



## The Food and Feeding Habits of Goldsilk Seabream, *Acanthopagrus berda* (Forsskal, 1775)

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### Abstract

The feeding habits of Picnic seabream, *Acanthopagrus berda* (Forsskal, 1775) from estuarine waters of Calicut, southwest coast of India was investigated. The study was conducted by collecting thirty fishes monthly from January 2016 to December 2016. The highest value of gastro-somatic index was obtained in January ( $2.65 \pm 2.31$ ) and lowest in October ( $0.12 \pm 0.31$ ) with an annual average of  $0.64 \pm 1.07$ . The highest level of vacuity index was observed in October ( $70.17 \pm 4.71$ ) and the lowest in June ( $6.00 \pm 2.71$ ). The results of gastro-somatic index and vacuity index revealed that feeding activity of *A. berda* is reduced during the spawning season. Barnacles, crab and bivalves are the major food items found in the stomach of *A. berda* which altered according to season and size of fish. The Index of relative importance (%) was 26.65 for barnacles, 24.96 for crabs, 21.56 for *Modiolus* spp and 14.87 for oyster. The secondary food items ingested were clam (mainly *Paphia* sp. and *Meretrix* sp. (5.04)) green mussel (*Perna viridis* (4.46)) and shrimp (1.96). The other smaller proportion of food items ingested include fish, aquatic plants and squid. The average relative length of gut was  $1.11 \pm 0.11$  cm showing that *A. berda* is omnivorous.

### Introduction

Food is one of the key factors that greatly influence the distribution, growth, reproduction, migration rate and behavior of organisms (Priyadharsini, Manoharan, Varadharajan, & Subramaniyan, 2012). The quality and quantity of food directly affect fish growth while indirectly affect its maturation and survival (Sourinejad, Nikkiah Khaje Ataei, Kamrani, & Ghodrati Shojaei, 2015). Information on the food and feeding habit of fish in their natural habitat provide cues for the selection of suitable cultivable species and for the development of their successful farming practices (Manon & Hossain, 2011).

Research on food habits and feeding ecology of fishes are the basis to understand their roles within the ecosystems (Hajisamaea, Choua, & Ibrahim, 2003). In

addition, the knowledge of the feeding behavior of marine fishes is essential for fish stock assessment, ecosystem modeling and to assess the role of marine fishes within an ecosystem (Bachok, 2004; Salavatian, Gholiev, Aliev, & Abassi, 2011; Mohanraj & Prabhu, 2012); prey selection (Stergiou & Fourtouni, 1991), predator-prey size relationships (Scharf, Juanes, & Rountree, 2000; Priyadharsini *et al.*, 2012; Mohanraj & Prabhu, 2012), distribution of feeding habits with latitude (Pauly, 2000) and habitat selection (Labropoulou & Smith, 1999).

Sparidae, commonly known as porgies or sea bream, belonging to the Order Perciformes is a predominantly marine, widely distributed along the Indian, Pacific and Atlantic oceans (Nelson, 1994; Sheaves, 2006). The family sparidae contains many species of commercial, recreational and aquaculture

importance (Ingram, McKinnon, & Gooley, 2002; Oh, Kim, Kwon, & Maran, 2013; Mongile *et al.*, 2014). Among various seabreams, *Acanthopagrus* spp. are considered as commercially important food fishes for aquaculture throughout several regions of the world such as China, South-east Asia, Africa, UK and USA (Rahim, Abbas, Ferrando, Gallus, & Ghaffar, 2017).

