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Feeding habits of blue swimming crab *Portunus segnis* (Forskal, 1775) in the northern coastal waters of Iran

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Abstract

Background: The study of food and feeding habits of crab has manifold importance in fishery sciences. The blue swimming crab *Portunus segnis* is an opportunistic predator and the diet of which depends on local availability of food items. The distribution and biological aspects of crabs are largely dependent on the availability of preferred prey organisms.

Methods: Feeding habits of the blue swimming crab, *P. segnis* were studied in the northern Persian Gulf by trawl nets during the period from May 2010 to April 2012. The stomach contents of 1722 crabs, ranging from 36 to 175 mm carapace width, were analyzed.

Results: The stomach contents appeared to consist of mainly large quantities crustaceans, fish and molluscs, also small quantities of unidentifiable matter and debris. Based on the major food groups were observed in different season, the crustaceans was the most dominant in summer (56 %) and the fish items and Mollusca were the most dominant in autumn (67 %) and winter (45 %) respectively.
In Juvenile and sub adult crabs, crustaceans constituted the dominant food source and these were present in 56.7 % and 45.1 % respectively. In the adult groups and larger size groups, fish were the principal food item and these were present in 44.5 % and 53.5 % respectively, of the stomachs analyzed.
There were no difference observed in the quantity of the food consumed in both sexes and also significant differences observed in the preference for food items in the different size groups.
The crabs without barnacle comparatively voracious with barnacle-carrying crabs. Their diet also increased with increasing ovary stages while that the percentage of empty stomachs in ovigerous females was higher than non-ovigerous females.
The C.V. index varied significantly in both sex that was ranged between 6.9- 56.0 % and 16.5- 48.0 % for male and female, respectively.

Conclusions: This study shows that, despite the diversity in blue crab diets and feeding habits, there are carnivores with a preference for animal food and the behavior of active predators of sessile and slow-moving macro-invertebrates. It is suggested that a major reduction in availability of one prey group would not have a major effect on the crab population.

Keywords: Dietary compositions, Carapace width, *Portunus segnis*, Persian Gulf and Oman Sea, Iran

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Background

According to study by Apel and Spiridonov (1998) about 48 species of Portunid crabs was observed in the Persian Gulf and Oman Sea, that only 4 species including *Scylla serrata* (Forskål, 1775), *Portunus segnis* (Forskal, 1775), *P. sanguinolentus* (Herbst, 1783) and *Charybdis feriata* (Linnaeus, 1758) are important shellfish commodities of commercial fisheries in the south of Iran. The blue swimming carb (*P. segnis*) occur in west Indian Ocean; western Indian Sub-continent, Pakistan, Persian Gulf, Red Sea, Mediterranean Sea and East coast of Africa (Lai et al. 2010).

The study of food and feeding habits of crab has manifold importance in fishery sciences. The distribution, growth, reproduction, behavior and migration rate of crabs are largely dependent on the availability of preferred prey organisms (Sanchez-Paz et al. 2006; Vinagre et al. 2007).

Knowledge of the dietary habits of a species is essential for understanding its nutritional requirements and thus its interactions with other groups of animals. This information is also useful for its successful culture. Crabs include filter feeders, sand cleansers, mud, plant, and carrion feeders, predators, commensals, and parasites (Dall and Moriarty 1983). The crab uses its mouthparts to chop the food into small pieces and then the gastric mill ossicles further reduce the food to unidentifiable fragments. The majority of researchers use the foregut contents to study the quantity and nature of the different food items the crab has consumed (Williams 1981; Sukumaran and Neelakantan 1997; Chande and Mgaya 2004; Josileen 2011).

Previous studies on crab stocks in the northern Persian Gulf have mainly focused on population parameters, estimation biomass and size distribution and reproductive biology of blue swimming crab (Kamrani et al. 2010; Safaie et al. 2013a, b; Safaie et al. 2015) and on some biological aspects of *P.pelagicus* in north western Persian Gulf (Jazayeri et al. 2011; Hosseini et al. 2012). The sole study on Dietary Compositions of the blue swimming crab *P. segnis* have been studied by Pazooki et al. (2012) in Boushehr coastal waters, south Iran.

