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THE DIET COMPOSITION AND SEASONAL VARIATION IN FEEDING HABITS OF *JOHNIUS DUSUUMIERI* (CUVIER, 1830) FROM KARACHI COAST, PAKISTAN

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ABSTRACT

The 322 specimens (♀=198; ♂= 124) of *J. dussumieri* (Cuvier, 1930) were collected from commercial landing of Karachi fish harbor and were used to determine the diet composition and variation in feeding habits of fish in relation to size, sex and season. The gut content analysis showed that crustaceans (54.14%) were the primary food source among which zooplanktons were dominant (24.49%) over shrimps (19.89) and crabs (18.35). The other food items recorded in the gut contents were fishes (11.31%)), molluscs (4.09%) and miscellaneous digested matter (22.31%). There was insignificant ($P>0.05$) variation in quantity and quality of consumed food with sex and size of the predator fish, however there was significant ($P<0.05$) variation in feeding habits of fish during pre-monsoon, post-monsoon and monsoon season. The highest percentage of empty stomachs was observed during pre-monsoon and S-W monsoon seasons due to gonadal maturity and spawning activity. The GaSI of *J. dussumieri* ranged between 2.57 and 6.78 whereas H.S.I ranged between 0.89 and 4.83. The highest rate of cannibalism was observed during pre-monsoon and in both sexes - females showed highest percentage of cannibalistic fish in their stomach.

Key words: Cannibalism, Gastro-somatic index, Hepato-somatic index, monsoon, spawning.

INTRODUCTION

The *Johnius dussumieri* (Cuvier, 1830) is marine teleost fish belonging to the group Perciformes and is one of the dominant and commercially important species of family Scianidae. The *J. dussumieri* is commonly known as Sin croaker and commercially harvested along the Indian and Pakistan coasts (Madhu *et al*., 2013). It is distributed in Indo-pacific region extending from Pakistan to Andaman Coast (Froese and Pauly, 2012 and Madhu *et al*., 2013).

The food is not only an important source of energy but also induce the physiological and behavioral changes in fish (Nikolsy, 1963). The qualitative and quantitative analysis of gut content of fish is important in estimation of population dynamics, rate of growth, physiological condition (Lott, 1996) and different aspects of fish ecology (Sivan and Radhakrishnan, 2011). The earlier studies revealed that feeding habits of a fish have significant effect on morphological and anatomical structure of the alimentary canal (Kapoor, 1976 and Ojeda, 1986). The fishes with carnivore mode of feeding have large oral cavity with sharp and pointed teeth to deal with variety of prey items, whereas omnivore and herbivore fishes have small oral cavity with flat dentition facilitating the food grinding (Lagler *et al*., 1977 and Sanderson *et al*., 1991).

Despite of great economic importance limited information is available on feeding habits of *J. dussumieri* and is reported to be an active carnivore species feeding on benthic crustaceans, fishes, shrimps and prawns (Chacko, 1949). Some of the aspect of feeding biology of *J. dussumieri* has been reported earlier along the Indian coasts by Venkataraman (1960), Suseelan and Nair (1969), Manojkumar (2011) and Venugopal *et al*. (2014). Recently the feeding ecology of *J. dussumieri* has been reported from Iraqi waters by Mohammad and Abood (2019). There is no information related to the biological parameters of *J. dussumieri* along Pakistan coast.

The present study is focused on the qualitative and quantitative analysis of diet composition of *J. dussumieri* from coastal waters of Pakistan (Northern Arabian Sea) which can be further extended and used in management, conservation and cultural activities.

MATERIALS AND METHODS

The 322 specimens of *J. dussumieri* (♀=198; ♂= 124) were collected monthly from commercial landing of Karachi fish harbor. The length and weight of specimens were recorded in laboratory and then dissected to determine sex and fullness of stomach visually and classified into different grades (full, $3/4^{th}$, 1/2, $1/3^{rd}$, $1/4^{th}$, empty). The stomach was removed, measured and dissected to extract the contents. The food contents were sorted, counted and identified to lowest possible taxon. The index of relative importance of prey (IRI) and absolute index (Al) were calculated by using following formulas:

IRI = (%F + %N)x %W
Al = %F + %N+ %W

The gastro-somatic index (GaSI), hepato-somatic index (% HSI), stomach fullness index (SFI) and cumulative index (CV) were also determined to assess the variation in feeding intensity of fish with the following formulas:

