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# Insights into the food and feeding habits of eight gestating females of elasmobranchs from Mumbai waters

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Food and feeding habits of eight species of female elasmobranchs in gestation stages were studied. The low feeding intensity and smaller mean volume of food per fish (in ml) attributed with their gestating activities and cease feeding in the nursery region as protecting measures for young ones. The prey items occurred in guts content of these species were analyzed by index of relative importance (IRI). *Carcharhinus macloti* and *Rhizoprionodon acutus* (100 %) were piscivorous which feed exclusively on teleosts found above the bottom. *Rhizoprionodon oligolinx* (96.5 %) *and Scoliodon laticaudus* (50.3 %), were generalized predators, feeding throughout the water column and occasionally at bottom chiefly on teleost and small quantities of crustaceans and molluscs. *Amphotistius imbricate* (86.06 %)*, Rhinobatos annandalei* (68.9 %) and *Rhynchobatus djiddensis* (61.58 %) were carnivores, feeding mainly on free-living crustaceans and supplemented by teleost at the sea bottom. *Pastinachus sephen* (76.59 %) showed a predacious carnivorous character exhibiting a tendency to feed mainly on bivalves along with small portion of crustaceans, teleost and mud by browsing at bottom. The prey organisms observed in stomach content of these species conferred with environment biota harvested by single and multi-days trawlers operating off Mumbai waters.

[**Keywords**: Feeding, Food, Gestating females, Index of relative importance]

## Introduction

Recently, increasing attention has been given to the studies on feeding behavior in sharks and in contrast, rays, skates and guitarfish have received comparatively little, attention[1-3]. Knowledge of food habits is vital in assessing the ecological requirement, of a species[4] and information gathered on diet and feeding habits adds insight into the biology and distribution of a species[5]. Different species of fishes have evolved individual predatory strategies so that they could avoid direct competition with each other[6]. An opportunistic feeder is one that generally consumes whatever prey is encountered; its stomach contains a variety of prey, similar in composition and abundance to the prey fauna in the predator's habitat[7]. Off Mumbai, among shark species: *Carcharhinus macloti*, *Rhizoprionodon acutus*, *R. oligolinx and Scoliodon laticaudus*; rays: *Amphotistis imbricata* and *Pastinachus sephen* and skates: *Rhinobatus annandalei* and *Rhyncobatus djiddensis* form an important component of the elasmobranch catch, inhabiting at same fishing ground and have opportunity of predating on the prey species at same netted region. Though the diet of many species of elasmobranchs have been described earlier[8-17], there is no specific information on food and feeding habits of gestating females of elasmobranchs in Indian waters. Hence, an attempt has been made here to elucidate the food items, the quantity consumed and similarity/ diversity exhibited in predatory behavior in these eight species of elasmobranch.

## Material and Methods

In analyzing the diet of gestating females contributing in sharks, rays and skates were identified and separated from adults, caught in trawlers operating from New Ferry Wharf and Versova during January 2005 to January 2010 (Fig. 1). The length of sharks and skates were measured from tip of snout to upper caudal lobe and rays by disc width in cm. Fresh specimens of gestating females of *C. macloti* (n = 20, length range of females = 87 – 93 cm, length range of embryos = 270 – 330 mm), *R. acutus* (n = 54, 77 – 88 cm, 141 – 295 mm), *R. oligolinx* (n = 37, 64 – 83 cm, 159 – 275 mm), *S. laticaudus* (n = 64, 44 – 59 cm, 32 – 132 mm), *A. imbricata* (n = 82, 26 – 29 cm, 65 –


Fig. 1 — Fishing grounds under exploitations by single and multiday trawlers from Mumbai base

99 mm), *P. sephen* (n = 41, 53 – 86 cm, 157 – 250 mm), *R. annandalei* (n = 62, 70 – 83 cm, 115 – 200 mm) and *R. djiddensis* (n = 14, 170 – 210 cm, 210 – 438 mm). The various stages of gestation were classified on the basis embryonic development as early, intermediate, advance, pre-parturition and parturition pregnancy as defined by Setna & Sarangdhar[18]. Stomachs of all females were examined in the fresh condition during cutting ventrally for marketing and curing. The intensity of feeding was determined by base of degree of distension of stomachs and these stomachs were grouped as active (Gorged and full), moderate (3/4 full and ½ full), poor (1/4 full and traces) and empty[19]. The stomachs were dissected from large animal and brought in ice to laboratory for further study and small specimens were studied in laboratory. The wet weight of the stomach contents was taken by using an electronic balance to the nearest mg. Stomach contents were sorted to the lowest possible taxon[20-22] and expressed as frequency of occurrence (% F). Further, items in each groups were counted and a wet mass obtained, making it possible to express stomach contents in terms of percentage by mass (% M) and by the numbers (% N) as described by Pinkas *et al*.[23].