Gold silk seabream, *Acanthopagrus berda* (Forsskål, 1775), two bar seabream, *A. bifasciatus* (Forsskål, 1775) and yellowfin seabream, *A. latus* (Hottuyn, 1782) are the only representatives of the *Acanthopagrus* genus found in Indian Ocean (Behera, Loveson, Ghosh, & Krishna, 2013). These three species are commercially important and are cultured in various parts of the world. *Acanthopagrus latus* is cultured commercially in Japan (Abol-Munafi & Umeda, 1994), Taiwan (Leu & Chou, 1996), Kuwait (Abou-seedo, Dadzie, & Al-Kanaan, 2003) and Persian gulf (Vahabnezhad, Kaymaram, Taghavi Motlagh, Valinassab, & Fatemi, 2016); *A. berda* is cultured in Hongkong (Mok, 1985) and Pakistan (Rahim *et al.*, 2017) and *A. bifasciatus* is cultured in Saudi Arabia (Hassan, Osman, Aswathan, Al-Shwared, & Fita, 2015).

*A. berda* is a fairly small euryhaline, estuary-dependent sea bream (van der Elst, 1988; Leu & Chou, 1996) with a wide distribution throughout the tropical Indo-West Pacific region (Garratt, 1993b; Nelson, 1994), occurring from South Africa to India and extending to Japan, the East Indies and northern Australia (Iwatsuki & Heemstra, 2010) at a depth range of about 50 m (Randall, 1995). *A. berda*, commonly known as the river bream or the gold silk sea bream is a marine fish native to the Indian Ocean and is distributed along the estuarine and shallow coastal waters of Kerala, Tamil Nadu, Andhra Pradesh, Maharashtra and Gujarat coasts. They are locally exploited by artisanal fisheries both in cast net and hook & line along the Indian coasts (Fischer & Bianchi, 1984) and are sold in the markets @ Rs. 400-500/ kg. *A. berda*, the only reported *acanthopagrus* species in estuaries of Calicut waters (Shilta *et al.*, 2018) due to its high quality meat (Rahim *et al.*, 2017), is extremely popular with consumers as protein source of their food.

*A. berda* is an important sparid fish in fisheries and aquaculture (Abbas & Siddiqui, 2013) because of its recreational value (James, Mann, Beckley, & Govender, 2003), excellent meat quality, market place acceptance, high economic value (Anonymous, 2012), strong resistance to diseases, easy adaptation to captivity (Rahim *et al.*, 2017), ability to tolerate wide variations in both salinity and temperature and fast growth rate (Sarwat, 2014).

Sparids typically consume a wide range of benthic prey and occasionally a substantial amount of plant material (Nasir, 2000; Sarre, Platell, & Potter, 2000; Mariani, Maccaroni, Massa, Rampacci, & Tancioni, 2002; Tancioni *et al.*, 2003 and Platell, Ang, Hesp, &

Potter, 2007). Though Fischer *et al.* (1990) reported that *A. berda* feed mainly on echinoderms, worms, crustaceans and molluscs, no literature data is available on the food and feeding of *A. berda* from Indian waters.

An understanding of the feeding biology is not only a basic requirement for fisheries management in the study area, but also would be useful for its captive breeding and culture practices. In this back drop, the present study was undertaken to examine the feeding habits and natural diet composition of gold silk seabream in relation to size and spawning season in the tropical Indian waters so that the findings can be applied in aquaculture development of this species.

## Materials and Methods

### Study Area and Sampling Regime

*A. berda* was sampled monthly from Korapuzha estuary of Calicut district, Kerala, India during January 2016 till December 2016. The site was located in rocky areas outside the creeks, at depths less than 5 m and within 50 m from the shore. The fishes were caught by cast net fishing. The total length and the standard length of the fish were measured to the nearest 0.1 cm and the total body weight and gonad weight to the nearest 0.1 g using a measuring board and a sensitive weighing balance respectively.

