The reproductive biology and feeding habits of yellow fin seabream, *Acanthopagrus latus* (Houttuyn, 1782), in the Northern Persian Gulf

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Abstract

Monthly samples of *Acanthopagrus latus* (Hottuyn, 1782) were used to determine (1) feeding habits and (2) reproduction characteristics of the species in relation to its size, spawning season and sex in the Northern part of the Persian Gulf from January to December 2013. The smaller length classes of all samples were dominated by male fish. All gonads examined, were ovotestis during the spawning period from February till May. Male and female ovotestes were dimorphic in structure which represented a transitional stage in a protandrous sex change. Length at first sexual maturity of female *A. latus* was 24.40 cm. *A. latus* fed predominantly on bivalves, gastropods, cephalopods, stomatopods, fish and decapods which showed changes according to the season and body size. According to our results, it appears that *A. latus* feeds throughout the year; the highest value of gastrosomatic index (GaSI) for both sexes was recorded in February, which was significantly different from that in other months. The results of this study also indicate that feeding in yellowfin seabream is very intense before reproduction (during January and February). It decreases gradually after February to June during the spawning season.

Keywords: *Acanthopagrus latus*, Diet, Spawning, Protandrous, Persian Gulf.

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Introduction

Food habits and feeding ecology research are fundamental to understanding fish roles within their ecosystems since they indicate relationships based on feeding resources and indirectly indicate community energy flux (Hajisamaea *et al*., 2003), which allows inferring competition and predation effects on community structure (Krebs, 1999).

The seabream family (Sparidae) inhabits both tropical and temperate coastal waters (Randall,1997). Many species of this family have been shown to be hermaphroditic (Smale, 1988). They typically consume a wide range of benthic prey and occasionally a substantial amount of plant material (Sarre *et al*., 2000; Mariani *et al*., 2002; Tancioni *et al*., 2003; Platell *et al*., 2007).

Acanthopagrus latus is a commercial species in the Persian Gulf and about 3500 tonnes of sparids were landed during 2012 from Iranian waters (Iranian Fisheries Organization, 2013). In addition, *A. latus* has a good potential for mariculture in Iran. Therefore, studies on various aspects of its culture have been carried out (Zakeri *et al*., 2010; Karimi *et al*., 2014).

In spite of its wide distribution and commercial importance, published information on feeding habits and reproductive biology of *A. latus* is limited, but numerous studies attempted to explain population dynamics of Sparid family (Druzhinin, 1976; Hussain and Abdullah, 1977; Edward *et al*., 1985; Morgan, 1985; Lee and Al-Baz, 1989; Mathews and Samuel, 1991; Al-Sakaff and Esseen, 1999; Hoseini and Savari, 2004; Al-Mamry *et al*., 2009).

With regard to this background, the present study was undertaken to examine the feeding habits and reproduction characteristics of this species in relation to size, spawning season and sex. Such information is not only a basic requirement for fisheries management in the study area, but also would be useful for its culture practices.

Materials and methods

The study was undertaken from January 2013 to December 2013 in the Northern part of the Persian Gulf extending from 27°14′to 30°16′N to50°60′to 52°58′E (Fig. 1). Altogether, 435 specimens were obtained from forty five randomly selected stations on a monthly basis using bottom trawl nets. Each specimen was measured to the nearest 0.1 cm body length (FL) and to the nearest 0.01 g for both body weight (TW) and Gonad weight (GW).

