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FOOD AND FEEDING HABITS OF PHARAOH CUTTLEFISH, *SEPIA PHARAONIS* EHRENBERG, 1831 ALONG THE GUJARAT COAST OF NORTH-EASTERN ARABIAN SEA

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ABSTRACT : The pharaoh cuttlefish, *Sepia pharaonis* is one of the economically important molluscan species along the North-west coast of India. Sampling carried out at fortnightly intervals from August 2017 to March 2018 to study the food and feeding habits. Samples with an empty stomach were prevalent in almost all months. The index of relative importance (IRI) showed that the dominant prey group were fishes (68.12%), followed by crustaceans (19.84%), molluscs (6.1%) and miscellaneous (5.97%). Acetes sp. (6.91%) was the most dominant prey item during the study period. The empty stomach ratio (ESR) ranged from 18.75% (September, 17) to 63.63% (December, 17).The high value of Gastro somatic index recorded in September month. Stomach fullness index (SFI) was higher during September and February months. Feeding intensity found to be high during September months. Significant variations were not seen (p>0.05) in the feeding indices during different months, different sizes, and between sexes. The findings of the present study can be useful in managing the commercially important species, *S. pharaonis* as a unit stock in Arabian Sea of Northern Indian Ocean and reinforces the need for regional cooperation on fisheries management.

Key words : Diet composition, feeding indices, IRI, seasonal variations, *Sepia pharaonis*.

INTRODUCTION

The pharaoh cuttlefish *Sepia pharaonis* (Ehrenberg, 1831) is a neritic demersal predator and one of the most important and highly valued commercial species distributed throughout the Indo-West Pacific region ranging from the Red Sea to Japan and Australia. Pharaoh cuttlefish, *S. pharaonis* is the largest cuttlefish in the Indian seas (Nair *et al*, 1993). In India, it distributed along the Arabian Sea, including Lakshadweep Islands and Bay of Bengal including the Andaman Islands. The species thrive predominantly in shallow coastal waters associated with continental shelves. *S. pharaonis* called as 'Dedaka' or 'Makul' in the local language of Gujarat. The estimated catch of cuttlefishes in India during 2017 was 109089 t and it contributed 2.84% to the total marine fish landings (CMFRI, 2018). In Gujarat, the Cephalopods formed the dominant molluscan resource with landings of 61662.68 t forming 7.96% of the total landings.

Information on the feeding habits of marine fishes and predator-prey relationship is useful to assess the role of marine fishes in the ecosystem and food web. However, since the demersal group is important in trawl fisheries, its assessment is crucial to draw trophic relationship, which may be useful in recognizing the areas of their occurrence and abundance (Qasim, 1972).

Oommen (1977) studied morphology, food and feeding of the *Sepia aculeata* and *Sepiella inermis* of the southwest coast of India.Unnithan (1982) studied the biological aspects of the *Sepiella inermis* of Mandapam waters, Tamil Nadu. Kasim (1993) estimated population characteristics for *S. elliptica* in Saurashtra waters. Studies carried out on the stock assessment of the pharaoh cuttlefish *S. pharaonis* from Indian waters (Nair *et al*, 1993). Abdussamad *et al* (2004) studied on stock assessment of *Sepia aculeata* and *S. pharaonis* from Kakinada waters along the east coast of India. Sasikumar *et al* (2013) studied the inter-cohort growth patterns of *S. pharaonis* in the Eastern Arabian Sea.

The available information on the feeding habit of this species is limited to those by Gabr *et al* (1999) from Suez Canal, Silas *et al* (1985) from EEZ of India and Sundaram (2014) from northwest coast of India. It forms one of the major components of exploited marine fishery resources along the North West coast of India. However, investigations on its feeding biology are relatively meager. Therefore, considering the commercial and economic

importance of this resource, there is an urgent need for a better understanding of the feedingbiology of this species.

Hence, the present study was carried out to understand the food and feeding habit of *S. pharaonis* along the North West coast of India.

MATERIALS AND METHODS

Sample collection and laboratory process

Samples for the biological studies were collected at fortnight interval from the identified multiday trawler operated along Gujarat coast along with Geo-coordinates (19^0 10 N 71^0 30 E and 22^0 15 N 68^0 40 E) between August 2017 and March 2018 (Fig. 1). A total of 179 (102 males, 77 females) individuals were collected from the Veraval landing centre were iced and bring to the laboratory and kept frozen. During the biological sampling, the following measurements were taken dorsal mantle length (DML, to the nearest 0.1 mm), total weight (TW to the nearest 0.1 g), stomach weight (SW to the nearest 0.01g), stomach length (SL to the nearest 0.1mm), etc. for detailed studies on feeding biology.

Cuttlefish resources were exploited by multi-day bottom trawling along the continental shelf by medium sized trawlers (42-58 feet) operating at depth range of 60 - 200 m. Trawl nets hauled for 2-3 hrs/haul at a towing speed of1.8 - 2.2 knots.

The length as well as wet weight of whole stomach was recorded for the collected specimens. Stomach contents were analysed employing frequency of occurrence, numeric and point volumetric methods and food items identified up to generic or group level depending on the state of digestion and due to mutilation. Each group of the food items thus identified were counted and weighed (g). In addition to this, the size of the fish and fullness of the stomach is considered in the allotment of points.

Data analysis

The relative importance of various food items in the stomach was determined by the Index of Relative Importance (Pinkas *et al*, 1971).

IRI = (%N + %V) × %F

Where, N = number, V = volume and F = frequency of occurrence.