GaSI= Gut weight/ Body weight x 100
HSI= Liver weight/ Body weight x100
CV= Number of empty stomach/ Total number of stomach observed x 100
SFI= Weight of stomach contents/Body weight-Weight of stomach

RESULTS

The *J. dussumieri* is an active carnivore fish have broad oral cavity and well developed teeth in upper jaw whereas, lower jaw is provided with villiform teeth. The gut contents of *J. dussumieri* include crustaceans (54.14%), fishes (11.31%), molluscs (4.09%) and miscellaneous digested matter (22.31%). Among crustaceans zooplanktons were fairly abundant as compared to crabs (19.89%) and shrimps (24.49%) (Fig. 1)

Food in relation to sex of fish

In males of *J. dussumieri* the gut content *Penaeus mondon* was dominant with respect to %F (15.27), % IRI (12.34) and % Al (10.80), mysids by % N (14.91), whereas miscellaneous digested matter was highest in terms of %W (12.49). In females *P. semisulcatus* was dominant by %F (18.64%), %W (11.21%), and % Al (11.30), with respect to %N *Lucifer* constituted highest number(13.84%) and with respect to relative importance of food items (%IRI) fish parts were slightly more in number (11.23) (Table 1). One-way ANOVA showed insignificant variation in diet composition of both sexes ($P>0.05$).

Food in relation to size of fish

In *J. dussumieri* the *Portunus pelagicus* was dominant by %F (14.68), %W (19.23) and %IRI (19.39), whereas Lucifer was dominant by %N (18.94) and %Al (13.98) in fishes of 20-30 cm. In fishes of 31-40 cm the *P. monodon* was dominant by %F (18.05),%W (18.63), %IRI (29.56) and %Al (15.49), however decapods larvae were also greater in number (%N=19.17). Whereas, in specimens of 41-50 cm mysids constituted highest number by %N (19.26) and %Al (10.71) and *P. semisulcatus* was dominant food item by %F (10.67), %W (12.97) and %IRI (15.53) (Table 2). The variation in feeding habits of three size groups was found to be insignificant ($P>0.05$).

Food in relation to season

In *J. dussumieri* active feeding was observed during post-monsoon season (62.58%) whereas, poor in SW (42.04%) and pre-monsoon (30%) seasons.

During pre-monsoon there was dominance of mysids by %F (12.39), *P. monodon* by %W (10.94) and %IRI (13.28) and amphipods by %N (11.76) and %Al (10.40). In SW monsoon season there was dominance of Lucifer by %N (17.82), *Metapenaeus affinis* by %F (15.34) and %Al (12.74) and miscellaneous digested matter by % W (17.45) and % IRI (21.86). During post-monsoon season there was dominance of amphipods by %N (13.94), *M. monoceros* by % W (12.84) and % IRI (24.78) and mysid by % F (16.52) and % Al (11.45). During NE monsoon *P. semisulcatus* dominated over other food items in term of % F (17.92), % W (13.97), % lRI (30.34) and % Al (14.08), miscellaneous digested matter was dominant by % N (16.71) as shown in Table 3. The variation in feeding preference among all seasons was found to be significant ($P<0.05$) in *J. dussumieri*.

Cumulative index (CV) and Stomach fullness index

The mean value of empty stomachs was 58.11% and stomach fullness was 41.89%. The highest percentage of cumulative index was observed in fishes of 41-50 cm (68.61%) during pre-monsoon (61.49%) and summer monsoon season (63.69%) (Fig. 2).

Gastro-somatic (GaSI) and Hepato-somatic index (H.S.I)

The GaSI ranged between 3.16-5.68 with mean value of 4.42 in pooled, 4.33 in male and 4.12 in female fishes. The higher values of GaSI were observed during December (5.68) in males and February (4.97) in females. The hepato-somatic index was 1.22-4.94 with mean value of 3.45 in females, 2.71in males and 3.08 in pooled specimens

respectively. The highest values of HSI has been observed during August (4.94) in females and during December (3.78) in males (Fig.3).

Cannibalism

In *J. dussumieri* there were several events of cannibalism in fishes of all size groups but showed lowest percentage in fishes of 31-40 cm (% IRI = 3.47) and highest in small sized fishes of 20-30 cm (% IRI = 8.86). The females have greater percentage of cannibalistic fish in their stomach contents (% IRI = 4.19) than males (% IRI = 3.10). Seasonally the highest percentage of cannibalism was found during pre-monsoon season (% IRI = 8.92) especially in March.