$$IRI = (\%N+\%V) \times \%F$$

Where, %N, %V and %F represent the number, volume and frequency of occurrence of prey, respectively.

## Results

### Feeding

Data on feeding intensity (Table 1) revealed a dominance of empty stomachs in *R. acutus* (63 %), *R. oligolinx* (64.9 %), *S. laticaudus* (45.2 %), *A. imbricata* (62.2 %), *R. annandalei* (54.9 %). The mean volume of food per species including empty stomach in *R. acutus* was 1.6 ml, in *R. oligolinx* 2.5 ml, in *S. laticaudus* 3.4 ml, in *A. imbricata* 1.56 ml and in *R. annandalei* 1.21 ml and excluding empty stomachs were 4.5 ml, 7.1 ml, 6.2 ml, 4.14 ml and 2.69 ml, respectively. Compared to above species, *C. macloti* had 5 % empty guts, *P. sephen*, 14.6 % and *R. djiddensis* 28.7 %. Mean volume of food per fish including empty stomach in *C. macloti* was 22.9 ml, *P. sephen* 14.8 % and in *R. djiddensis* 68.2 ml and excluding empty stomach 24.0 ml, 12.6 % and 95.5 ml, respectively. The low feeding intensity and mean volume of food per fish obtained in most of the

Table 1 — Feeding intensity in % and mean volume of food per fish of Elasmobranchs species

| Species | No. of specimens | Condition of stomach (%) | | | | Mean volume of food (ml) per fish | |
|---|---|---|---|---|---|---|---|
| | | Active | Moderate | Poor | Empty | Including empty stomach (ml) | Excluding empty stomach (ml) |
| *C. macloti* | 20 | 30 | 50 | 15 | 5 | 22.9 | 24 |
| *R. acutus* | 54 | 1.8 | 16.6 | 18.6 | 63 | 1.6 | 4.5 |
| *R.oligolinx* | 37 | | 10.8 | 24.3 | 64.9 | 2.5 | 7.1 |
| *S. laticaudus* | 64 | 1.6 | 21.9 | 31.3 | 45.2 | 3.4 | 6.2 |
| *P. sephen* | 41 | 12.2 | 7.1 | 56.1 | 14.6 | 14.8 | 12.6 |
| *A. imbricata* | 82 | | 4.9 | 32.9 | 62.2 | 1.56 | 4.14 |
| *R. annandalei* | 62 | | 12.9 | 32.2 | 54.9 | 1.21 | 2.69 |
| *R. djiddensis* | 14 | 17.1 | 27.4 | 35.7 | 28.7 | 68.2 | 95.5 |

Table 2 — Details of the prey are presented by frequency of occurrence (% F), by mass (% M), by number (% N) and index of relative importance (IRI) of sharks