Stomach fullness index (SFI) was used to measure the degree of feeding intensity [SFI = weight of the stomach contents/ (body weight - weight of the stomach contents) × 100] (Chiou *et al*, 2006). Feeding periodicity was determined by analysing the feeding intensity and the empty stomach ratio (ESR). The ESR was calculated as percentage of the number of specimens with an empty stomach, of the total number of specimens examined (Rohit *et al*, 2015). Gastro-somatic index (GaSI) was calculated using the equation (GaSI=Weight of gut/Weight of body × 100) suggested by Desai (1970). The stomach distension was classified as full, ¾ full, ½ full, ¼ full and empty. The intensity of feeding was determined based on the degree of distension of the stomach due to feeding and the amount of food items contained. Test of analysis of variance (ANOVA) was carried out for food

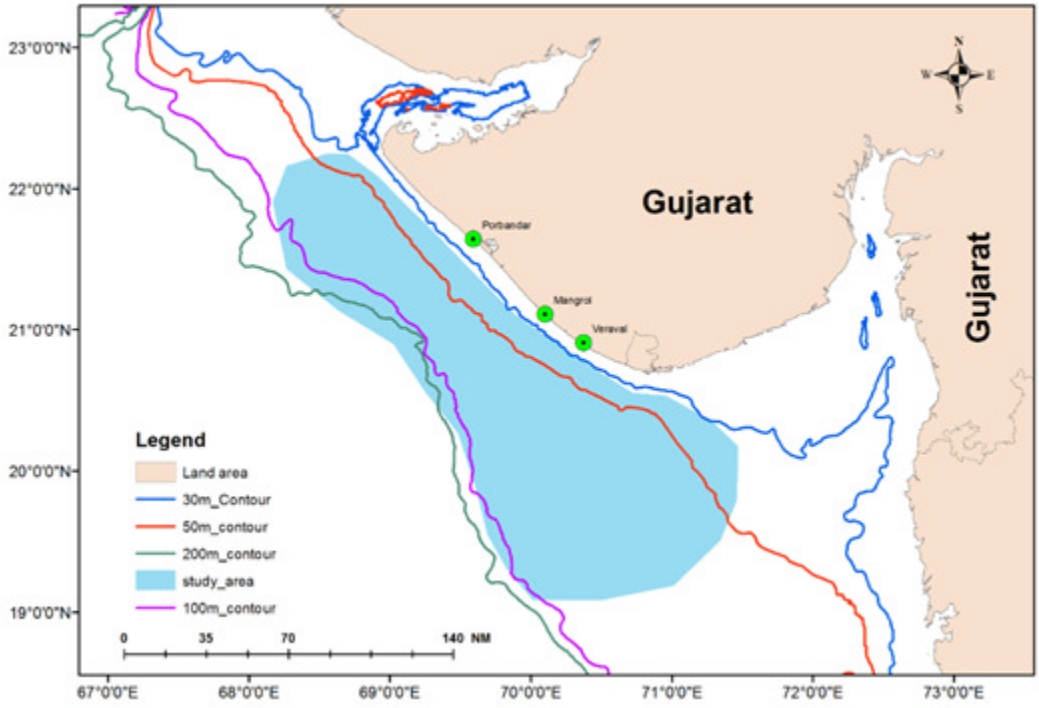

Fig. 1 : Study area along the North West coast of India.

components and feeding conditions between males and females, between different length groups and between months,while Tukey's test was performed at the significance level of a = 0.05.

RESULTS

The stomachs of 179 individuals of *S. pharaonis* ranging its size from 146 to 358 mm dorsal mantle length (DML) were examined during the study period. The major fish group identified in the diet was *Trichiurus lepturus*. Crustaceans included *Acetes* sp., *Solenocera* spp., unidentified crabs and other shrimps. Squid and cuttlefish were the two groups of cephalopods present in the stomach. Few prey items found in the stomach could not be identified, as they were in advanced stages of digestion with only skeletal remains. Gut contents indicate individuals of the species were found cannibalistic in nature frequently. The gut content of this species was found in digested condition. The remains of fishes, exoskeleton of crustaceans, shells of molluscs, beaks of cephalopods and fluid with different colours was found abundantly in gut content that used for identification of prey groups.

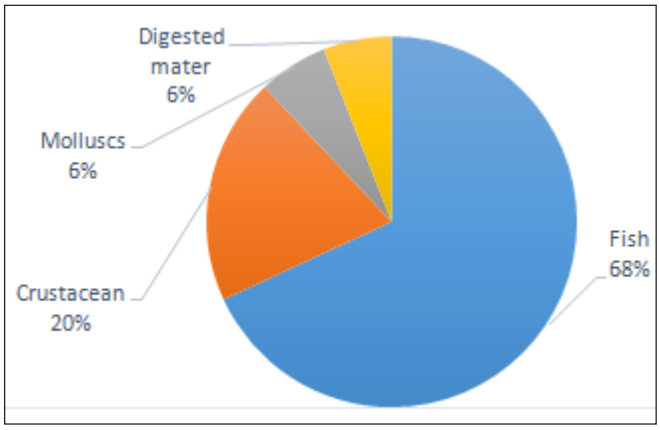

Fig. 2 : Diet spectrum of *S. pharaonis* landed along Gujarat coast.

The diet spectrum of *S. pharaonis* groups in four categories *viz.*, fishes, crustaceans, molluscs and digested matter and the IRI of each category was; fishes 68%, crustaceans 20%, molluscs 6% and digested matter 6% (Fig. 2).

Monthly Index of relative importance

The index of relative importance (IRI) of different food items ingested by *S. pharaonis* during different months (2017-18) is given in Fig. 3. Month-wise analysis of stomach contents of *S. pharaonis* revealed that remains of fishes formed the major constituent in all the months with dominance in February.Fishes represented IRI = 68.12% of the average food composition. *Trichiurus* sp. constituted 5.15% of the annual average food composition. It was found in about 1.93% to 12.78% in August 17 and October 17, respectively. It was present in all months as preferred food item.

