75	3.19	4.62	5.21	3.48	3.14	2.08	3.94	4.29	4.51	2.98	1.99	3.93	6.81	7.22	4.81	5.98	6.28
Crabs																				
P. pelagicus	16.75	5.27	14.19	11.59	12.07	6.17	5.86	12.2	9.99	8.07	3.87	3.76	3.47	1.90	3.70	6.51	6.34	10.55	13.92	6.47
P. sanguinolentus	4.2	4.87	5.73	4.07	4.94	4.29	5.37	6.39	4.98	5.35	4.89	6.89	7.29	6.18	6.36	5.34	5.21	6.84	5.90	5.80
Zooplanktons																				
Isopods	7.65	19.58	7.89	20.53	11.71	5.67	4.86	3.52	2.94	4.68	6.52	7.52	7.38	6.95	7.14	4.55	11.94	3.29	2.80	10.12
Decapod larvae	5.56	5.92	4.86	4.35	5.45	4.76	3.87	2.19	1.71	3.61	6.54	5.92	2.37	2.29	4.92	5.58	3.21	3.87	4.26	5.22
Lucifer	4.19	3.52	4.35	2.47	4.02	17.83	7.86	5.68	8.06	10.46	4.89	5.45	2.08	1.82	4.14	3.89	4.19	4.25	3.12	4.11
Copepods	4.36	5.85	4.39	3.80	4.87	6.29	18.24	5.81	14.47	10.11	6.93	13.85	1.64	1.86	4.83	4.32	4.52	4.66	6.28	5.81
Gastropods																				
Tibia sp.	3.44	3.51	0.59	0.70	2.51	0.25	1.03	1.82	0.27	1.03	3.93	3.93	2.62	1.60	3.49	2.46	2.79	2.58	1.39	2.61
Cerathium sp.	5.25	5.77	1.98	2.11	4.33	0.76	0.96	2.39	0.39	1.37	0.83	1.04	4.21	0.58	2.03	1.67	2.45	2.73	1.20	2.28
Cephalopods																				
Octopus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.03	2.18	2.91	1.21	2.37
Digested matter	8.69	7.92	12.3	13.39	9.62	9.67	6.72	15.85	14.98	10.75	7.64	5.39	17.26	25.24	6.76	10.19	8.40	5.03	6.33	4.04

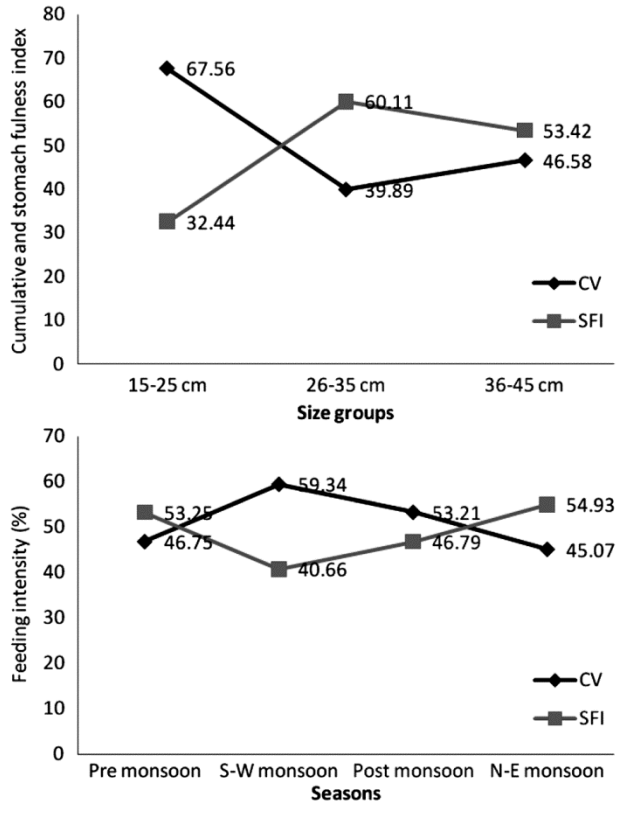

Fig. 2 — Cumulative index and stomach fullness index in different size groups and seasons

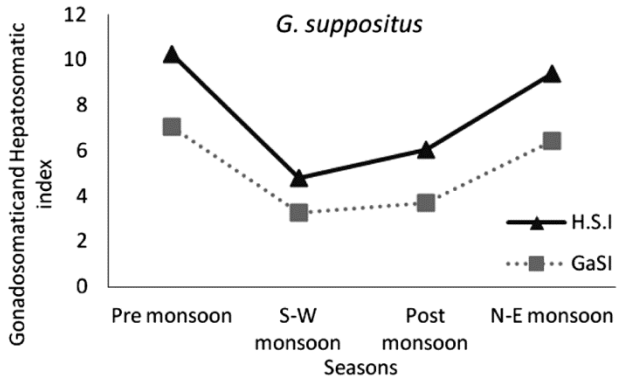

Fig. 3 — Gastro-somatic index (GaSI) and Hepato-somatic index (HSI) of *G. suppositus* in four different seasons

G. suppositus to feed dominantly on shrimp and crabs and showed high preference towards crustaceans[17]. Similarly study carried out along Persian Gulf proposed that *G. suppositus* show less preference towards fish consumption and 60 % of its diet regimen is composed of crustaceans[30].