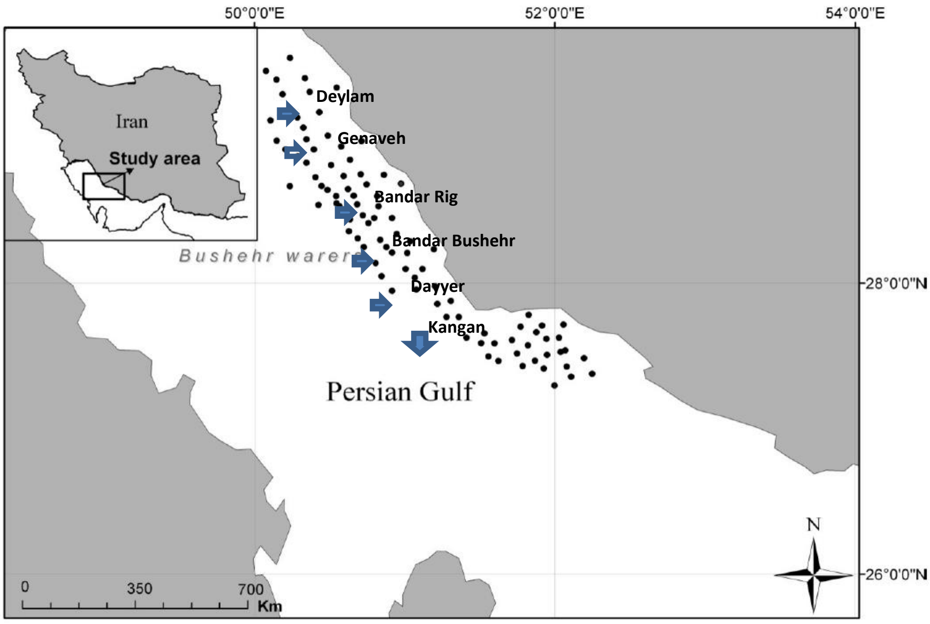

Figure 1: Map of sampling coverage in Bushehr coastal waters.

Sex of each specimen was determined by macroscopic examination of the gonads in the laboratory. The maturity stages of females were assigned macroscopically according to the description of Nikolsky (1963) based on five stages (Table 1), and the spawning period was established from the analysis of two variables: (i) percentage frequency of the maturity stages; (ii) Gonadosomatic index (GSI)=(Gonad weight/ total fresh weight of fish) ×100. The proportion of the two sexes relative to one another was used to calculate the sex ratio.

Fork length of all individuals was used to estimate the size at first maturity (Lm_{50}). The proportions of mature fish were estimated at length classes of 2 cm, and the data fitted by a logistic curve (King, 2007): $P=1/(1+\exp[-r(L-L_m)])$, where, p is the percentage of mature individuals as a function of size class FL, The mature fish was considered from stage III.

To investigate food and feeding habits, the digestive tracts of the sampled fish were immediately removed and preserved in a 4% formalin solution to stop the digestion process. Prior to this, the full stomach was weighed to the nearest 0.01 g. The contents of each stomach and foregut were examined under a microscope and further identification within each taxonomic group was done following appropriate taxonomic identification guides (Jones, 1986; Asadi and Dehghani, 1996; Sadeghi, 2003; Jereb and Roper, 2005). The number of each prey item was recorded. Feeding habits were determined using the indices: (i) frequency of occurrence (%F)=(number of stomachs in which an especial food item was found/total number of full stomachs)×100; (ii) percentage of numerical abundance (%N)=(number of each prey item in all full stomachs/total number of food items observed)×100 (Hyslop, 1980).

The monthly gastrosomatic index (GaSI) was calculated as: GaSI= (fresh weight of stomach / total fresh weight of fish)×100 (Hyslop, 1980). This method is useful for estimating the feeding intensity of fish.

To assess the possible changes in diet with respect to size, the individuals were classified into six size groups based on 6 cm intervals.

The variation of the sex ratio was tested by chi-square test. Parametric independent t-test was applied to determine differences in frequency and abundance between sexes. Statistical differences in monthly GaSI and GSI were also tested by analysis of variance (ANOVA), while Tukey's test was performed at the significance level of a = 0.05 (Zar, 2010).

Table1: Description of macroscopic characteristics of females at each maturity stage.

Stage	Stage name	Macroscopic characteristics
I	Immature or rest	Invisible or very small ovaries (cord shaped), translucent or slightly colored (when resting)
II	Developing	Wider ovaries occupying 1⁄4 to 1⁄3 of body cavity; pinkish or yellow color. Visible oocytes are not present
III	Imminent spawning (mature)	Ovaries occupying 3⁄4 to almost fitting body cavity; opaque with yellow or orange color. Opaque oocytes are visible
VI	spawning	Large ovaries occupying the full body cavity; fully or partially translucent with gelatinous aspect. Hyaline oocytes are visible
V	Spent	Reddish ovary shrunken; Size <2⁄3 of abdominal cavity Flaccid ovary. Some small opaque oocytes

Results

From a total of 435 fish examined, 168 males and 204 females were sexed; 37 individuals belonging to the length class 14.5-19.5 cm FL were immature and 26 fish were intersexual (20-29 cm FL). The smaller classes of all samples were dominated by male fish; and females dominated larger length classes (Fig. 2).