The monthly IRI of crustaceans exhibited considerable variation. Among the crustaceans *Acetes* sp. represented 6.91% of the annual average food composition. It was found in the stomach contents in all the months except December 17 and highest (13.34%) in November 17. *Solenocera* spp. contributed 6.75% to the annual average food composition. It was found in stomach content in all the months except February 18. The highest percentage of this group was 23.07% in August 17, while the lowest was 2.10% in November 17. Other shrimp was present in all the months partially. They formed 2.19% of the annual average food

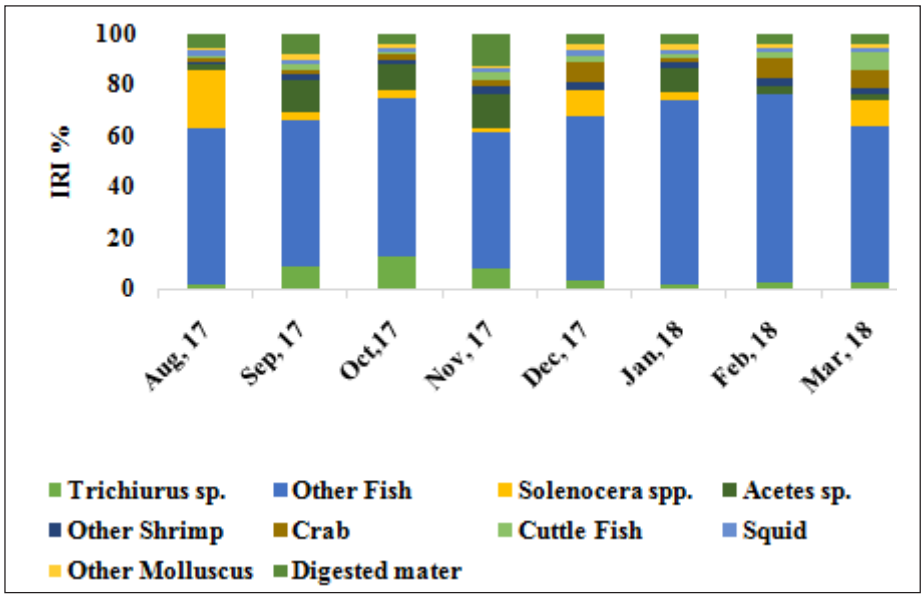

Fig. 3 : Monthly IRI of prey groups of *S. pharaonis.*

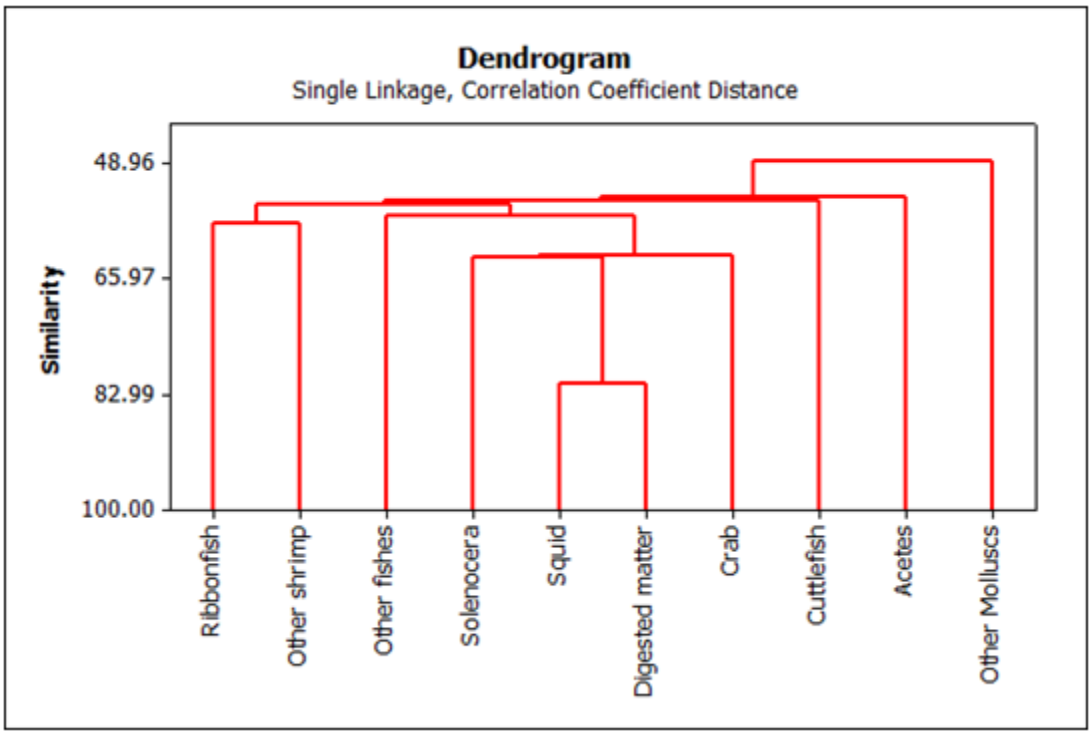

Fig. 4 : Cluster analysis of diet groups of *S. pharaonis*.