Table 1. Feeding intensity of males and females specimens of *J. dussumieri.*

	Male					Female				
Food category	**%F**	**%N**	**%W**	**%IRI**	**%Al**	**%F**	**%N**	**%W**	**%IRI**	**%Al**
Fish										
Cyprinus sp.	1.32	5.31	3.69	3.33	3.44	3.88	4.23	4.39	3.45	4.17
Johnius belangri	3.59	4.52	4.62	3.89	4.24	2.68	2.72	4.42	2.26	3.27
J. dussumieri	3.18	3.75	4.35	3.10	3.76	5.29	3.26	6.75	4.19	5.10
Trichiurus sp.	2.39	3.69	5.45	3.58	3.84	4.21	4.13	5.68	4.25	4.67
Ilishia sp.	3.79	3.68	4.25	3.09	3.91	6.33	3.87	7.21	5.26	5.80
Gerres sp.	7.17	4.29	8.86	7.19	6.77	4.88	5.11	5.21	4.84	5.07
Fish parts	10.49	6.59	9.3	11.42	8.79	9.78	7.30	8.67	11.23	8.58
Crustaceans										
Shrimps										
Penaeus monodon	15.27	6.53	7.61	12.34	10.80	5.21	4.26	4.74	3.90	4.74
P. semisulcatus	3.81	5.61	4.19	4.35	4.54	18.64	4.05	11.21	9.84	11.30
Metapenaeus monoceros	7.21	5.61	3.95	4.67	5.59	4.21	4.31	4.32	3.51	4.28
Metapenaeus affinis	5.73	4.81	5.45	5.08	5.33	6.32	6.14	5.89	6.53	6.12
Crabs										
Portunus pelagicus	5.38	4.48	6.36	5.39	5.41	2.62	4.48	3.92	3.10	3.67
Zooplanktons										
Amphipod	3.45	6.81	3.45	4.29	4.57	3.62	4.16	3.37	2.71	3.71
Decapod larvae	4.39	7.81	2.65	3.99	4.95	8.42	7.82	4.29	6.45	6.84
Mysids	5.69	14.91	3.39	8.95	8.00	6.23	9.62	6.38	10.39	7.41
Lucifer	2.49	4.42	4.91	3.85	3.94	1.90	13.84	4.16	9.14	6.63
Molluscs										
Cephalopods										
Octopus sp.	0.68	0.92	2.25	0.44	1.28	0.38	1.15	1.58	0.34	1.04
Loligo sp.	1.54	1.06	2.78	0.71	1.79	0.19	1.12	2.09	0.39	1.13
Digested matter	12.43	5.2	12.49	10.31	9.04	5.21	8.43	5.72	8.21	6.45

(F = frequency of occurrence, N = frequency of number, W = frequency of weight, IRI = index of relative importance and Al = absolute index).

Table 2. Feeding intensity of *Johnius dussumieri* in different size group.