For several years now, Hormuzgan has been the major fishing ground for *P. segnis* in Iranian waters of the Persian Gulf and Oman Sea. Despite its importance in these fisheries, however, there is no information on the diet and preferred food items of the species from this area. The present study has been undertaken to investigate the food and feeding habits of *P. segnis* along the coast of Hormuzgan and the results of some information in this study may be potentially interesting to trophic studies in this species.

Methods

The crab specimens were collected during daytime by commercial catches of shrimp bottom trawlers in the Hormuzgan area (Fig. 1) extending from 26° 25' N, 57° 29' E to 27° 07' N, 56°06' E. Samples were collected during a period from May 2010 to April 2012.

After recording sex composition and the carapace width (C.W.) and carapace length (C.L.) of the crab, the dorsal side of the body was dissected and the foregut was removed carefully. In order to relation between

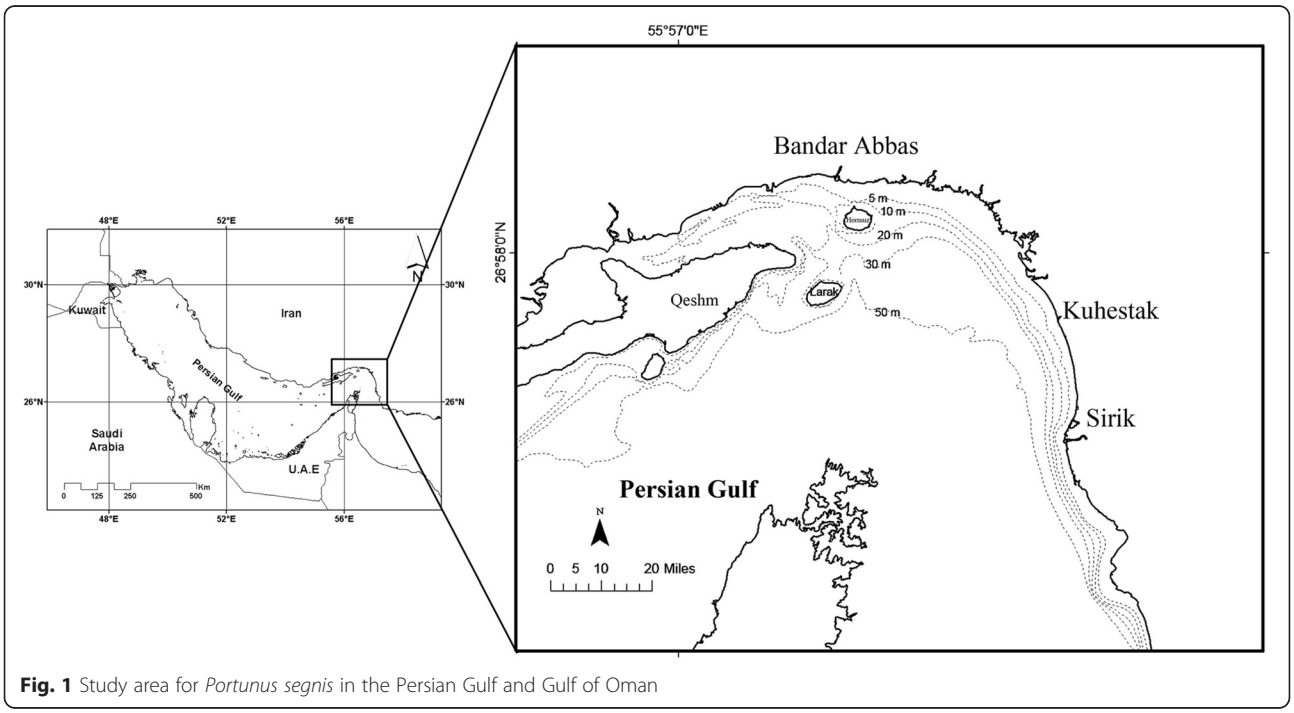

Fig. 1 Study area for *Portunus segnis* in the Persian Gulf and Gulf of Oman

feeding and gonad maturity stage in female crab, after its carapace was opened the maturity stages of the ovaries was recorded. The maturity stages of ovaries were grouped into five stages included four main classes and ovigerous stage (stage 5) following the procedure adopted by Kumar et al. (2000).