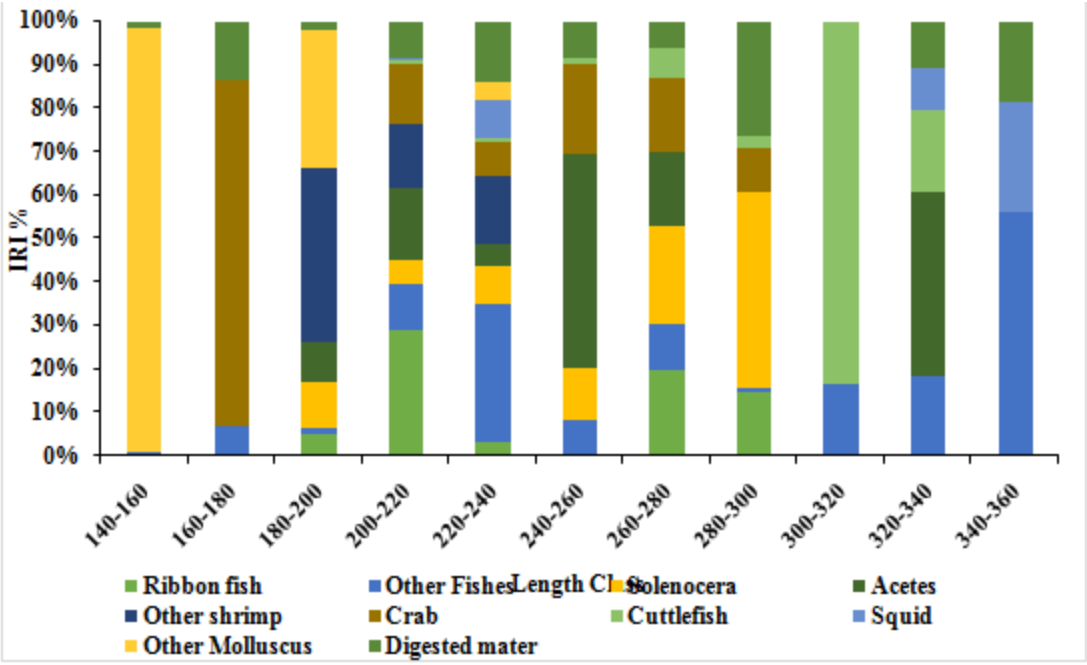

Fig. 5 : Length-wise IRI of prey groups of *S. pharaonis*.

composition. Crabs were present in all the months. They formed 3.98% of the annual average food composition with a maximum of 8.10% recorded in December 17 and minimum of 1.43% in August 17.

In molluscs cuttlefishes formed 2.60% of the annual average of food composition and observed in considerable quantities in February 18 and March 18, hence cannibalism appears to be frequently in these months. *Loligo* spp formed 1.65% of the annual average food composition. It constituted from 2.56% to 1.09% in December 17 and October 17 respectively. It was present in all the months of study period in smaller quantities. Other mollusc contributed about 1.82% to the annual average food composition. Its percentage was the highest in September 17 (2.56%) and the lowest in August 17 (1.18%).

Digested material was in liquid form in the stomach throughout the study period in major proportion. It formed

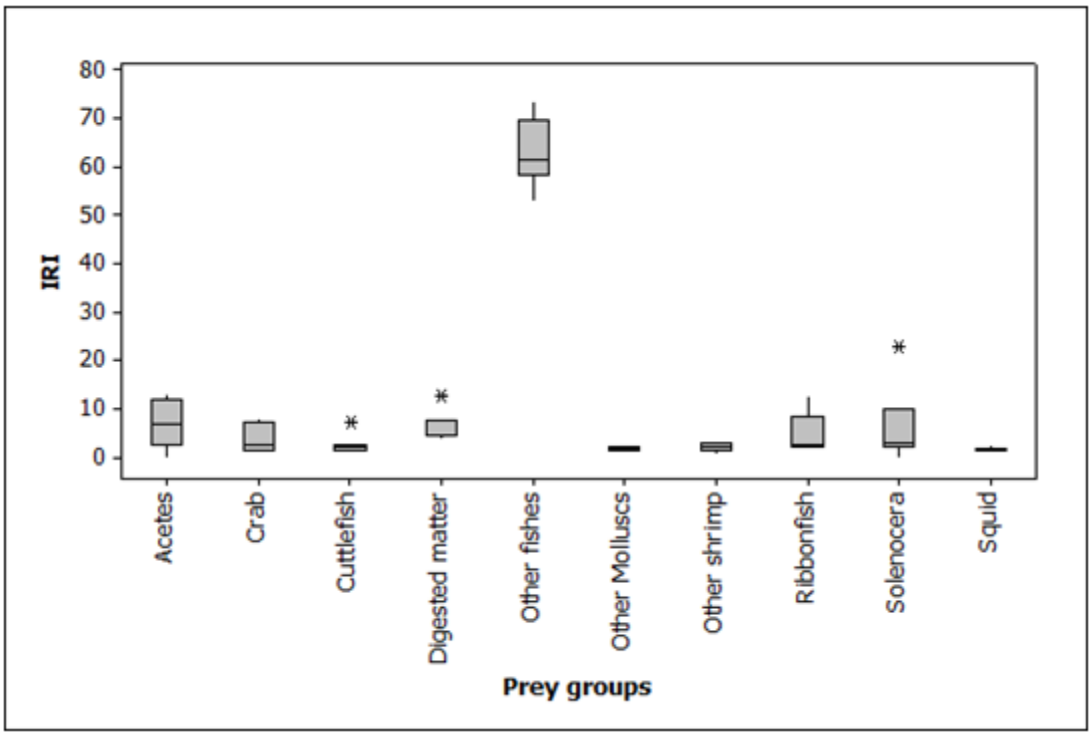

Fig. 6 : Boxplot of IRI of prey group of *S. pharaonis.*

5.97% of the annual average food composition. The higher percentage was recorded in November 17 (12.57%) and the lowest was in October 17 (3.85%).

Cluster analysis revealed grouping of dietary components over the months in *S. pharaonis.* Cluster analysis did not reveal any definite pattern over the months due to its voracious feeding nature. The highest similarity was observed between squid and digested matter whiles other molluscs group were the distant among all other groups (Fig. 4).

Index of Relative importance in relation to size

Analysis of the ontogenetic variation in the feeding intensity is depicted in (Fig. 5). There appeared to be some food preference by different length groups of *S. pharaonis*. The present investigation indicated that fishes become an important item of diet and was preferred by all length groups. Crustaceans exhibited considerable variation among the size groups and they were maximum in the size group 200-300 mm. Cuttlefish parts were observed in small quantities in a higher size group of 200-340 mm hence cannibalism appears to be increased with the size of animals. The occurrence of fishes and digested matter in the stomach was found to increase with the size of individuals.