| Species | Prey items | % F | % M | % N | IRI | Species | Prey items | % F | % M | % N | IRI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. macloti* | Teleost: | | | | | | Crustaceans: | | | | |
| | Apogon spp. | 16.13 | 11.57 | 18.75 | 19.31 | | *Parapenaeopsis stylifera* | 5.56 | 1.08 | 5.55 | 0.51 |
| | *Otolithes cuvier* | 6.45 | 21.4 | 6.25 | 7.04 | | Prawns remain | 11.11 | 3.24 | 11.12 | 2.18 |
| | *Platycephalus* spp. | 9.68 | 6.55 | 9.37 | 6.08 | | Total | 16.67 | 4.32 | 16.67 | 2.68 |
| | Sciaenids | 6.45 | 7.42 | 6.25 | 3.48 | | Molluscs | | | | |
| | *Trichiurus* spp. | 6.45 | 4.15 | 6.25 | 2.65 | | *Sepia* spp. | 5.55 | 4.32 | 5.56 | 0.75 |
| | *Johnieops vogleri* | 3.23 | 6.55 | 3.13 | 1.23 | *S. laticaudus* | Teleost: | | | | |
| | *Johnieops* spp. | 3.23 | 2.18 | 3.13 | 0.68 | | *Apogon* spp. | 9.26 | 8.33 | 8.2 | 7.7 |
| | *Decapterus* spp. | 3.22 | 1.09 | 3.12 | 0.53 | | *Harpodon neherus* | 5.56 | 9.72 | 6.56 | 4.6 |
| | *Sardenella* spp. | 3.22 | 0.44 | 3.13 | 0.48 | | *Coilia dussumieri* | 3.7 | 10.41 | 3.28 | 2.5 |
| | *Cynoglossus* spp. | 3.23 | 0.44 | 3.13 | 0.45 | | *Trichiurus* spp. | 3.7 | 2.55 | 3.25 | 1.1 |
| | Unidentified fishes | 22.58 | 16.81 | 21.87 | 34.49 | | *Cynoglossus* spp. | 1.85 | 1.25 | 1.64 | 0.3 |
| | Digested fish | 16.13 | 21.4 | 15.62 | 23.58 | | Sciaenids | 1.85 | 0.55 | 1.64 | 0.2 |
| | Total | 100 | 100 | 100 | 100 | | Puffer fish | 1.85 | 0.92 | 1.64 | 0.2 |
| *R. acutus* | Teleost: | | | | | | Unidentified and digested fish | 12.96 | 28.64 | 22.96 | 33.7 |
| | *Decapterus* spp. | 23.82 | 14.49 | 25 | 23.11 | | Total | 40.73 | 62.37 | 49.17 | 50.3 |
| | *Johnieops vogleri* | 9.52 | 10.35 | 8.33 | 4.37 | | Crustaceans: | | | | |
| | *Priacanthus hamrur* | 9.53 | 7.87 | 8.33 | 3.79 | | *Squilla* spp. | 9.26 | 6.02 | 8.2 | 6.6 |
| | Cynoglossus spp. | 9.52 | 6.22 | 8.33 | 3.4 | | Crabs | 3.71 | 4.63 | 3.28 | 1.5 |
| | *Trichiurus lepturus* | 4.76 | 16.56 | 4.17 | 2.42 | | *Parapenaeopsis stylifera* | 3.71 | 3.01 | 3.28 | 1.2 |
| | *Johnieops* spp. | 4.76 | 4.97 | 4.17 | 1.07 | | *Nematopalaemon tenuipes* | 3.7 | 1.48 | 3.28 | 0.9 |
| | *Otolithes cuvier* | 4.76 | 2.48 | 4.17 | 0.79 | | *Solenocera* spp. | 1.85 | 0.92 | 1.64 | 0.3 |
| | Unidentified fishes | 33.33 | 37.06 | 37.5 | 61.05 | | Prawn remains | 16.67 | 8.65 | 13.12 | 18.3 |
| | Total | 100 | 100 | 100 | 100 | | Total | 38.9 | 24.71 | 32.8 | 28.8 |
| *R. oligolinx* | Teleost: | | | | | | Molluscs | | | | |
| | Sciaenids | 11.2 | 9.7 | 11.11 | 3.17 | | *Loligo duvacelli* | 1.85 | 2.79 | 1.64 | 0.4 |
| | *Cynoglossus* spp. | 5.55 | 14.02 | 5.56 | 1.49 | | *Octopus* spp. | 1.85 | 0.69 | 1.64 | 0.2 |
| | *Apogon* spp. | 5.56 | 3.24 | 5.55 | 0.67 | | Total | 3.7 | 3.48 | 3.28 | 0.6 |
| | Unidentified fishes | 55.55 | 64.4 | 55.55 | 91.24 | | Miscellaneous digested food | 16.67 | 9.44 | 14.75 | 20.3 |
| | Total | 77.78 | 91.36 | 77.77 | 96.57 | | | | | | |

species due to females examined were in gestation condition. It indicated some relationship between low feeding intensity and the gestation period. Appukuttan & Nair[9] noticed incidence of empty stomach was more in gravid females. Dudley *et al*.[24] noticed pregnant females of *Carcharinus obscurus* with a low percentage of stomachs content (22.5 %).