### Gastro-Somatic Index (GaSI)

The specimens collected were properly cleaned in the laboratory, dissected and the stomachs were removed. The total weight of the stomach with its contents was measured to the nearest 0.01 g. The contents of stomach and foregut were examined under a microscope and further identification within each taxonomic group was done following appropriate taxonomic identification guides. GaSI based on monthly and seasonal calculation was obtained as described by Biswas (1993):

$$\text{GaSI} = (\text{Total weight of stomach} / \text{Bodyweight}) \times 100.$$

### Index of Relative Importance (IRI)

Stomachs of *A. berda* samples collected are removed by cutting above the cardiac sphincter (oesophagus) and below the pyloric sphincter (large intestine). An incision was made along the longitudinal axis and the contents of stomachs were emptied onto a 500 µm mesh sieve for rinsing and sorting. Contents were blotted dry on paper towels before counts, displaced volumes in 1 L graduated cylinder. IRI for all prey items combined was calculated according to, Pinkas, Oliphant, and Iverson (1971), following the formula

$$IRI_i = (\%N_i + \%V_i)\%O_i$$

Where  $N_i$ ,  $V_i$ , and  $O_i$  represent percentages of number, volume and frequency of occurrence of prey  $i$  respectively.

### Vacuity Index (VI)

Vacuity Index or the stomach emptiness index determines the amount of fish appetite for food. VI was calculated using the equation given by Euzen (1987):

$$VI = (\text{The number of empty stomachs} / \text{total number of the stomachs examined}) \times 100.$$

The interpretation of the obtained VI is determined under the following conditions (Euzen, 1987). If,  $0 \leq VI < 20$ , the logical conclusion is that the fish is gluttonous,  $20 \leq VI < 40$ , the fish is comparatively gluttonous,  $40 \leq VI < 60$ , fish is middle alimentary,  $60 \leq VI < 80$ , fish is comparatively hypoalimentary,  $80 \leq VI < 100$ , fish is hypoalimentary. Each gut was examined and its fullness estimated visually on a scale of 0 (empty) to 20 (100% full).

### Food Preference index (FP)

After dissecting the stomach, all the food items were sorted out and identified. To analyze the composition of the stomach and determine the food preference index, percentage frequency of occurrence was obtained through the following equation described by Chrisfi, Kaspiris, and Katselis (2007):

$$FP = (\text{number of stomachs with a specific food item} / \text{the number of non-empty stomachs}) \times 100$$

The different values of this index, allow separation of the prey items into three categories: If  $FP > 50\%$ , the prey eaten is dominant and the main diet. If  $50\% > FP > 10\%$ , the prey eaten is secondary. If  $FP < 10\%$ , the prey is eaten accidentally (Euzen, 1987).

### Variations In Diet Composition In Relation to Fish Size

In earlier studies it is reported that the majority of *A. berda* in the length class 100-149 mm were classified macroscopically as immature (Garratt, 1993a) and 22 cm total length is the size at which 50% of *A. berda* mature (Wallace, 1975). Based on this, in the present study the fishes are grouped into three categories, <15 cm, 15-22 cm and > 22cm and randomly 60 fishes are collected from each category to study the variation in diet composition between small, medium and adult fishes.

### Relative Length of Gut (RLG)

Relative length of gut was measured to the nearest 0.1 cm as described by Euzen (1987) through the following equation:

$$RLG = \text{Length of gut} / \text{total body length}$$

### Statistical Analysis

Statistical differences in monthly GaSI were tested by analysis of variance (ANOVA), while Tukey's test was performed at the significance level of  $\alpha = 0.05$  (Zar, 2010).

### Results

#### Feeding Intensity of *A. berda*

From the total 360 fishes examined, 138 males and 167 females were separated; 35 individuals were immature and 20 were intersex individuals. The size of fish ranged from  $24.05 \pm 4.48$  cm (in January) to  $28.30 \pm 4.33$  cm (in May) in total length and from  $313.50 \pm 236.42$  g (in March) to  $486.65 \pm 285.45$  g (in November) in weight (Table 1). Out of 360 stomachs of *A. berda* examined, 68.90% contained food and the rest 31.09% were without food, which varied during different months. Among these, 58 were full, 115 were  $\frac{3}{4}$  full, 69 were  $\frac{1}{2}$  full, 39 were  $\frac{1}{4}$  full and 79 were empty. The highest percentage of empty stomach was in the month of October (70%) and the lowest percentage of empty stomach was in the month of June (2%). The highest percentage of full stomachs was found in the month of June (98%) and the lowest percentage of full stomachs was found in October (30%) (Table 1).