Box plotwere also drawned amongst the prey groups during the study period which indicates dominancy of other fishes among all other groups. The other fishes group shows highest spread while squaid and other molluscan shows least spread. Groups such as Cuttlefish, digested matter solenocera shows the value outside the range, which is represented by astericks and most of cases the data is skewed right which indicates most of the observation are concentrated on the low end of the scale

Seasonalfeeding intensity

Seasonal variation in the feeding intensity of *S. pharaonis* was studied by analyzing the stomach fullness. The percentage of full stomachs was the highest during January, 18 and February, 18 showing active feeding. Stomach with three fourth was highest (31.25%) in September, 17. Proportion of empty stomach was higher in October, 17 to December, 17 (Fig. 7) depicted that poor feeding in October,17 and December,17 months. Overall, *S. pharaonis* is a poor feeder throughout the

Table 1 : Monthly variations in mean GaSI of *S. pharaonis.*

Month	Male			Female		
	Mean	Min	Max	Mean	Min	Max
Aug, 17	0.67±0.08	0.575	0.77	0.72±0.32	0.45	1.49
Sep, 17	1.34±0.99	0.546	3.17	1.24±0.38	0.74	1.7
Oct, 17	1.15±0.57	0.604	1.74	0.63±0.45	0.17	1.53
Nov, 17	0.89±0.44	0.461	1.78	0.70±0.41	0.3	1.55
Dec, 17	0.92±0.99	0.27	3.78	0.43±0.05	0.39	0.5
Jan, 18	0.91±0.57	2.321	0.33	0.78±0.30	0.54	1.27
Feb, 18	0.83±0.56	0.323	2.33	1.25±0.51	0.59	1.97
Mar, 18	0.90±0.67	0.27	3.78	0.81±0.36	0.4	1.51
Annual	**0.92±0.62**	**0.293**	**2.29**	**0.84±0.45**	**0.17**	**1.97**

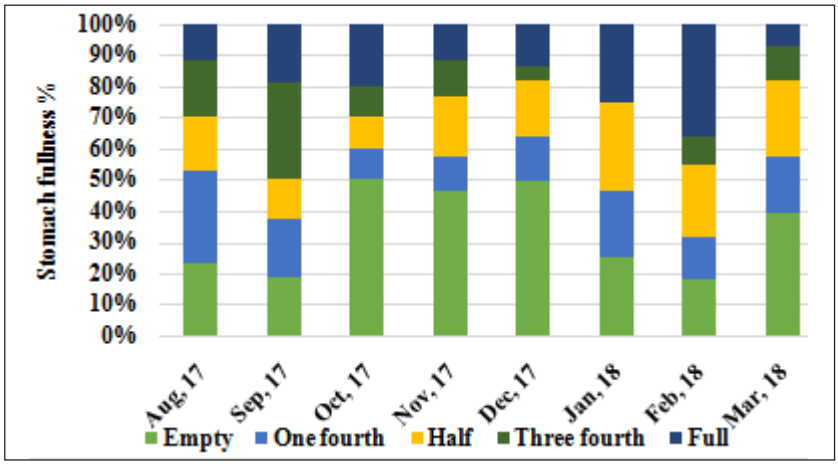

Fig. 7 : Variation in feeding intensity for *S. pharaonis* as function of season.

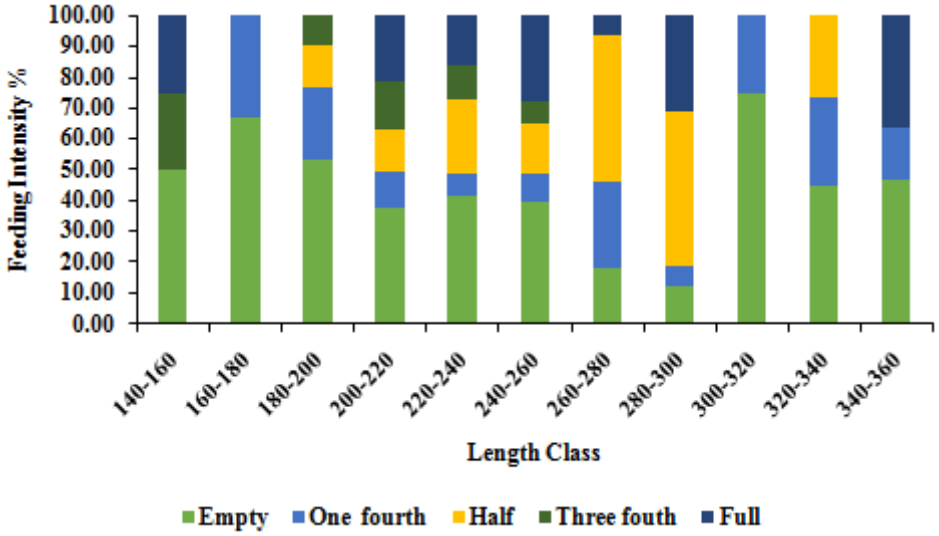

Fig. 8 : Variation in feeding intensity of *S. pharaonis* as function of body size.