	20-30 cm					31-40 cm					41-50 cm				
	%F	%N	%W	%IRI	%Al	%F	%N	%W	%IRI	%Al	%F	%N	%W	%IRI	%Al
Fish															
Cyprinus sp.	3.61	4.81	5.34	4.32	4.59	4.80	5.09	4.16	3.80	4.68	5.29	4.81	5.02	4.29	5.04
Johnius belangri															
J. dussumieri	6.04	6.54	8.26	8.86	6.95	4.29	3.67	5.29	3.47	4.42	5.29	4.13	5.64	4.17	5.02
Trichiurus sp.	4.87	3.79	5.21	3.63	4.62	2.89	3.28	3.7	2.20	3.29	4.93	5.21	6.81	5.89	5.65
Ilishia sp.	3.61	2.18	3.12	1.54	2.97	3.54	3.51	4.23	2.69	3.76	3.24	4.62	3.95	3.14	3.94
Gerres sp.	2.58	3.29	4.86	2.74	3.58	4.96	4.86	5.41	4.58	5.08	4.83	3.62	4.84	3.26	4.43
Mugil sp.	2.59	2.32	4.64	1.97	3.18	3.64	2.89	4.36	2.38	3.63	4.57	3.20	4.76	2.89	4.18
Fish parts	5.69	4.63	8.69	6.78	6.34	8.93	6.75	5.15	6.40	6.94	9.23	8.07	7.36	10.01	8.22
Crustaceans															
Shrimps															
Penaeus monodon	6.23	7.28	5.39	6.71	6.30	18.05	9.87	18.63	29.56	15.49	4.86	3.91	5.23	3.69	4.67
P.semisulcatus	9.26	3.62	2.53	2.72	5.14	3.84	4.48	4.39	3.44	4.24	10.67	7.39	12.97	15.53	10.34
Metapenaeus monoceros	5.29	5.68	2.34	2.74	4.44	3.91	3.53	7.28	4.34	4.91	3.47	4.03	5.09	3.50	4.20
M. affinis	6.58	8.5	4.69	6.85	3.59	5.63	3.45	6.36	4.04	5.15	6.83	9.71	7.24	11.25	7.93
Crabs															
Portunus pelagicus	14.68	6.54	19.23	19.39	8.47	4.32	2.36	6.54	2.89	4.41	5.42	4.47	6.21	4.84	5.37
Zooplankton															
Amphipod	5.63	6.92	8.54	10.89	10.05	4.96	9.76	3.2	5.30	5.97	3.35	2.81	3.40	1.88	3.19
Decapod larvae	3.68	4.21	2.18	1.90	3.36	4.27	19.17	4.29	2.62	3.91	4.29	2.39	4.41	2.16	3.70
Mysid	5.21	3.29	5.29	3.34	4.60	4.84	4.29	3.18	11.55	11.41	8.81	19.26	4.06	12.70	10.71
Lucifer	3.54	18.94	1.67	5.19	13.98	7.08	5.96	6.3	4.67	5.14	4.52	4.64	5.49	4.37	4.88
Cephalopods															
Octopus	-	-	-	-	-	0.32	1.20	2.32	0.45	1.28	0.65	0.34	1.11	0.15	0.70
Loligo	-	-	-	-	-	-	-	-	-	-	0.59	0.59	1.63	0.23	0.94
Digested matter	10.91	7.46	8.02	10.44	7.87	9.72	5.89	5.21	5.63	6.30	9.16	6.79	4.78	6.07	6.91

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Table. 3 Seasonal variation in feeding intensity of *Johnius dussumieri*