#### Annual and Monthly Variation in Diet Composition

Barnacle, crab, oyster and *Modiolus* spp. formed the major food groups of *A. berda*. Barnacles made up of 71.98% by volume composition, whereas crab (71.69%) was in the second position of importance. Oyster (58.32%) comes in third position which was mainly composed of *Crassostrea madrasensis*. *Modiolus* spp. contributed 50.46% to the total food items. The secondary food items were shrimp constituting 25.53%, followed by clam (21.80%) including *Paphia* sp. and *Meretrix* sp., and green mussel (15.49%). Other accidental food items consumed by *A. berda* were fish (7.72%), aquatic plants (2.31%) and squid (1.54%) (Table 2). The oyster, *Crassostrea* spp. were found in the diet during March to October; *Modiolus* spp. during January-June; shrimp during June-December. Green mussel dominated the diet during November and clam during December (Table 2).

### Variations in Diet Composition in Relation to Fish Size

Small size-classes (<15 cm) mainly consume *Modiolus* spp., while oyster and barnacle preys are dominant in medium size specimens (15-22 cm TL). Adults (>22 cm) tended to consume diverse range of prey species, comprising mostly of crab followed by barnacle and oyster (Table 3).

### Seasonal Occurrence of Different Food Items and Food Preference Index

During the study period, in autumn, the fish preferred crab (26.09%) and barnacle (26.09%). During winter, the fish ingested bivalve (36.53%) and crab (21.15%). During summer, the fish preferred feeding oyster (41.02%) and crab (33.33%). In monsoon season, the fish feed mainly on barnacles (27.91%) and

*Crassostrea* spp. (18.6%). Occurrence of crabs, barnacles, oyster, mussel and shrimp was recorded during all seasons i.e. autumn, winter, monsoon and summer. Crab, barnacles and oysters were the major food items found in the stomach of *A. berda*. The FP index (%) was 23.63 for crabs, 18.67 for barnacles and 18.47 for oyster in the whole period. Other food items included *Modiolus* spp. (9.57%), shrimp (8.81%), mussel (8.30%), clam (6.44%), fish (3.93%), squid (0.69%) and aquatic plants (1.19%) (Table 4).

### Index of Relative Importance

IRI values for barnacles (772) and crab (723) were higher than IRI values for other prey items such as *Modiolus* Spp. (625), *Crassostrea* Spp. (431), Clam (146), *Perna viridis* (129), Shrimp (57), Fish (14), Squid (0.27), Seaweed (0.06) (Table 4).

**Table.1.** Season and feeding activity of *A. berda* (based on percentage of fullness and emptiness)

Months	Number of fishes examined	Total length (cm) (Mean ± SD)	Total weight (g) (Mean ± SD)	% of fullness*	% of emptiness*
January	30	24.05± 4.48	338.03±225.10	83.33	16.66
February	30	25.01±4.05	364.41±218.03	82.14	17.85
March	30	24.11± 5.65	313.50±236.42	88.88	11.11
April	30	26.01±4.15	384.41±208.03	85.01	14.99
May	30	28.30± 4.33	482.79±248.96	91.66	8.33
June	30	26.16± 5.50	430.86±341.96	98	2
July	30	26.75± 4.68	411.26±239.87	87.5	12.5
August	30	25.91± 5.70	400.39±345.70	63.63	36.36
September	30	28.12± 4.63	454.17±256.59	66.66	33.33
October	30	26.19± 4.29	398.44±207.46	30	70
November	30	27.57± 4.83	486.65±285.45	55	45
December	30	26.37±5.20	427.00 ± 301.91	55	45
Average			68.90	31.09	