According to monthly percentage evaluation of female maturity stages, spawning females appeared in December, becoming dominant during the winter months and spent females (stage V) were recorded mainly in the spring months. The spawning season was determined after February to May (Fig. 3).

The GSI showed significant differences throughout the year ($p<0.05$), the highest value of GSI was recorded in February, which was significantly different from other months and lowest value was recorded in August. Time series of GSI values per sampling month were plotted for females individually by box and whisker plot (Fig. 4). The GSI value was in accordance with spawning season by maturity stage. The monthly sex ratio on specimens indicated that the dominance of females were from June to the end of October and December. Males were more abundant from January to the end of May (Table 2). The highest percent of female was found in June. The overall ratio of females to males was 1.15: 1 and sex ratio Chi-square analysis showed no significant differences from 1:1 (df=1, $p>0.05$). However, when the samples were analyzed by month, the sex ratios were found to be insignificant in March, July, and November (Table 2). Also, the length at 50% maturity for females (Lm_{50}) was calculated as: 24.40 cm (FL) (Fig. 5).

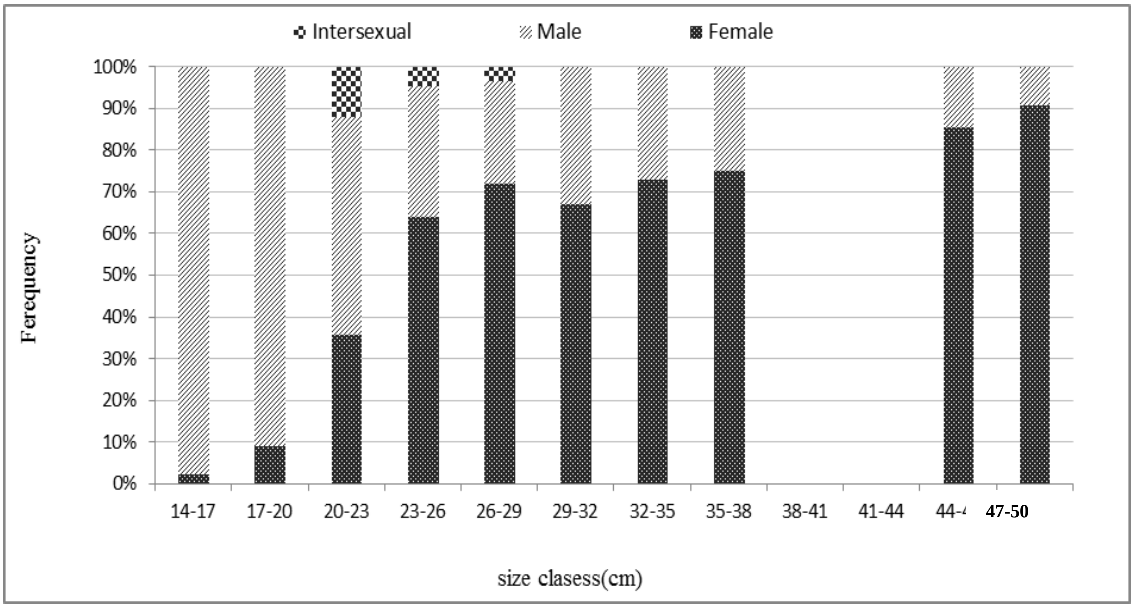

Figure 2: Percentage occurrence of fork length classes for each sex of *Acanthopagrus latus* for the year 2013.