**Diet**

***Carcharhinus macloti***

Only teleost were found most preferred prey items in this species (Table 2). Among the fishes, *Apogon* spp. (IRI – 19.31 %) formed major diet item followed by *Otolithes cuvieri* (7.04 %), *Platycephalus* spp. (6.08 %), unidentified sciaenids (3.48 %), *Trichiurus* spp.

(2.65 %), *Johnieops borneensis* (1.23 %), *Johnius* spp. (0.68 %), *Decapterus* spp. (0.53 %), *Sardinella* spp. (0.48 %), *Cynoglossus* spp. (0.45 %) and unidentified fishes (34.44 %) and digested fish included scales, bones and eye lenses (23.58 %).

Analysis of the stomach contents of this species indicated preference for teleost fishes that lived at the surface to bottom. Devadoss *et al*.[12] noticed small fishes, crustaceans and squids in diet consisting of this species. Wetherbee *et al*.[7] had listed index of relative importance of teleost in diet content of seven shark species from 88 % in *Negaprion brevirostris* and 36 % in *Scyliorhinus canicula*.

***Rhizoprionodon acutus***

This species feeds (Table 2) mainly on teleost in which *Decapterus* spp. (IRI = 23.11 %) contributed most dominant food items followed *J. borneensis* (4.37 %), *Priacanthus hamrur* (3.79 %), *Cynoglossus* spp. (3.40 %), *Trichiurus lepturus* (2.42 %), *Johnieops* spp. (1.07 %), *Otolithes cuvieri* (0.79 %) and semi digested fish (61.05 %). It is evident that *R. acutus* appeared to be piscivorous. Appukuttan & Nair[9] had observed that from the south east coast of India this species feed mainly on variety of fish among which silver bellies were found to be most important. As silver bellies are not that abundant on the west coast of India their absence in the stomachs is obvious, except for certain minor difference of other item including crustaceans and cephalopods. Dudley *et al*.[24] noticed teleosts dominated the diet in terms of frequency of occurrence in *Carcharinus obscurus* (63 %).

***Rhizoprionodon oligolinx***

This species (Table 2) mainly fed on teleost (IRI = 96.57 %) followed by crustaceans (IRI = 2.68 %) and molluscs (0.75 %). Representative in teleost prey items were unidentified sciaenids (3.17 %), *Cynoglossus* spp. (1.49 %), *Apogon* spp. (0.67 %) and unidentified fishes (91.24 %), crustaceans by *Parapenaeopsis stylifera* (0.51 %) and prawn remains (2.18 %), whereas molluscs diet by *Sepia* spp. (0.75 %). Appukuttan & Nair[9] noted that sharks fed on pelagic fishes, crustaceans and cephalopods.

***Scoliodon laticaudus***

In the gut content of this species, teleost were the dominant prey item, accounting for 50.3 % on the basis of relative importance followed by crustacean (28.8 %) and molluscs (0.61 %) indicating carnivore feeding nature (Table 2). Teleost were contributed by *Apogon* spp. (7.7 %), *Harpadon neherus* (4.6 %), *Coilia dussumieri* (2.5 %), *Trichiurus* spp. (1.1 %), *Cynoglossus* spp. (0.3 %), unidentified sciaenids (0.2 %), Puffer fish (0.12 %) and digested fish (33.7 %). Crustacean food composed of *Squilla* spp. (6.6 %) as dominant food item followed by crabs (1.5 %), *Parapenaeopsis stylifera* (0.9 %), *Nematopalaemon tenuipes* (0.3 %), *Solenocera* spp. (0.3%) and rest digested prawns (18.3 %). Molluscan diet was constituted by *Uroteuthis (Photololigo) duvaucelii* (0.4 %) and *Octopus* spp. (0.2 %). Appukuttan & Nair[9] on a study from Bombay noted this species as bottom feeder based on cephalopods, a variety of crustaceans (Squilla, prawns and crabs) and demersal fishes (sciaenids, Bombay duck, threadfins, *Nemipterus* spp. and *Platycephalus* spp.) from Bombay. Mathew & Devaraj[25] has recorded average percentage composition of its diet as fish (50.32 %), prawns (28.48 %), molluscs (10.91 %), *Squilla* spp. (2.98 %) and other crustaceans (4.83 %) from coastal waters of Maharashtra. Raje *et al*.[16] collected data on food and feeding habits of this species during January 1991 to 2005. Based on percentage of volumetric method they recorded teleost as the most preferred prey item (52.08 %) followed by crustaceans (29.98 %), molluscs (6.80 %), polychaets (0.37 %), mud (0.75 %) and rest unidentified food items. The analysis of main categories of food items in gut contents of *S. laticaudus* on the basis of index of relative importance, average percentage composition and percentage volume in the present study conducted during January 1991 – 2005 showed similar grade of preference as the study of Raje *et al.*[16], which may be due to similar grade of preference and occurrence of prey fauna in the habitat.