	Pre-Monsoon (Mar-Apr)					SW-Monsoon (May-Sep)					Post-Monsoon (Oct-Nov)					NE-Monsoon (Dec- Feb)				
Food category	**%F**	**%N**	**%W**	**%IRI**	**%Al**	**%F**	**%N**	**%W**	**%IRI**	**%Al**	**%F**	**%N**	**%W**	**%IRI**	**%Al**	**%F**	**%N**	**%W**	**%IRI**	**%Al**
Fish																				
Cyprinus sp.	2.81	3.49	4.36	2.67	3.55	3.05	2.42	3.87	1.57	3.11	3.68	4.02	4.67	2.82	4.12	2.45	2.70	3.79	1.52	2.98
Johnius dussumieri	4.35	8.69	6.43	8.92	6.49	3.76	2.86	4.25	2.01	3.62	4.21	3.75	5.21	2.99	4.39	3.19	3.26	4.39	2.09	3.61
Trichiurus sp.	3.61	4.81	5.66	4.57	4.69	2.67	2.41	3.97	1.54	3.02	3.16	2.89	4.95	2.20	3.67	2.66	2.81	3.91	1.63	3.13
Ilisha sp.	5.61	3.54	5.83	3.89	4.99	3.94	2.54	4.83	2.04	3.77	2.89	3.28	4.76	2.33	3.64	4.81	2.72	3.24	1.63	3.59
Gerres sp.	3.89	2.65	4.28	2.26	3.61	3.42	1.85	4.19	1.41	3.15	2.93	2.54	4.18	1.70	3.22	3.78	2.48	4.26	1.72	3.51
Johnius cuvieri	2.44	3.51	4.89	2.90	3.61	3.94	3.59	5.45	2.97	4.33	3.59	2.53	4.68	1.94	3.60	3.08	3.66	3.76	2.02	3.50
Fish parts	5.44	9.76	8.77	6.82	9.66	-	-	-	-	-	5.78	7.42	9.46	9.56	7.55	4.28	5.16	6.39	4.46	5.28
Crustaceans																				
Shrimps																				
Penaeus monodon	8.71	7.85	10.94	13.28	7.83	6.84	5.27	8.29	6.37	6.80	5.78	8.64	8.63	10.11	7.68	4.31	5.68	6.34	4.83	5.44
P.semisulcatus	5.32	4.36	6.29	4.85	5.32	8.55	7.21	9.16	9.41	8.31	6.43	5.74	3.76	3.52	5.31	17.92	7.35	13.97	30.34	14.08
Metapenaeus monoceros	6.32	5.35	5.81	5.54	5.83	5.76	8.63	6.42	7.72	6.94	7.25	4.78	12.84	24.78	9.62	7.34	9.66	8.61	10.84	8.54
M affinis	4.65	6.97	5.48	6.35	5.70	15.34	9.24	7.63	11.83	12.74	9.78	7.43	6.89	7.67	8.03	6.34	8.24	9.16	9.80	7.91
Crabs																				
Portunus pelagicus	3.48	3.65	5.69	3.59	4.27	5.33	8.44	7.67	8.84	7.15	6.81	8.12	7.92	8.95	7.62	5.76	4.39	5.38	3.52	5.18
Zooplanktons																				
Amphipod	6.24	11.76	4.19	8.22	10.40	4.81	5.06	3.22	2.66	4.36	4.66	13.94	3.45	2.30	4.02	4.61	6.38	5.69	4.90	5.56
Decapod larvae	8.45	4.32	3.82	3.70	4.53	8.43	6.82	5.13	5.48	6.79	4.82	5.38	4.51	3.66	4.90	5.22	6.49	5.39	4.82	5.70
Mysid	12.39	4.89	3.79	12.54	4.69	5.77	6.57	3.76	3.84	5.37	16.52	6.52	5.32	6.44	11.45	8.21	7.18	6.34	6.44	7.24
Lucifer	5.69	4.83	3.72	3.50	4.75	6.89	17.82	4.71	10.46	9.81	4.19	3.54	3.87	2.25	3.87	5.98	5.14	4.61	3.55	5.24
Molluscs																				
Cephalopods																				
Octopus	1.52	1.45	3.61	1.00	2.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Loligo	1.82	1.69	2.96	1.01	2.16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Digested matter	7.26	6.43	3.48	4.39	5.72	11.5	9.27	17.45	21.86	10.74	7.52	9.48	4.9	6.79	7.30	10.06	16.71	4.77	5.88	9.51

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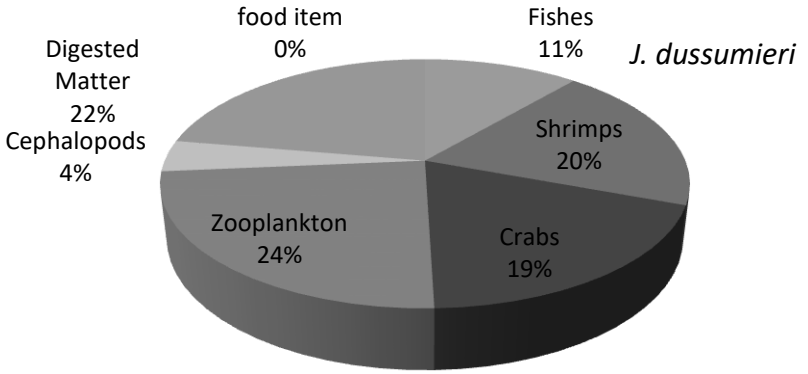