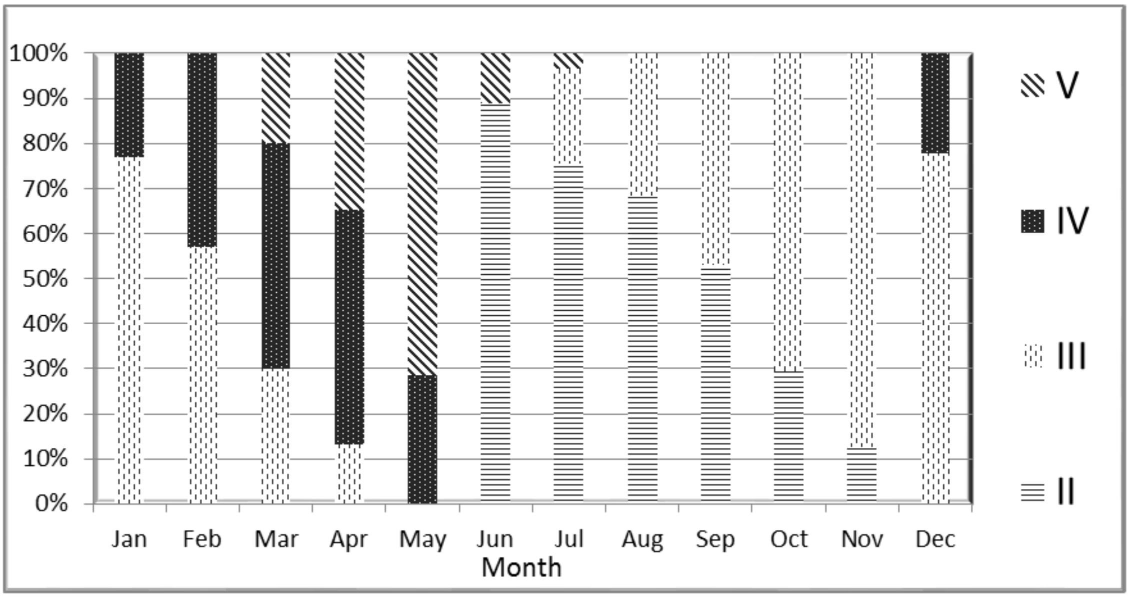

Figure 3: Percentage contribution of the maturity stages of female's *Acanthopagrus latus* for the year 2013.

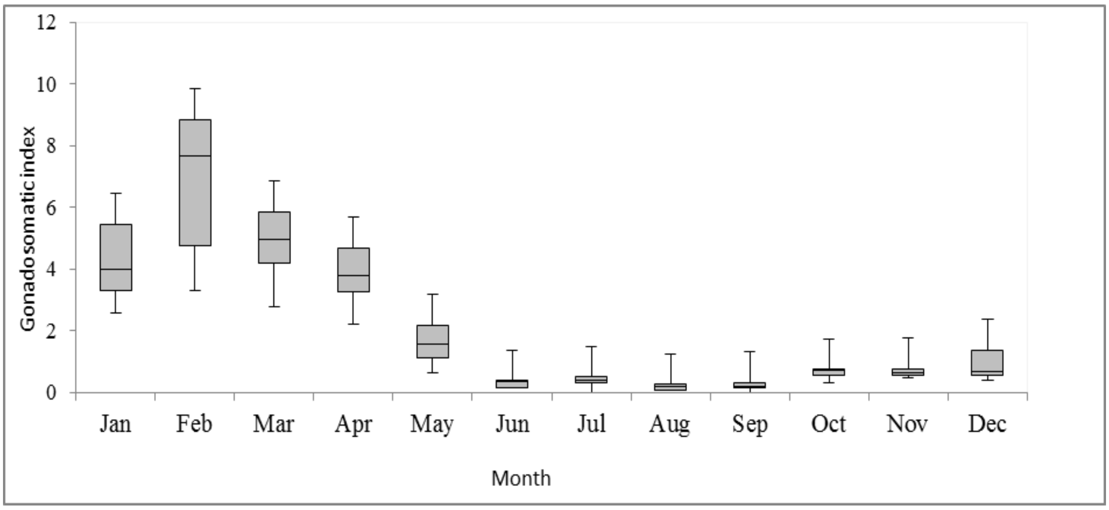

Figure 4: Mean gonadosomatic index (±SE) of female *Acanthopagrus latus* for the year 2013.