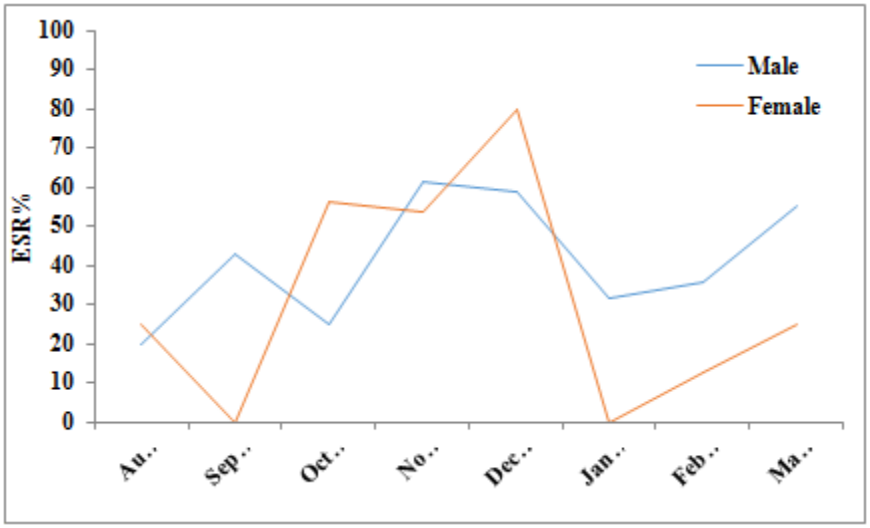

Fig. 9 : Monthly variations of empty stomach ratio (ESR) of *S. pharaonis.*

year.

Feeding intensity in relation to size

Analysis of the ontogenetic variation of stomach status is depicted in Fig. 8. Most of the examined specimens were with empty stomachs. There is no definite trend in feeding intensity and there are wide fluctuations in the stomach fullness percentage in different length groups. Empty stomachs were more

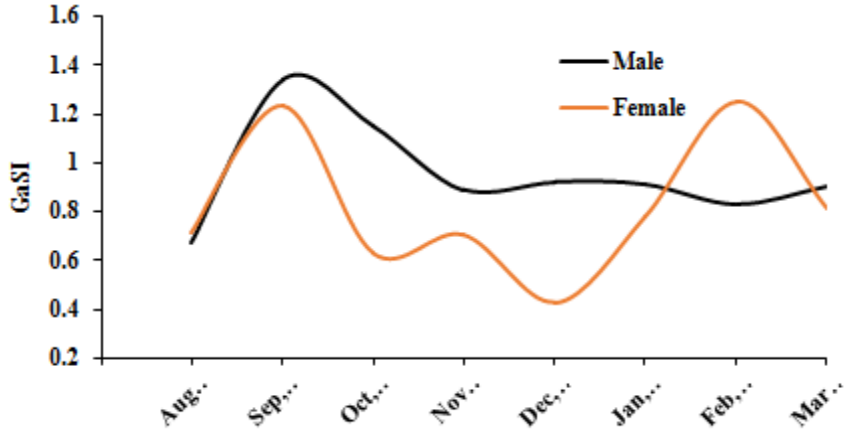

Fig. 10 : Monthly variations of gastro-somatic index (GaSI) of *S. pharaonis*.

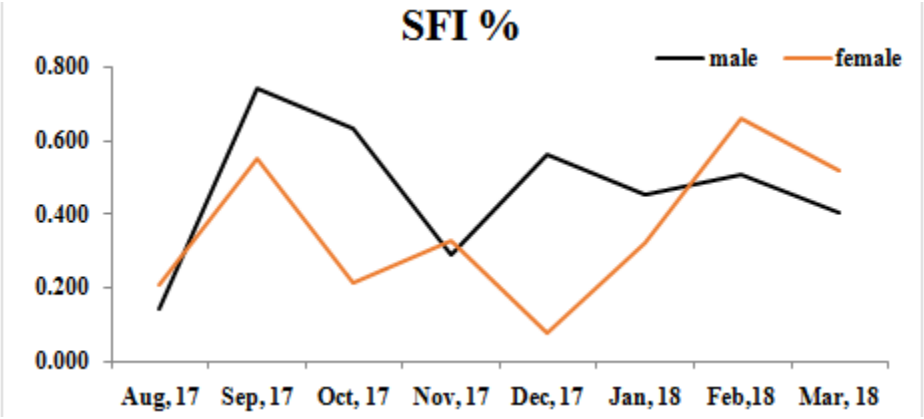

Fig. 11 : Monthly variations of stomach fullness index (SFI) of *S. pharaonis.*

Table 2 : Monthly Stomach fullness index of *S. pharaonis.*

Month	N (total)	SFI %	Male		Female	
			N	SFI %	N	SFI %
Aug, 17	17	0.188	5	0.143	12	0.206
Sep, 17	16	0.634	7	0.743	9	0.549
Oct, 17	20	0.300	4	0.635	16	0.216
Nov, 17	26	0.311	13	0.293	13	0.330
Dec, 17	22	0.428	17	0.564	5	0.078
Jan, 18	28	0.410	22	0.454	6	0.325
Feb,18	22	0.540	14	0.508	8	0.658
Mar, 18	28	0.407	20	0.404	8	0.516
Annual	**179**	**0.405**	**102**	**0.438**	**77**	**0.349**

prevalent in smaller (<200) and bigger (>300) length individuals. The highest proportion of empty stomachs, 75% was observed in 300-320 mm DML group and 66.66% at 160-180 mm DML. Stomach '¼ full' contents was found moderately in all size groups. Stomach '½ full' found in middle length individuals and ranged between 16.67% (180-190 mm) and 50% (290-300 mm). The percentages of stomach with three fourth full stomach contents were found mainly in 200-250 mm length class. Stomachs with full contents are more abundant in medium length group (200-300 DML).

Empty stomach ratio

Empty stomach ratio was studied to estimate the feeding intensity and stomach fullness of *S. pharaonis* during different month. The monthly changes in the ESR varied from 18.75% in Sep, 17 to 63.63% in Dec, 17. Maximum ESR values were noticed during Oct, 17 to Dec, 17 and a lower was observed during Sep, 17 and Jan, 18 to Mar, 18 (Fig. 9). The mean ESR was 41.34% in males and 31.57% in females.