\*N. B: Fullness includes full, ¾ full and ½ full stomachs. Emptiness includes ¼ full and empty stomachs

**Table 2.** Monthly variations in diet composition of *A. berda* from India during the period from January to December 2016

Months	Primary feed				Secondary feed			Tertiary feed		
	Barnacle	Crab	Oyster	<i>Modiolus</i> spp.	Shrimp	Clam	Mussel	Fish	Aquatic plants	Squid
Jan	15.02	22.7	A	62.28	A	A	A	A	A	A
Feb	6.25	25	A	68.75	A	A	A	A	A	A
Mar	33.33	22.22	11.11	33.33	A	A	A	A	A	A
Apr	28.5	25.72	32.78	13	A	A	A	A	A	A
May	20	28	50	2	A	A	A	A	A	A
Jun	6	32.33	40	2.33	12.33	2.33	2.33	2.33	A	A
July	31.25	31.25	18.75	A	6.25	6.25	6.25	A	A	A
Aug	16.66	5.55	22.22	A	27.77	5.55	5.55	11.11	A	5.55
Sept	44.44	3	10.11	A	21.22	21.22	A	A	A	A
Oct	33.33	25	25	A	16.66	A	A	A	A	A
Nov	16.66	33.33	A	A	A	A	41.66	A	8.33	A
Dec	7.69	4	A	A	7.69	43.15	A	14.38	A	A
Total	259.13	258.1	209.97	181.69	91.92	78.5	55.79	27.82	8.33	5.55
FPI (%)	71.98	71.69	58.32	50.46	25.53	21.80	15.49	7.72	2.31	1.54

\*Remarks: data expressed as percentage, (A) = Absence of food in the gut, FPI-Food preference Index

### Gastro-Somatic Index (GaSI) and Vacuity Index (VI)

The GaSI of *A. berda* had the highest value in the month of January ( $2.65 \pm 2.31$ ) and the lowest in October ( $0.12 \pm 0.31$ ). The maximum value of GaSI was found in summer ( $1.32 \pm 0.33$ ) and its minimum in autumn ( $0.14 \pm 0.39$ ) (Table 6). The annual average of GaSI was  $0.64 \pm 1.07$ . The highest level of VI was observed in October ( $70.17 \pm 4.71$ ) and the lowest in June ( $6.00 \pm 2.71$ ). The annual average VI was  $28.54 \pm 19.8$ . The highest level of VI was observed in autumn ( $55.83$ ) and the lowest level of VI was found in summer ( $8.33$ ) (Table 5). Annual average of vacuity index was  $34.66 \pm 21.5$  exhibiting that *A. berda* was comparatively gluttonous.

### Relationship between the Total Length and Length of the Alimentary Canal

The alimentary canal length ( $29.42 \pm 1.22$  cm) of *A. berda* was more than the total length ( $27.01 \pm 0.76$  cm) (Table 6). The ratio of total length and alimentary canal length was 1: 1.09. The average relative length of gut was  $1.11 \pm 0.11$ .

### Discussion

The food and feeding habits of various sparid fishes have been studied by many authors (Hadj Taieb, Sley, Ghorbel, & Jarboui, 2013; El-Maremie & El-Mor, 2015). Sparids consume a wide range of benthic prey

and occasionally substantial amounts of plant material (Tancioni *et al.*, 2003; Platell *et al.*, 2007). The present study indicates that the sparid, *A. berda* consumes a wide range of food items such as barnacles, crabs, oysters, *Modiolus* spp., shrimps, clams, mussels, fish, squid and aquatic plants which is similar to the feeding habits of other sparid members. The black bream, *A. butcheri* (Munro, 1949) is an opportunistic carnivore which feeds on shellfish, worms, crustaceans, small fish and algae (Holt, 1978; Sarre *et al.*, 2000; Chuwen, 2009). Silver seabream, *Pagrus auratus* (Forster, 1801) was identified feeding on crustaceans, teleosts, echinoderms and molluscs (Ang, 2003; French, Platell, Clarke, & Potter, 2012). Adults of Gilt-head seabream *S. aurata* (Linnaeus, 1758) have diets comprising mostly molluscs, teleosts and crustaceans (Hadj Taieb *et al.*, 2013).