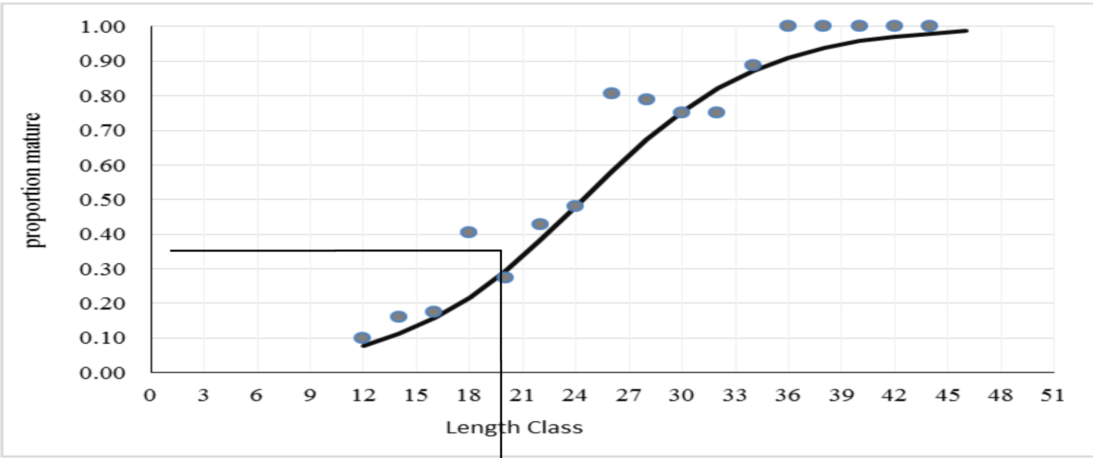

Figure 5: proportion of mature female of varying body lengths of the females of *Acanthopagrus latus.*

Table 2: Monthly variation of sex ratio in *Acanthopagrus latus* for 2013.

Month	No. of fish	Female (observed value)		Male (observed value)		Ratio of female: male	Chi-square significant level
		No.	%	No.	%		
January	30	8	27	22	73	0.36:1	3.79*
February	30	9	30	21	70	0.42:1	4.63*
March	31	15	48	16	52	0.9:1	0.15
April	30	9	30	21	70	0.42:1	4.63*
May	31	12	39	19	61	0.63:1	11.77*
June	30	23	77	7	23	3.28:1	79.05*
July	30	16	53	14	47	1.14:1	1.40
August	41	30	73	11	27	2.72:1	23.69*
September	33	25	76	8	24	3.12:1	31.79*
October	32	21	66	11	34	1.9:1	23.69*
November	33	16	48	17	52	0.9:1	0.11
December	21	15	71	6	29	2.5:1	28.76*

*significant at the 5% level of error or 95% confidence

The GaSI showed no significant differences between the two sexes throughout the year ($p>0.05$), but there were significant monthly variations in the GaSI of both males and females ($p<0.05$). The highest value of GaSI for both sexes was recorded in Feb, which was significantly different from that in other months (Fig. 6).

Table 3: Major diets of *Acanthopagrus latus.*

Category	Species
Stomatopods	
	Squilla mantis
Gastropods	
	Bassina sp.
	Truncatella sp.
	Nassarius sp.
	Nerita sp.
	Cerithiea sp.
	Umbonium sp.
Bivalves	
	Paphia gallus
	Tellina sp.
	Donax sp.
	Solen roseomaculatus
	Irus irus
	Pteria sp.
Scaphopods	
	Dentalium sp.
Decapods	
	Xanthidae
	Portunidae
	Penaeidae
Echinoderms	
	Echinometra sp.
Fish	
	Gerreidae
	Nemipteridae
	Synodontidae
	Engraulidae
Cephalopods	
	Sepia pharaonis
Seaweeds	-