Fig. 1. Percent composition of food items in stomach of *J. dussumieri.*

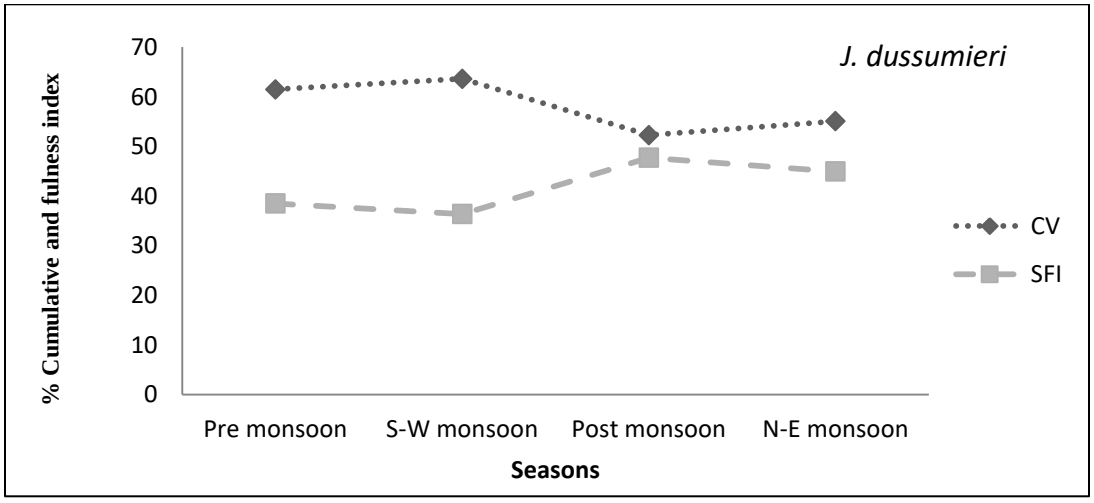

Fig. 2 Cumulative index and stomach fullness index of *J. dussumieri.*

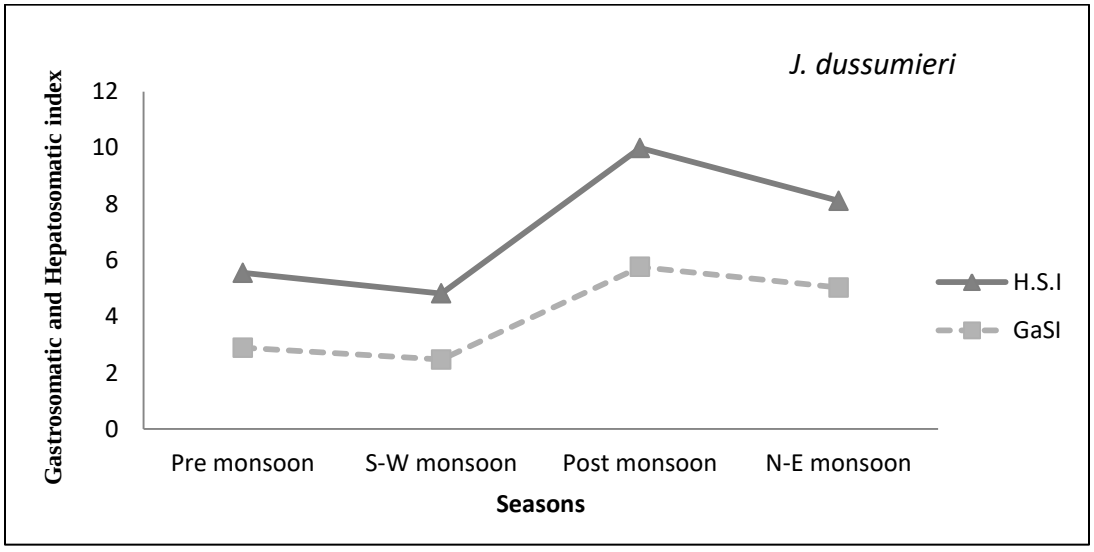

Fig.3. Seasonal variations in gastro-somatic and hepato-somatic index of *J. dussumieri.*

DISCUSSION

The stomach contents analysis of the *J. dussumieri* revealed carnivore mode of feeding showing strong preference toward crustaceans, such as zooplanktons, crabs and shrimps. Beside crustaceans the fishes also constitute important diet source of sin croaker and were considered as secondary important diet source, whereas molluscs constitute very small amount of gut contents and considered as incidental food source (Nikolsy, 1963). Earlier studies carried out on feeding habits of *J. dussumieri* suggest that it is a carnivore species mainly feeds on crustaceans like prawns, *Acetes*, stomatopods (Chacko, 1949; Bapat and Bal, 1952). The *J. dussumieri* from Cochin coast of India has been reported to feed on crustaceans like *Penaeid* shrimps, *Acetes*, crabs and stomatopods and also on fishes like *Saurida*, *Nemipterus* , *Leiognathus* and *Cynoglossus* (Venugopal *et al*., 2014). The Mohammad and Abood (2019) from Iraqi waters reported the *J. dussumieri* as carnivore species feeding mainly on shrimps (77.4%), fishes (18.4%) and crabs (7.3%). The Piscivorous nature of *J. dussumieri* has also been documented (Manojkumar, 2011).