The primary food items (50% > FP) observed in the diet of *A. berda* were barnacles, crabs, *Modiolus* spp. and oysters and the secondary food items (50% > FP > 10%) were shrimp, clam and mussel. Fish, squid and aquatic plants occurred with FP indices of lower than 10, revealing that these items are not the major food items of this fish. Earlier studies also described similarly that the diet of *A. berda* has been wide, feeding on teleost, bottom invertebrates including worms, molluscs, crustaceans, echinoderms, small fishes and plant material (Beumer, 1978; Fischer & Bianchi, 1984; van der Elst, 1988; Fischer *et al.*, 1990). Studies in Durban Bay (Day & Morgans, 1956) found that the diet of *A. berda* consisted of planktonic copepods,

**Table.3.** Variations in Diet Composition for three length categories of *A. Berda*

Food Item	<15 cm (n=60)	15-22 cm (n=60)	>22 cm (n=60)
Crab	7.89	17.24	25
Barnacle	21.05	20.68	19.82
Oyster	26.31	27.58	16.37
Clam	0	0	9.48
Shrimp	7.89	17.24	8.62
Mussel	5.26	3.44	7.75
<i>Modiolus</i> spp.	31.57	13.79	6.89
Fish	0	0	4.31
Squid	0	0	0.86
Aquatic plants	0	0	0.86

**Table 4.** The average Food preference Index (FPI) and Index of Relative Importance (IRI) examined in *A. berda* from January-December 2016 (N =360)

Prey Season	Crab	Barnacle	<i>Modiolus</i> spp.	Oyster	Clam	Mussel	Shrimp	Fish	Squid	Aquatic plants
Winter FPI	21.15	15.38	36.53	3.85	13.46	3.85	1.92	3.85	0	0
Summer FPI	33.33	5.13	2.56	41.02	2.56	2.56	10.26	2.56	0	0
Monsoon FPI	13.95	27.91	0	18.6	9.3	4.65	13.95	9.3	2.32	0
Autumn FPI	26.09	26.09	0	13.04	0	21.73	8.69	0	0	4.35
Annual FPI	23.63	18.67	9.57	18.47	6.44	8.30	8.81	3.93	0.69	1.19
Annual IRI	723	772	625	431	146	129	57	14	0.27	0.06
IRI (%)	24.9	26.64	21.56	14.87	5.04	4.45	1.96	0.48	0.009	0.002

amphipods, polychaetes and bivalves.

The stomach food content of *A. berda* showed monthly and seasonal variations. It is reported that the food spectrum of fishes depends on various factors like prey abundance and habitat (marine, estuarine or mangrove), age of fish, prey energy content, prey size selection and changes in the composition of food organisms occurring at different seasons of the year (Cyrus & Blaber, 1983; Shalloof & Khalifa, 2009; Manon & Hossain, 2011; Hadj Taieb *et al.*, 2013).

The crabs, oyster, barnacles and *Modiolus* spp. are available in plenty along Calicut waters all round the year to constitute the most important preys of this species (Rao, 1974). During autumn the fish preferred feeding crab and barnacle; whereas in winter, the fish ingested on bivalve and crab. In summer, the fish preferred feeding oysters and crabs and in monsoon season, the fish mainly feed on barnacles and oyster. The crab dominated the diet in all seasons and earlier reports shows that mud crabs are available in Korapuzha estuary throughout the year with a peak during December-June (Sarada, 1998).