***Amphotistis imbricata***

Crustaceans (IRI = 85.06 %) formed the principal diet item of this species (Table 3). *Acetes* spp. (38.17 %) ranked highest followed by *Nematopalaemon tenuipes* (17.30 %), *Solenocera crassicornis* (3.36 %), *P. stylifera* (1.17 %), *Squilla* spp. (0.16 %) and digested prawns (24.90 %). Teleost (10.02 %) diet was represented by *Coilia dussumieri* (0.66 %) and unidentified fish juveniles (9.36 %). Devadoss[26] reported that this species feed on small burrowing and buried crustaceans and polychaetes. The presence of crustaceans in high percentage indicated the benthic habit of this species.

Table 3 — Details of the prey are presented by frequency of occurrence (% F), by mass (% M), by number (% N) and index of relative importance

| Species | Prey items | % F | % M | % N | IRI |
|---|---|---|---|---|---|
| *A. imbricata* | Teleost | | | | |
| | *Coilia dussumieri* | 1.9 | 7.8 | 0.5 | 0.66 |
| | Unidentified fishes | 13.5 | 12.1 | 4.6 | 9.36 |
| | Total | 15.4 | 19.9 | 5.1 | 10.02 |
| | Crustaceans: | | | | |
| | *Acetes* spp. | 9.6 | 27.4 | 68.4 | 38.17 |
| | *Nematopalaemon tenuipes* | 17.3 | 14.4 | 9.7 | 17.3 |
| | *Solenocera crassicornis* | 11.6 | 9.4 | 4.6 | 3.36 |
| | *Parapenaeopsis stylifera* | 3.8 | 6.4 | 1 | 1.17 |
| | Squilla spp. | 1.9 | 1.5 | 0.5 | 0.16 |
| | Prawn remains | 25 | 17.4 | 6.6 | 24.9 |
| | Total | 69.2 | 76.5 | 90.8 | 85.06 |
| | Miscellaneous digested food | 15.4 | 3.6 | 4.1 | 4.92 |
| *P. sephen* | Teleost | | | | |
| | *C. dussunieri* | 2.7 | 7.4 | 2.5 | 0.43 |
| | Sciaenids | 7.7 | 12.5 | 5.4 | 2.29 |
| | Total | 10.4 | 19.9 | 7.9 | 2.72 |
| | Crustaceans | | | | |
| | *P. stylefera* | 6.4 | 6.2 | 4 | 1.07 |
| | *P. sculptilis* | 1.3 | 0.6 | 0.4 | 0.02 |
| | *Solenocera* spp. | 5.1 | 2.2 | 2.2 | 0.38 |
| | *N. tenuipes* | 6.4 | 3 | 5 | 0.84 |
| | *Squlla* spp. | 3.8 | 4.2 | 2.2 | 0.39 |
| | Prawn remain | 5.1 | 4 | 1.4 | 0.46 |
| | Total | 28.1 | 20.2 | 15.2 | 3.16 |
| | Moluscs | | | | |
| | Bivalves | 39.7 | 46.8 | 70.8 | 76.59 |
| | Digest matter | 2.7 | 1.2 | 0.7 | 0.08 |
| | Mud | 19.1 | 11.9 | 5.4 | 17.45 |