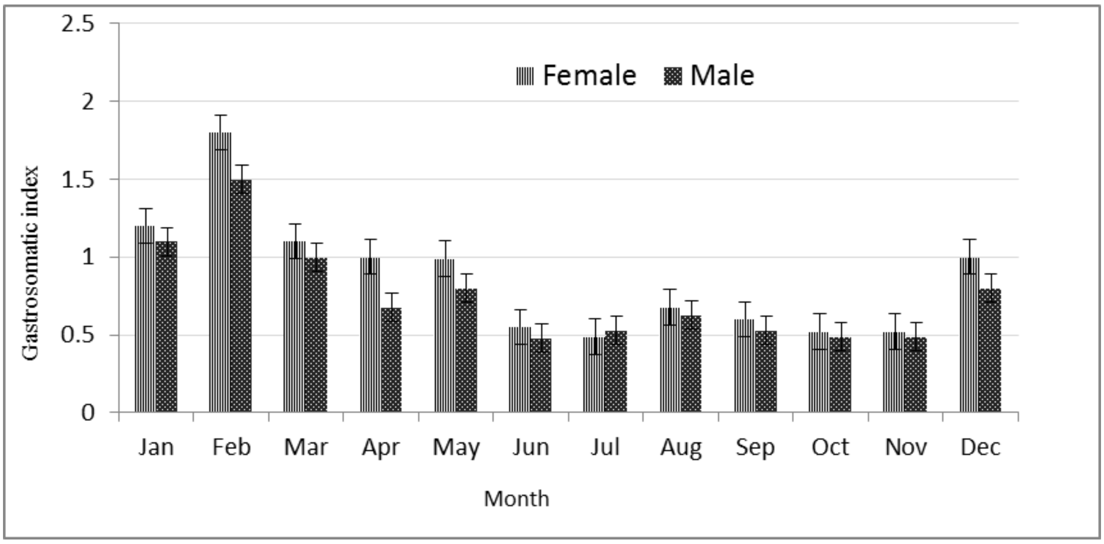

Figure 6: Mean monthly variations in gastrosomatic index (±SE), *Acanthopagrus latus* males and females.

Food regime examination showed that six groups of animals comprised the main food items, dominated by bivalves, gastropods, cephalopods, stomatopods, fish and decapods. Other prey included to a lesser extent were seaweeds, scaphopods and echinoderms (Table 3).

Frequency of occurrence with regard to size-classes for the main prey groups is shown in Fig. 7. Bivalves, decapods and teleostei fish were the most important food items in all size-classes, and constituted the highest frequency (%F) in the larger fish. Gastropods increased when *A. latus* reached 32 cm in length, and then declined so that larger size-classes were absent. Decapods and fish were present in all size-classes. Seaweeds and echinoderms were a part of stomach contents until fish attained 26 cm. One-way ANOVA revealed no significant differences among different size-classes.

Frequency of occurrence (%F) and numerical (%N) composition of different prey items are presented in Table 4. Seasonal variations in the major food items (mollusk, crustacean and fish) in stomach contents were noticed so that a peak in the occurrence of stomatopods (%F=14.28), echinoderms (%F=25.00) occurred in autumn, bivalves (%F=72.61), cephalopods (%F=55.01) and gastropods (%F=44.99) in winter, fish (%F=39.28) and decapods (%F=80.99) in summer (Table 4). Seaweeds only appeared in autumn. Differences in the mean number of prey items were not significant among the seasons. Penaeid shrimp (*Penaeus semisulcatus*) and Gerreidae (fish family) were only recorded in stomachs of males.