Clam (*Meretrix* sp.) dominated the diet of *A. berda* during the month of December which coincided with the peak availability backwater clam, *Meretrix casta* during the month of December-January in Korapuzha estuary (Seshapa, 1967). The presence of mussel in the diet during June-August coincide with the reports by Venkataraman and Sreenivasan (1955) stating that the numbers of green mussel in Korapuzha estuary are low in January, but increase slightly in April, reach phenomenal figures in July immediately after the South-West monsoon.

The results of the present study also shows that feeding habits of *A. berda* changes considerably as fish grow. Small size-classes mainly consume *Modiolus* spp., while oyster and barnacle preys are dominant in medium size specimens. Adults tended to consume diverse range of prey species, comprising mostly of

crab followed by barnacle and oyster. Beumer (1978) reported that smaller *A. berda* specimens, do not have well-developed molars but the foliaceous structure of their gill-rakers is efficient in retaining smaller food items whereas adult *A. berda* have sharp, pointed incisors which seize and retain food items, whilst broad, powerful molars crush the food. Therefore in the present study maturing juveniles mainly consumed soft shell bivalves; later undergo dentition changes to the characteristic molariform teeth that assist them in the consumption of hard shell of crab, barnacle and oyster. Differences in feeding structures, relative to fish length may therefore help reduce intraspecific competition between new recruits and growing juveniles of *A. berda* (Harrison, 1990).

The present result was justified with the previous reports stating that size-related change in diet was observed in juveniles, sub-adult and adult fish of *A. berda*. Day, Blaber and Wallace (1981) reported that the diet of juvenile *A. berda* (20-60 mm) is characterized by small prey like zooplankton, mainly amphipods, chironomid larvae, tanaids and small crabs, whereas sub-adults (60-120 mm) focus on feeding larger foods items mainly amphipods, bivalves, gastropods, gobies and weed. Harrison (1990) reported that fry and small juveniles of *A. berda* (< 30 mm S.L.) consumed amphipods, crustacean remains, polychaetes, algal material, fish scales and ostracods. In Durban Bay, Day and Morgans (1956) found that the juveniles of *A. berda* (up to 100 mm) mainly feed on small size planktonic copepods, amphipods polychaetes and bivalves. The adult *A. berda* over 300 mm are observed feeding crabs in its diet (Tobin, Sheaves, & Malony, 1997; Sheaves & Malony, 2000).

Higher intensities of feeding activity of *A. berda* in summer could be related to temperature and maximal abundance of benthic organisms (Pallaro, Santic, & Jardas, 2003). Favourable environmental conditions, or the nutrient enrichment of coastal area, during the

**Table 5.** The average Gastro-somatic Index and Vacuity index examined in *A. berda* from January-December 2016 (N = 360)

Month	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov
Season	Winter			Summer			Monsoon			Autumn		
GaSI	1.16±1.60			1.32±0.33			0.41±0.58			0.14±0.39		
	0.74± 1.24	2.65± 2.31	0.88± 1.15	0.74± 0.72	1.34± 0.45	1.33± 0.41	1.21± 0.23	0.44± 0.40	0.31± 0.69	0.52± 0.51	0.12± 0.31	0.17± 1.14
VI	41.66			8.33			43.66			55.83		
	57.14	38	30	28.57	7.69	10	6	18.75	43.75	60.86	70.17	45