The factors like, nutrient value, availability and abundance of prey item affect the prey selectivity of a fish[31]. The gut contents of males and females showed slight variation in terms of number and occurrence of prey items, though variation was statistically insignificant (ANOVA, $F = 0.052$; $P > 0.05$). The varieties of food items were present in gut contents, but preferred food items were determined through index of relative importance (%IRI) and absolute index (%AI). The males showed strong preference towards shrimp *P. indicus* (%IRI = 15.86 and %AI = 10.83) while that of females towards *Acetes* sp.

(%IRI = 21.30) and *Cynoglosus* sp. (%Al = 10.76). It has been observed that the size of prey and predator has strong influence on food preference of fish[32]. The males fed more actively than females because extended gonads of females causes less intake of food during spawning season[33]. The earlier studies have suggested the ontogenic variation in feeding preference of fish[11,34] *i.e.*, increase in body size result in increased demand of protein and fat contents which cause the fish to feed on large sized prey[35]. The broad oral cavity and extensible stomach of *G. suppositus* facilitated to feed on large sized prey like crabs, shrimps and fishes. The small sized fishes of 15-25 cm preferably feeds on small crabs, *Portunus pelagicus* (%Al = 14.88) and *P. sanguinolentus* (%IRI = 27.20), fishes of 26-35 cm preferably feeds on copepods (%Al = 12.09) and shrimp *P. indicus* (%IRI = 29.08), however fishes of 36-45 cm showed strong preference towards copepods (%IRI = 19.13) and large size shrimp *i.e. Parapenaeopsis stylifera* (%Al = 14.58). The earlier study reports that the juveniles of *G. suppositus* (14-16 cm) feeds on teleost fishes, whereas other (> 16 cm) feeds on crabs and stomatopods[17]. The feeding intensity deduced from degree of fullness of stomach was comparatively high in medium sized fishes (26-35 cm) as compared to small (15-25 cm) and large size fishes (36-45 cm), because small sized fishes feed slowly whereas large sized fishes were reproductively mature and ceased feeding during spawning season. The feeding intensity of three size groups did not showed significant difference when tested through one way (ANOVA, $F = 0.036$, $P > 0.05$).

There was significant (ANOVA, $F = 5.12$, $P < 0.05$) statistical difference in feeding intensity of observed fish during different seasons. The low feeding intensity was observed during SW monsoon and post-monsoon due to the low food availability[36] and cessation of feeding during peak spawning activity, extending from May to June and August to November during present study. High feeding intensity during pre-monsoon and NE monsoon suggests the fishes feed actively during post spawning period due to greater energy demand[37]. However, along southeast Arabian Sea, highest number of empty stomach in *G. suppositus* was reported during pre-monsoon[17]. The earlier studies also suggest the seasonal change in diet composition of fish[37-39].

The gastro-somatic and hepato-somatic index reflects the degree of feeding, and showed higher values during post spawning period due to increased food supply and active feeding. The highest percentage of GaSI and HSI was recorded during pre-monsoon period. Among both sexes GaSI of male was greater than females because they feeds actively and have less percentage of empty stomach, whereas HSI of female was higher than males due to increased deposition of oil globules utilized in development of oocytes[40]. The high cannibalism observed in female specimens may be due to high calorific demand during spawning season, similarly low food availability during monsoon season causes the *G. suppositus* to feed on its own kind. The earlier study from southeast Arabian Sea supports the cannibalistic nature of *G. suppositus*[17].

Conclusion

The present investigation reveals that crustaceans constitute the major portion of diet of *G. suppositus* followed by fishes, molluscs and digested matter. The statistically insignificant ($P > 0.05$) variation was observed in diet composition of *G. suppositus* in relation to sex and size, whereas the seasonal variation in diet composition of *G. suppositus* was significant ($P < 0.05$). The higher percentage of empty stomach and lower values of gastro-somatic and hepato-somatic index during SW monsoon and post-monsoon season attributes to the low food availability and peak spawning activity. The high rate of cannibalism during SW monsoon also suggests low food availability due to unfavorable environmental conditions.

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Conflict of Interest

Authors declare no conflict of interest.

Author Contributions

This manuscript is part of Ph.D dissertion of corresponding author (TB) and has been investigated and written by corresponding author and has been supervised by GS.

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