Table 4 — Details of the prey are presented by frequency of occurrence (% F), by mass (% M), by number (% N) and index of relative importance (IRI) of skates

| Species | Prey items | % F | % M | % N | IRI |
|---|---|---|---|---|---|
| *R. annandalei* | Teleost: | | | | |
| | *Harpodon neherus* | 7.4 | 10 | 6.9 | 3.4 |
| | *Trichiurus* spp. | 7.4 | 5.3 | 10.3 | 3.2 |
| | *Cynoglossus* spp. | 3.7 | 8 | 3.4 | 1.2 |
| | *Priacanthus hamrur* | 3.7 | 6.6 | 3.5 | 1 |
| | Unidentified fishes | 11.1 | 18.5 | 10.3 | 8.7 |
| | Total | 33.3 | 48.4 | 34.4 | 17.5 |
| | Crustaceans: | | | | |
| | *Parapenaeopsis stylifera* | 3.7 | 10.6 | 3.5 | 1.4 |
| | *Squilla* spp. | 3.7 | 2.7 | 3.5 | 0.6 |
| | Unidentified crustaceans | 37.1 | 28 | 37.9 | 66.9 |
| | Total | 44.5 | 41.3 | 44.9 | 68.9 |
| | Mud | 3.7 | 1.7 | 3.5 | 0.5 |
| | Miscellaneous food items | 18.5 | 8.6 | 17.2 | 13.1 |
| *R. djiddensis* | Teleost: | | | | |
| | *Harpodon neherus* | 7.4 | 54.4 | 33.3 | 31.6 |
| | *Coilia dussumieri* | 11.1 | 2.6 | 6.2 | 4.75 |
| | *Bregmaceros mcclellandi* | 7.4 | 0.2 | 2.6 | 1.01 |
| | *Trypauchen vagina* | 3.7 | 1.2 | 1.7 | 0.54 |
| | Sciaenids | 3.7 | 1.3 | 1.7 | 0.52 |
| | Total | 33.3 | 59.7 | 45.5 | 38.42 |
| | Crustaceans: | | | | |
| | *Squilla* spp. | 22.3 | 24.3 | 7 | 34 |
| | Crabs | 14.8 | 6.7 | 9.6 | 11.74 |
| | *Nematopalaemon tenuipes* | 7.4 | 2.1 | 25.4 | 9.91 |
| | *Acetes* spp. | 7.4 | 0.2 | 6.1 | 2.27 |
| | Semi digested lobsters | 3.7 | 4.2 | 1 | 0.93 |
| | *Parapenaeopsis stylifera* | 3.7 | 0.2 | 1 | 0.21 |
| | Prawn remains | 7.4 | 2.6 | 4.4 | 2.52 |
| | Total | 66.7 | 40.3 | 54.5 | 61.58 |

***Pastinachus sephen***

*P. sephen* is predacious carnivore exhibiting a tendency to feed at the bottom, evidenced by occurrence of bivalve (IRI = 76.50 %), crustaceans (3.15 %), teleost (2.72 %) along with mud (17.45 %) in the diet (Table 3). Crustaceans prey contributed by *P. stylifera* (1.03 %), *N. tenupies* (0.84 %), Squilla spp. (0.39 %), *Solenocera* spp. (0.38 %), *P. sculptilis* (0.02 %) and prawn remain of exoskeleton and broken appendage. Teleost was constituted by unidentified sciaenids (2.29 %) and *C. dussumieri* (0.43 %) and rest digested matter included fish skeleton, scales, eye lens and digested fishes. Carnivorous feeding habit (fish, prawns and crabs) in these species has been reported by Devadoss[27] from Porto Nova.

***Rhinobatos annandalei***

Food was in highly macerated condition and most of the components were in advanced stages of digestion (Table 4). Hence, specific identification of various items was not possible. Crustaceans (IRI = 68.9 %) formed most dominant feed of this species. Among the food items, contribution of digested and unidentified crustaceans was 66.9 % comprising of exoskeleton and broken appendages of prawns and other crustaceans. The contribution of *P. stylifera* was 1.4 % and *Squilla* spp. 0.6 %. The teleosts formed 17.6 % of food item of this species, in which 8.7 % was comprised by unidentified fishes, rest by *Trichiurus* spp. (3.7 %), *H. neherus* (3.0 %), *Cynoglossus* spp. (1.2 %) and *Priacanthus hamrur* (1.0 %). Mud (0.5 %) occurred in one specimen attributed as accidental entry. It showed that this specimen fed mostly on crustacean than teleost at bottom.

Springer[28] noted that stomach content of Sandbar sharks was usually not identifiable owing to an advance state of digestion. Stevens[29] was able to

identify only 50 % of food in the stomachs of blue sharks, because most items were in an advanced state of digestion.