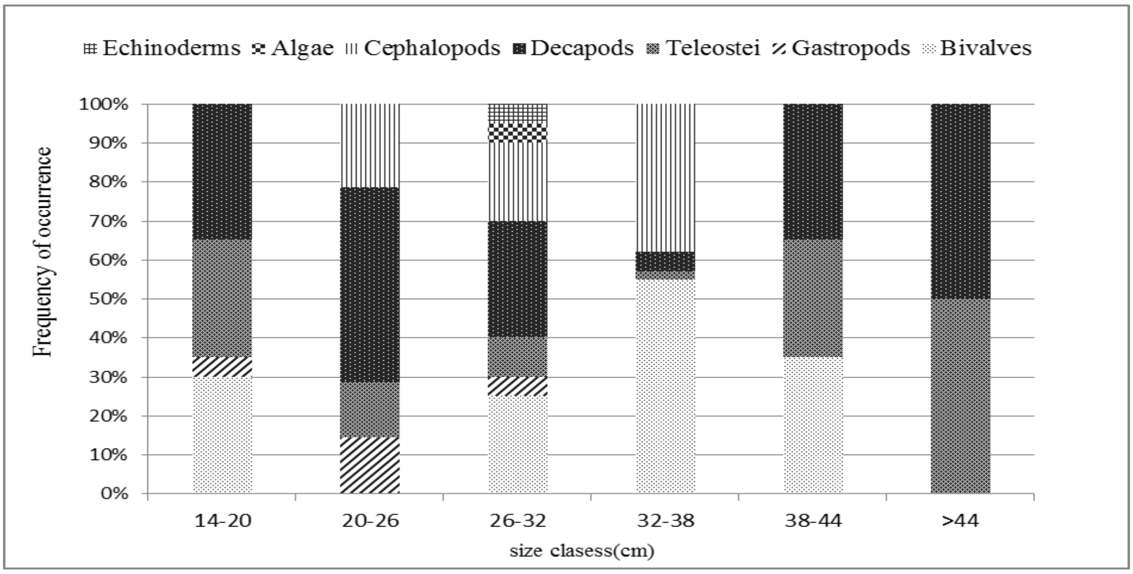

Figure 7: Variations in frequency of occurrence (%F) of food items in relation to size *Acanthopagrus latus.*

Table 4: Seasonal variation of diet based on %F and %N values for both sexes combined in the year 2013.

Food items	**Season**							
	Spring		**Summer**		**Autumn**		**Winter**	
	%F	**%N**	**%F**	**%N**	**%F**	**%N**	**%F**	**%N**
Stomatopods	25.55	34.45	0	0	14.28	1.90	0	0
Bivalves	55.55	65.43	23.97	12.34	38.00	19.95	72.61	44.57
Gastropods	15.60	8.39	10.70	10.63	22.89	10.63	44.99	14.07
Fish	9.99	6.48	39.28	14.05	37.5	14.07	18.90	31.42
Decapods	20.47	16.39	80.99	50.71	15.17	2.31	0	0
Cephalopods	22.71	20.00	0	0	12.50	8.39	55.01	40.71
Echinoderms	0	0	0	0	25.00	11.73	0	0
Seaweed	0	0	0	0	40.87	34.56	0	0

Discussion

According to our data, the males were dominant in small sizes. These results were in accordance with those of Abu-Hakima (1984), Abol-Munafi and Umeda (1994), Abou-Seedo *et al*. (2003) and Hesp *et al*. (2004). Furthermore, according to Abou-Seedo *et al*. (2003) *A. latus* is a gonochorist fish, due to the fact that fish possessed ovotestis and there were no functional females among fish less than 29 cm TL. Hesp *et al*. (2004) found that 54 % of fish with 36–37.90 cm TL had predominant ovarian tissue, while Abol-Munafi (1994) mentioned sex transition to functional female *A. latus* occurred at about 33 cm SL. In general, Buxton and Garratt (1990) reported that sex change of this species is an alternative reproductive style that enables individuals to maximize their lifetime reproductive success by functioning as one sex. From the data on the changes in maturity stages with season, the presence of mature fish indicated that *A.latus* has a prolonged spawning season in the Persian Gulf.

Our study also found that there are still males amongst the larger fish size (Fig.

2). Hesp *et al*. (2004) reported that after the spawning period, the testicular tissue will regress markedly and will become a gonad that is predominantly characterized either by a testicular zone containing spermatids or an ovarian zone containing oocytes. The fish will remain as a female throughout the rest of its life once the fish becomes a functional female.

The annual cycle of the GSI also demonstrated that the spawning season of *A. latus* occurred from February to May. This was in agreement with the study done by Abol-Munafi and Umeda (1994) and Hoseini and Savari (2004). However Abou-Seedo *et al*. (2003), through the analysis of GSI of this species, considered evidence to the effect that although mature individuals occurred in December, their numbers are too low to take into consideration. The greater proportion of individuals begins to spawn in January in Kuwaiti waters. The spawning in January was reported by Abu-Hakima (1984) who also asserted that the activity ends in March. In contrast, however Abou-Seedo *et al*. (2003) observed the end of spawning in April, not in March. Nevertheless, in the Northern Hemisphere, the spawning season of *A. latus* varied markedly based on their localities (Abu-Hakima, 1984; Abou-Seedo *et al*., 2003). Hesp *et al*. (2004) mentioned that in Shark Bay, Australia the spawning period of yellowfin black seabream took place predominantly during a relatively short period in late winter and early spring which is in accordance with our study.