Gastro-somatic index (GaSI)

Gastro-somatic index (GaSI) of *S. pharaonis* was analyses to depict the feeding intensity (Fig. 10). GaSI was recorded highest 1.34 (Sep, 17) in male and for female 1.25 (Feb, 18) and the lowest value was noticed as 0.67 (Aug, 17) for males and 0.43 (Dec, 17) for females (Table 1). Non-Significant variations ($p>0.05$) were noticed in monthly values of GaSI. As per Tukey's HSD *post hoc* test was also showed non-Significant variation in all months. Maximum feeding intensity was noticed both in males and females in the months of January to September. Lower feeding intensity was

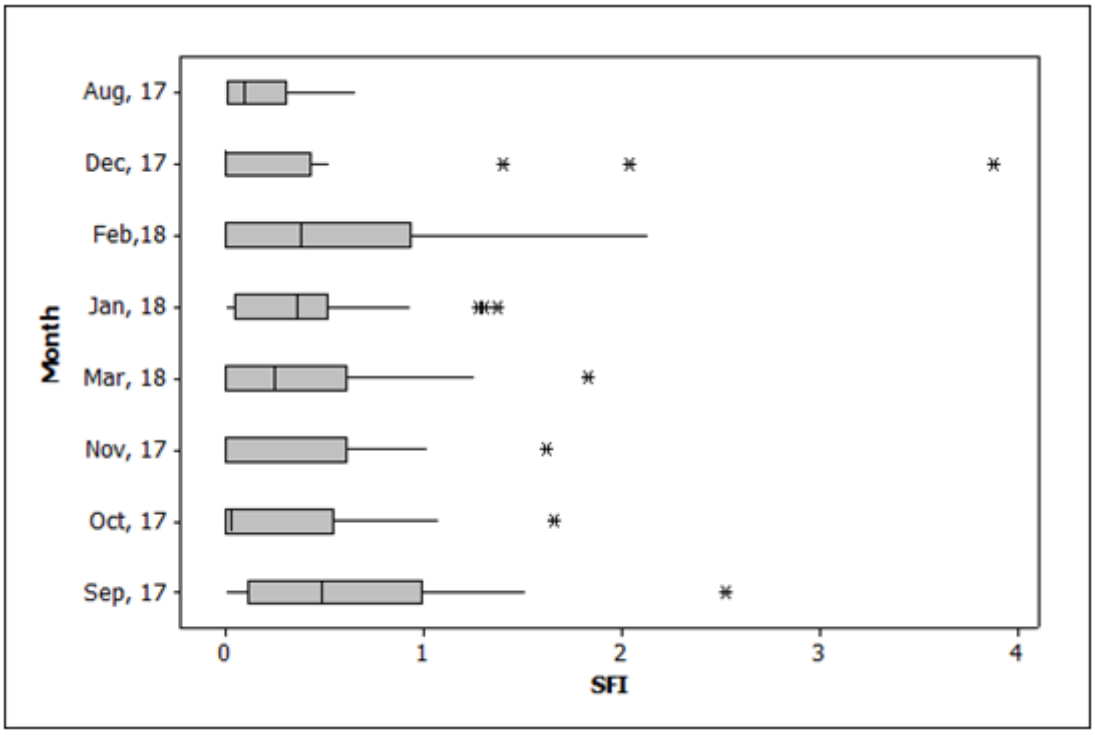

Fig. 12 : Boxplot of SFI Month wise.

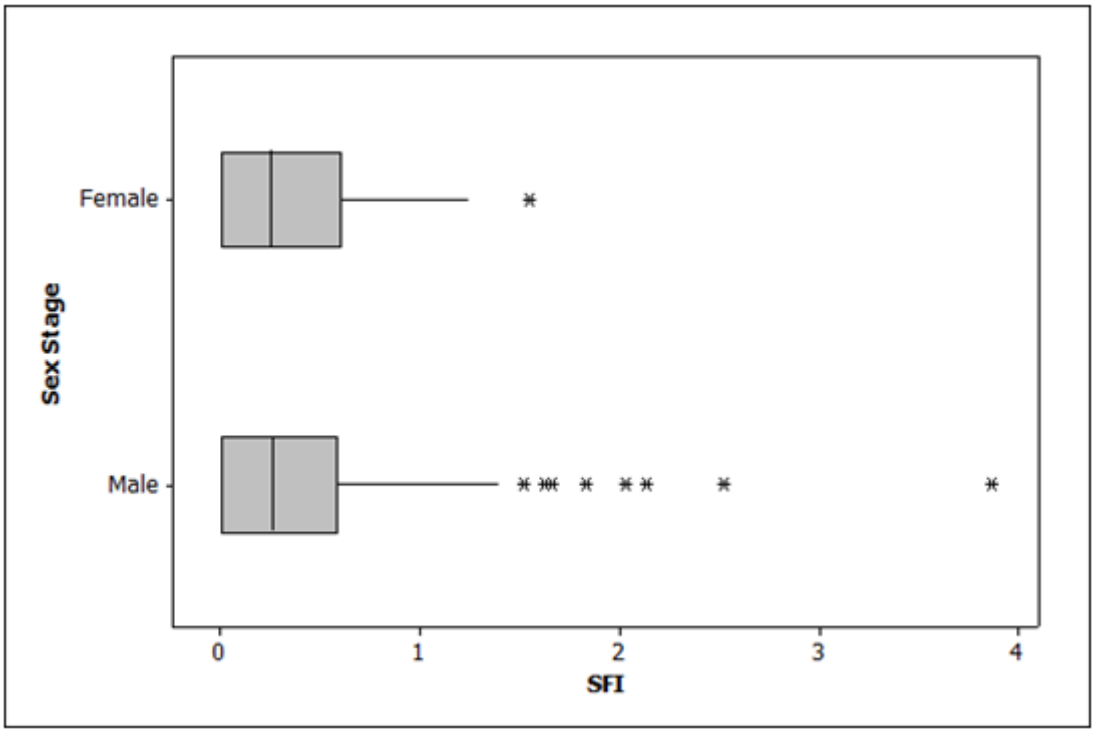

Fig. 13 : Boxplot of SFI - sex wise.

observed during Nov, 17 to Feb, 18 for males and Oct, 17 to Dec, 17 for females. Both sexes showing similar trend. No Significant difference ($p>0.05$) was observed in GaSI between sexes.