***Rhyncobatus djiddensis***

Examination of guts of *R. djiddensis* (Table 4) revealed that crustaceans (61.58 %) were major prey items than teleost (38.42 %). Among crustaceans, *Squilla* spp. (34.0 %) formed most dominant diet item followed by crabs (11.74 %), *N. tenuipes* (9.91 %), *Acetes* spp. (2.27 %), lobsters (0.93 %), *P. stylifera* (0.21 %) and prawn remains including exoskeleton and broken appendages of the prawns. *H. neherus* (31.6 %) occurred as major food item among teleost followed by *C. dussumieri* (4.75 %), *Bregmaceros mcclellandi* (1.01 %), unidentified sciaenids (0.52 %) and *Trypauchen vagina* (0.52 %) pointing to the benthic feeding habits.

Though, the small quantity of lobsters (IRI = 0.93 %) occurred in stomach contents of this species, of 208 cm in length does not indicates as accidentally consumed. Lobsters are regularly noticed in variable quantity contributing in the trawl catch at landing centers at Mumbai. Wetherbee[7] reported that the diversity of the diet also increases as elasmobranchs, adult jacks and lobsters become increasingly important. Further, Bigelow & Schroeder[30] observed that the chief food item of *Mustelus cani* (Family: Triakidae) from Western Atlantic are larger crustaceans with one species of crabs and lobster. Devadoss[11] recorded bottom fishes like squids, prawns, crabs, apogonids and juvenile eels in the stomach contents of these species from Cudalore.

## Discussion

It is obvious from the above data that there is low feeding activities and low average volume of food per pregnant female of eight elasmobranch species studied. Though, the free swimming young ones of *C. macloti* (300 – 390 mm), *R. acutus* (355 – 375 mm), *R. oligolinx* (225 – 355 mm), *S. laticaudus* (140 – 200 mm), *A. imbricata* (102 – 150 mm), *P. sephen* (157 – 250 mm), *R. annandalei* (224 – 304 mm) and *R. djiddensis* (417 – 520 mm) found in trace catch landed by trawlers from where the present samples was collected, in none of the pregnant female examined, neonate or new born was found as a prey item in these species, indicate absence of cannibalism. The occurrence of empty stomach in high percentage in these species, appeared to agree with Springer[28] that pregnant sharks cease feeding when they enter nursery area as a protection measure for young ones. Hobson[31] also suggested that shark refrain from feeding on member of their own species.

Alverson[32] considers that the exoskeleton of crustaceans is digested at a slower rate than fish and remains in the stomachs for longer period, thus reducing the percentage of empty stomachs. However, it was noticed in the present study that although crustacean remains form the main constituent of *A. imbricata*, *R. annandalie* and *R. djiddensis* even though the percentage of poorly feed and empty stomachs were high. It indicated that the low rate of feeding and mean volume of food per fish obtain in these gestating females might be attributing to the developing embryos, permitting limited space in the abdominal cavity for intake of food. Similar, relationship between low feeding intensity and gestating mothers have been reported by previous workers[9,24]. Raje *et al*.[33] studied breeding behavior at mating areas, pupping and nursery grounds of juveniles, segregation and aggregation of adults in selected species of elasmobranchs off Mumbai.

Shark species of *C. macloti* and *R. acutus* found to be exclusively piscivorous, showed feeding at a level slightly above the bottom. Similarly, in case of *Iago omanensis*, Compagno & Springer[34] have observed an unidentified fish alone as food. *R. oligollinx* noticed to be mostly piscivorous and crustaceans formed small portion of food. *S. laticaudus* found to be carnivore, largely feed on teleost and supplemented by invertebrates at entire water column. In a limited study, Schmidt[35] noted that teleost contributed 88 % of the diet of lemon shark *Negaprion brevirostris* caught in Florida Bay. Wetherbee *et al*.[7] noticed that diet of young lemon sharks and many other sharks is dominated by teleosts and stated that the importance of teleost in the diets of sharks is demonstrated by their prominence in the stomachs of many species of sharks. Dudley *et al*.[24] reported *Carcharhinus obscurus* as generalized predator, feeding throughout the water column on a variety of prey, mainly teleost. Schimdt[35] recovered large number of shrimps in stomach of Lemon shark caught in Florida Bay, while few shrimps were noticed in stomach content of same species at same region by Cortes[36]. Nair & Appukuttan[8] reported that fishes rank first in abundance in *Halaelurus haspidus*, *Eridacnis radcliffei* and *I. omanensis* in trawl catches off Mandapam in Gulf of Mannar.