Length at first sexual maturity of female *A. latus* occurred at 24.40 cm which seems to be almost consistent with Lee and Al-Baz (1989) who estimated Lm_{50} as 23.70 cm FL in Kuwaiti waters.

Generally, feeding intensity is negatively related to the percentage of empty stomachs (Bowman and Bowman 1980). According to our results, it appears that *A. latus* feeds throughout the year, but feeding intensity is variable with the highest intensity occurring in February. The suggestion of frequent feeding could perhaps be due to the prolonged desirable environmental conditions and productivity in the region (Ghanbarzadeh *et al*., 2014).

It is well known that the feeding intensity of fish changes in relation to reproductive periods. Many studies of various fish species report that feeding intensity increases before and after the reproductive period (Ozyurt *et al*., 2012).

Analysis of stomach indicated that this species was basically a predator and carnivore. The frequency of occurrence (%F) obtained in the present study demonstrated that the diet composition of *A. latus* in the study area was mainly dependent on crustacean (%F=80.99), bivalves (%F=72.61) and cephalopods (%F=55.01). Bivalves, gastropods, cephalopods, stomatopods, fish and decapods were the main prey items of *A. latus*, perhaps as a result of selective foraging or overall abundance. Thus, xanthidae, portunidae and penaeidae families were dominant in the diets of *A. latus* in their habitat; they made a two times greater volumetric contribution to the diets of *A. latus* in the Persian Gulf (Table 4).

Platell *et al*. (2007) assessed the food preference between fish in two habitats in Shark Bay and found that those in mangrove areas preferred sesarmid crabs and small gastropods while the Mytilid bivalves are preferred by those in rocky areas. These can be explained by the food availability for the populations in different habitats. Hence, sparids typically consume a wide range of benthic prey and occasionally substantial amounts of plant material (Sarre *et al*., 2000; Mariani *et al*., 2002; Tancioni *et al*., 2003; Platell *et al*., 2007). Furthermore, diets of sparid species often differ markedly with respect to location, reflecting the adaptable nature of the feeding behavior of the members of this family (Sarre *et al*., 2000; Mariani *et al*., 2002; Tancioni *et al*., 2003; Platell *et al*., 2007).

For the seasonality changes, the feeding niche showed that the *A. latus* becomes a more generalist feeder in autumn and a more selective feeder in other seasons (Table 4). Presence of some prey items such as cephalopods, echinoderms and seaweeds were affected by season, which are probably due to changes of prey availability in different seasons in the study area. Seasonal variations in the food spectrum were mentioned as being found in the stomachs of other sparids by various authors (Pallaoro *et al*., 2004; Figueiredo *et al*., 2005; Osman and Mahmoud, 2009).

According to our data, the frequency of the three prey groups, bivalves, crustacean and fish, was different by size-classes, and constituted the highest frequency (%F) in the larger size-classes. Crustacean and fish were significantly higher than in all length frequencies. Seaweeds (Alga) and echinoderms were a part of stomach contents until fish attained the 26-32 cm size class, meaning herbivouriness of young fish of this species. As with numerous other fish species, the dietary composition of sparids frequently changes with increasing body size (Platell and Potter, 2001; Osman and Mahmoud, 2009).

The types of food eaten by each sex have been recorded in different fish species (Schoener, 1971; Hixon, 1982; Hoffman, 1983). Pottle and Green (1979) found males were foraging time minimizers relative to females in conditions when both sexes shared the same habitat and morphology. In the present study some prey such as penaeid shrimp and Gerreidae were consumed only by males, but there were high diet overlaps regarding the major prey groups between sexes. Ghanbarzadeh *et al*. (2014) and Sano (1990) suggested the presence of more or less similar niches and a consistency between sexes in spatial overlap.

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