Stomach fullness index

The monthly variation in the stomach fullness index (SFI) were studied and plotted in Fig. 11. SFI values ranged from 0.188 in Aug, 17 to 0.634 in Sep, 17 (Table 2). SFI value showed two peaks during August to September and January to March, but was lower in October to December. No significant variations ($p>0.05$) were observed in SFI values in different months. The mean SFI values were higher for males compared to females.

Monthwise box plot were calculated for SFI. The distribution of Value of SFI were right skewed for the all the months of study except in January 2018 (Fig. 12). Value of SFI of male and female were compared by box plot, which indicates in male the SFI value were more symmetrically distributed compare to female (Fig. 13).

DISCUSSION

The biological studies like food and feeding habits etc. are very essential for the proper management of fishery resources.

Variations in diet composition

Studies of monthly variations in the IRI depict the changes in diet spectrum or selectivity of the food based on availability of the prey. Most of the stomachs have mixed type of feed like fishes, crustaceans, cephalopod and digested matter. Remains of *Sepia* spp. were noticed in the guts during February and March months, revealing the cannibalistic feeding behaviour of the species at times of spawning season. A complex prey-predator relationship exists in the feeding behaviour of *S. pharaonis* with significant predominant interaction with fishes.

The present study shows that the trophic profile of *S. pharaonis* is characterised by fishes, crustaceans and molluscs. Scales, eye balls, otolith and bones of fishes, macerated and partly digested fishes and parts of crustaceans such as prawns, crabs and *Squilla* are found in the stomachs (Silas *et al*, 1985). Sundaram (2014) revealed that fish formed the major constituent of food followed by prawns, cephalopods and digested matter, in both males and female fish. These findings are in agreement with the observations in the present study. Deep-sea shrimps for example, *Parapandalus spinipes, Heterocarpus gibbosus* and *Heterocarpus woodmasoni* abundantly found in gut content of *S. pharaonis* at south-west coast of India (Chembian and Mathew, 2011). In present study, shrimp species *Acetes* sp. and *Solenocera* spp. found abundantly in gut content. These findings suggested that food availability influenced the food preference of this species. This change may be occurred according abundance of prey items.

In the present study, lengthwise IRI indicate that size has an important influence on prey consumption. The youngest individuals mainly feed on small molluscs and crabs. Medium size individuals preferred mostly crustaceans and larger individuals feeds mainly on fishes and become cannibalistic. These changes in feeding related to body length might be due to increase in mouth size and improvement in swimming speed. As the size increases requirement of individuals for more energy may be influence the food preference.

Feeding intensity

The present research shows that the *S. pharaonis* stomach found with higher percentages of fishes with more stomach distension which indicates that the *S. pharaonis* feeding voraciously for energy reserves in the preceding month of spawning, i.e., September and February. They are 'very active' just before the spawning season and during spawning they seem to feed very less which is evident by the GaSI values and the large number of 'empty' stomachs observed during October-December months.

Feeding intensity of *S. pharaonis* of different length groups shows that the percentage of empty stomachs were more prevalent in smaller (<200 mm) and larger (>300 mm) size individuals. It indicates that the feeding intensity increased with length up to medium size (300 mm) after that it reduced. In smaller individual's lower feeding intensity may be due to lack of predation efficiency and in larger individuals feeding intensity may be limited by age. In medium size individual's higher feeding intensity may be to compensate their reproductive activity.

Empty Stomach Ratio (ESR)

The presence of high percentage of empty stomachs is characteristic of piscivorous fishes (Juanes and Conover, 1994). In the present investigation, ESR was higher during October to December it follow the spawning pattern of *S. Pharaonis* that reported by Sundaram (2014) from Mumbai waters. Lower values of ESR in females may be depicting their higher food requirements for reproduction than that of males.

Gastro-somatic index (GaSI)

Gastro-somatic index (GaSI) of *S. pharaonis* showed variations during different months. Maximum GaSI was during months September 17 and February 18 and lower during Oct 17 to Dec 17. Non-Significant variations ($p>0.05$) were noticed in monthly values of GaSI. The result indicates that feeding intensity was higher during pre-spawning and lower during spawning season, probably to increase spawning success. Alves *et al* (2006) reported that the diets of *Sepia officinalis* males and females are not significantly different. In present study also non-significant difference ($p>0.05$) was observed in GaSI between males and females.

Stomach fullness index (SFI)

Stomach fullness index (SFI), a proxy to feeding intensity varied moderately in different months, reaching its peaks in February and September, which can be the pre-spawning months. *S. pharaonis* spawns peak during

February to May and a minor spawning season between Octobers to December in the northwest coast of India (Sundaram, 2014). Monthly SFI values showed non-significant variation as per Tukey's HSD post hoc test. During breeding season, fishes need higher nutritional energy for their gonad development and maturation. A study by Gabr *et al* (1999) observed the degree of stomach fullness remained mostly constant in all the maturity stages, showing that *S. pharaonis* continued to feed when mature. Current study indicates that the fishes fed voraciously in the pre spawning months. This might be due to need of nutritional energy for gonad maturation. The mean SFI values were higher for males compared to females. In indeterminate lower SFI values 0.405% and this can be attributed to them having high basic metabolic rate and fast growth.

CONCLUSION

The pharaoh cuttlefish *S. pharaonis* is a fish/crustacean feeder. The principal food remains same in all age group throughout the study period indicating consistency in food preference. The findings of the present study can be useful in the management of this valuable species as a unit stock in Arabian Sea of Northern Indian Ocean and reinforces the need for international cooperation among management agencies on a global scale, for the conservation and management of the species.

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