The ray *A. imbricata* found to be carnivore, largely feed on crustaceans and occasionally on teleost that

live on bottom. Whereas, *P. sephen* was a carnivore, noticed voracious feeding mainly at bottom on bivalve along with crustaceans, teleost and mud. Skate, *R. annandalie* was found to be a carnivore, preferring a benthic habit as evidenced by presence of main diet crustaceans and intermitted on teleost along with mud. *R. djiddensis* is also a carnivore, chiefly feeds on crustaceans conspicuously at bottom and sometime at surface. An analysis of the stomach content of these species of sharks revealed that they feed mainly on teleost at surface to bottom. Rays and Skates found to be feeding chiefly on soft bodied invertebrates that live at the bottom.

The occurrence of the food organisms in environment and that in the gut contents in these species, the data of Bhendekar *et al*.[37] has given list of harvest species by single and multiday trawlers operating from Mumbai coast have been used. The species of fin fish, shrimps, crabs, cephalopods, stomatopods and shell fish showing a correction between the availability of the food organism in netted region and their occurrence in guts contents (Table 2). The occurrence of the diet in the guts of gestating females as a clue indicated elasmobranch species feed on fishing ground. Further, decline in catch and catch rate of skates from 1204.4 (1.3 kg/hrs) in 1989 to 194.6 t (0.12 kg/hrs) in 2003, rays from 765.1 t (0.63 kg/hrs) in 1993 to 205.7 t (0.12 kg/hrs) in 2002 and Sharks from 2565 t (2.1 kg/hrs) in 1993 to 1053 t (0.6 kg/hrs) in 2005 in trawl net and biological aspects off Mumbai have been reported[14,17,38]. The species may be attracted to the commercial fishing ground for feeding and cause to decline by capture. This appeared to the corroborate assumption made by Stobutzki *et al.*[39] reported that elasmobranch species with a restricted range and that feed on demersal organisms could be impacted more heavily by trawling.

It could be concluded that *C. macloti*, *R. acutus*, *R. oligolinx* and *S. laticaudus* are specialized predators feeding on teleost, *A. imbricate*, *R. annandalie* and *R. djiddensis* on crustacean, whereas *P. sephen* feed on bivalves. Teleost are the most dominant diet source to shark which corroborate with Wetherbee[7] that sharks are capable of capturing fast swimming fish, but consumed almost any type of animal matter available. Similarly, rays and skates are capable of feeding on crustaceans and bivalve by suction capture, bite manipulation and suction transport behaviour as observed in *Rhinobatos lentiginosus* by Wilga & Motta[3]. It is evident from analysis of guts contents that these species are opportunistic feeder, preying on wide range of organisms. Tiger shark, *Galeocerdo cuvier* and Bull shark, *Carcharhinus leucas* are also considered to be opportunistic feeders, select a wide variety of habitats[28,40].

The present study indicated that stomach of the opportunistic feeder contain a variety of prey, also similar to the composition and abundance of the prey fauna in the predator's habitat. The high proportion of unidentified and digested food items observed in stomach content indicated owing to process of advance stage of digestion. Similar, results have been reported in Sandbar shark, *C. plumbeus* by Springer[28] and in Lemon shark, *N. brevirostris* by Cortes[36]. The occurrence of high percentage of teleost diet in the sharks showed a opportunistic feeding throughout the water column, rays and skates on crustaceans and bivalve at bottom seem to be confirmed with suggestion given by Stevens[29] regarding opportunism feeding on fish in the epipelagic, squid in deep water and crustacean and gastropods when feeding on bottom. Though, limited specimens were studied, it indicated that this versatile food habit are advantageous to the individual because feeding will not be limited to a particular prey item throughout the year with sharks, this may allow for increase in population density, a decrease in competition and a broadening of range and distribution[4].

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**Conflict of Interest**

There is no conflict of interest.

**Author Contributions**

Arrangement of logistics and coordinated the work: SGR. SKC: guidance, reviewed the manuscript and editing. PK, RKR and TD: data collection and analysis.

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