Similarly the feeding habits of another species of family Scianidae i.e. *Johnius carruta* has been investigated along Vishakhapatnam coast suggesting that sciaenids are benthic feeders and mostly feeds on crustaceans, fishes, polychaetes and mollusc (Kumar, 2015). The diet composition of *Johnius elonagatus* investigated from Karachi coast showed similar feeding pattern and mainly feeds on crustaceans and secondarily on fishes (Ajazuddin, 2001).

The feeding preference of fishes of different sex and size showed variation in term of percentage of occurrence and number but these variations were not found to be significant. The males preferably feeds on *P. mondon* (%IRI =12.34 and %Al =10.80), whereas females on *P. semisulcatus* (%Al =11.30) and fish parts (%IRI=11.23).The prey size mostly increases with the increase in predator size to fulfill the high energy demand (Kamali, 2006). In *J. dussumieri* fishes of 20-30 cm feeds on *P. pelagicus* (%IRI =19.39) and Lucifer (%Al =13.98), fishes of 31-40 cm feeds on *P. monodon* (%IRI =29.5 and %Al =15.49), whereas, fishes of 41-50 cm feeds mainly on mysids (%IRI =15.53) and *P. semisulcatus* (%Al =10.71). The other studies have also reported the variation in feeding strategy of fish along with increase in body size (Ajazuddin, 2001; Kumar, 2015 and Qamar and Panhwar, 2015). The feeding intensity of fish is dependent on gonadal development, stage of maturity and availability of food with respect to environment (Kiran and Puttaiah, 2004). In *J. dussumieri* highest proportion of empty stomachs can be due the fast rate of digestion and indicated by highest percentage of miscellaneous digested matter (Binod, 2000). Among both sexes the females showed higher ratio of empty stomachs than males due to low feeding intensity during spawning season (Morte *et al.*, 2001 and Kumar, 2015).

Seasonally the higher proportion of empty stomachs was observed during pre-monsoon and SW monsoon due to peak spawning activity which extends from March to July according to the present study. The peak values of cumulative index was during May (65.33%) in females and June (76.34%) in males. The reduced feeding intensity during monsoon season may be due to spawning, temperature fluctuation and low food availability (Baloch *et al.*, 2012). Another study on feeding biology of *Megalaspis cordyla* carried out from Karachi coast suggest the active feeding during post-monsoon due to high food availability and poor feeding during monsoon due to spawning activity (Qamar and Panhwar, 2015). The present study also observed the active feeding during post-monsoon subjected to the increased food availability (Baloch *et al.*, 2012).

The earlier studies reported *J. dusuumieri* to feed vigorously during September to October and March to May and have low feeding intensity in other seasons (Suseelan and Nair, 1969). The Venugopal *et al*., (2014) from Cochin coast reported the poor feeding intensity in *J. dusuumieri* in most of observed months except December to January in females and April and September to November in males. Whereas Mohammad and Abood (2019) from Iraqi waters reported higher percentage of empty stomachs during October-April.

The hepato-somatic index and gonado-somatic index represent the feeding periodicity of fish and showed higher values during the period of high feeding intensity but also dependant on seasonal cycle (Yang and Bauman, 2006). Among both sexes the gastro-somatic index of males was higher than females because of active feeding showing highest percentage during December in males and February in females, whereas the hepato-somatic index of females was higher than males showing highest percentage during August in females and December in males as high fat and energy reserves are utilized during spawning seasons (Yang and Bauman, 2006). In the present study several incidents of cannibalism were observed with highest percentage during pre-monsoon season due to high calorific demand and poor feeding activity because of peak spawning activity (Di Beneditto, 2004 and 2007).The earlier studies have not reported cannibalism in *J. dussumieri* (Suseelan and Nair, 1969)

Conclusion

The conclusion drawn from the present study is that *J. dussumieri* is active carnivore specie feeding mainly on crustaceans like zooplanktons, crabs and shrimps and secondarily on fishes. There was insignificant variation

($P>0.05$) in feeding intensity of fish in relation to sex and size, however seasonal variations were found to be significant ($P<0.05$). The feeding intensity was greatly reduced during SW monsoon and pre-monsoon seasons due to high reproductive activity. The high feeding intensity during post-monsoon and NE monsoon represents the increased food availability. The highest percentage of cannibalistic fish during pre-monsoon suggests the high energy demand and low food availability.

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