**Table 6:** The mean Total length (TL) and Alimentary canal length (ACL) ratio of *A. Berda*

No. of fish examined	Mean ACL (cm)	Mean TL (cm)	TL:ACL
46	27.02	26.76	1:1.009716
52	29.62	25.91	1:1.143188
55	30.31	28.12	1:1.077881
60	30.14	26.66	1:1.130533
58	30.03	27.58	1:1.088832
	29.42±1.22	27.01±0.76	1: 1.09

warmer months and abundant food supply available over a larger part of the year might have resulted in high feeding activity during summer. More food consumption in summer than in winter was reported by Davis and Warren (1965) from their experiment with *Cottus perplexus*. Feeding intensity is variable with the highest intensity occurring before and after spawning period (January to July). Need for enough energy for the breeding period has probably resulted in an increase in feeding intensities from January to July. Feeding intensity in fishes is negatively related to the percentage of empty stomachs (Bowman & Bowman, 1980; Pallaro *et al.*, 2003) and is synchronized with the spawning seasons (Manon & Hossain, 2011; Salavatian *et al.*, 2011; Sourinejad *et al.*, 2015). Studies on various fish species reported that feeding intensity of fishes increases before and after the reproductive period (Ozyurt, Mavruk, & Kiyaga, 2012; Vahabnezhad *et al.*, 2016).

The highest level of vacuity index was observed in the month of October which coincided with the spawning season of *A. berda*. This may be due to the decreased feeding activity since the mature gonads take up more space in the peritoneal cavity, compressing the stomach and making feeding more difficult (Dadzie, Abou-Seedo, & Al-Qattan, 2000; Sourinejad *et al.*, 2015). The annual cycle of *A. berda* from our observations indicates that the spawning season occur from August to December with peak spawning during October. Hadj Taieb *et al.* (2013) also reported that VI values increased during the spawning season of *Sparus aurata* in the Gulf of Gabes.

In the present study, the highest IRI and FPI is observed for crustaceans followed by bivalves. Beumer (1978) and Harrison (1990) also reported that crustaceans formed the major invertebrate component in the diet of *A. berda* whereas Sheaves and Malony (2000) reported the dominance of Bivalves > gastropods > polychaetes > sesamids in the diet. Crabs contributed more than 50% dry weight to the diets of *Epinephelus suillus*, *Gnathanodon speciosus*, *Lutjanus argentimaculatus* and *Toxotes chatareus* which are mangrove associated fishes from the Embley Estuary in tropical Australia (Salini, Blaber, & Brewer, 1990; Sheaves & Malony, 2000). The same might apply to *A. berda*, an estuarine dependent seabream (Sheaves & Malony, 2000) and their diet might be opportunistic, flexible and alter the feeding ecology necessary for living in estuaries (Harrison, 1990).

From the results obtained there is a possibility of food chain with (1) the detritus base system of Odum and Heald (1975) (mangrove detritus + saprophytes + detritivores + lower consumer + higher consumer) and (2) two trophic interactions of Sheaves and Malony (2000) (mangrove leaves + crabs + fish) in the ecosystem. Since *A. berda* feed extensively on mangrove crabs, it may redirect part of the energy normally recycled by crabs directly into upper levels of estuarine food webs. Larger specimens of *A. berda*

appear to become less piscivorous (4.31% of fish in the diet). The low rate of piscivory is also reported in estuarine phases of *Lutjanus argentimaculatus*, *Epinephelus malabancus* and *E. coioides* which has implications for theories relating to the nursery ground values of mangrove systems (Sheaves & Molony, 2000).

The average relative length of gut in *A. berda* is measured to be  $1.11 \pm 0.11$  cm. Since this value is not much greater than 1, *A. berda* could be considered as an omnivore. Figueiredo, Morato, Barreiros, Afonso, & Santos (2005) reported that many sparids are omnivores in their feeding habit. Further the presence of diets of both animal (crabs, bivalves, barnacle, shrimp, squid) and plant origins (aquatic plants) in diet of *A. berda* confirms that the species is omnivorous.

The present study revealed that *A. berda* is an omnivore feeding mainly on crustaceans and bivalves. The feeding activity of *A. berda* altered according to season and size of fish and is high during pre-spawning and post-spawning seasons. The low incidence of piscivory in *A. berda* support to theories that reduced predation pressure may enhance the nursery ground value of tropical mangrove systems for fishes.

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