The vacuity index (CV) is the percentage ratio between the numbers of empty stomachs *ES* and the total number of stomachs analyzed *TS* (Biswass 1993:

$$CV = \frac{ES}{TS} \times 100$$

The CV indices data were normally distributed, thus the data were kept untransformed. The differences in CV index between different sex and months were determined using two way ANOVA test. Also, one way ANOVA test was used for determined relation between occurrences of barnacle [*Chelonibia patula* (Ranzani, 1820)] on outer surface of carapace and CV index in *P.segnis*.

Studies on food and feeding were adapted from Sukumaran (1995). The fullness of the stomach was visually examined and assessed as 0, 25, 50, 75, or 100 %. The foreguts were preserved in 10 % formalin for a week, prior to being cut open and their contents transferred into Petri dishes with distilled water. The food components of the gut contents were separated and identified under a stereomicroscope.

The most of food items were found to be unidentifiable as a result of having been highly crushed and hence only the hard structures that could be identified were relied upon for determining food composition and further evaluation. Gut contents were broadly classified into five Categories, as follows:

1. Crustacean remains — penaeid shrimp appendages; body parts of crabs and crab eggs and stomatopod parts.
2. Fish remains —fins, scales, bones, and vertebrae.
3. Mollusca remains— parts of bivalve and gastropod shells.
4. Miscellaneous—sea grass, seaweed, foraminifera and unidentified items.
5. Debris— sand, mud and plastic (gillnet fragments).

For each specimen, the whole stomach content was segregated according to food-groups, and each group's contribution was determined visually. Dominance of food groups was evaluated by ranking them by their percentage frequency of occurrence and so-called percentage points (see further below). The percentage frequency of occurrence was estimated as:

$$\frac{No.\ of\ stomachs\ with\ particular\ food\ group \times\ 100}{Total\ no.\ of stomachs\ with\ food}$$

To estimate the volume of the food by food-group, points were assigned to each group as suggested by Stehlik (1993). Percentage points were estimated as:

$$\frac{Point\ of\ particular\ food\ group\ \times 100}{Total\ points\ of allfood\ groups}$$

For the percentage point method, after the stomach was removed it was scored from 1–5, according to the degree of fullness, i.e., approximately 100 %, 75 %, 50 %, 25 % and 0 %. Food categories were given a value ranging from 0–100 according to the percentage of the stomach contents of a given individual represented by that category. The number of points that each category received was weighted according to the actual fullness of the stomach in which it was found. For example, in a stomach that was half full and contained 25 % molluscs and 75 % crustaceans, the molluscs received a score of 12.5 points, the crustaceans a score of 37.5 points.

Results

Out of 1722 individuals (865 male and 857 female) of *P.segnis* were analyzed, in male crabs which 520 (60.12 %) contained (trace-full) stomachs and 345 (39.88 %) empty stomachs and in females 576 (67.21 %) contained and 281 (32.79 %) empty stomachs were observed. The CV index (for both sexes) showed monthly decline fluctuations from October 2010 to September 2011. Also, the highest and lowest values for males were observed in December (56.0) and August (25.6), February (52.6) and September (6.9), September (56.0) and August (6.9) for 2010, 2011 and 2012 respectively. While, in female crabs the order mentioned were observed in November (60.9) and May (18.2), May (38.9) and July (7.1), February (31.3) and March (9.1) (Fig. 2). There was no significant differences between means of vacuity stomachs for both sex in different months, but there was a significant difference ($p < 0.05$) between means of vacuity stomachs of female and male during survey.

The relation between occurrence of barnacle *C. patula* and CV indices, also relation between these indices with ovary maturity stages of *P. segnis* in the study area are given in Figs. 3 and 4. Based on the results presented in Fig. 3, it can be the crabs without barnacle comparatively voracious with barnacle-carrying crabs. Their diet also increased with increasing ovary maturity stage while that the percentage of empty stomachs in ovigerous females (stage 5) was higher than non-ovigerous females (Fig. 4).

The stomach contents of *Portunus segnis* appeared to consist of mainly large quantities crustaceans, fish and

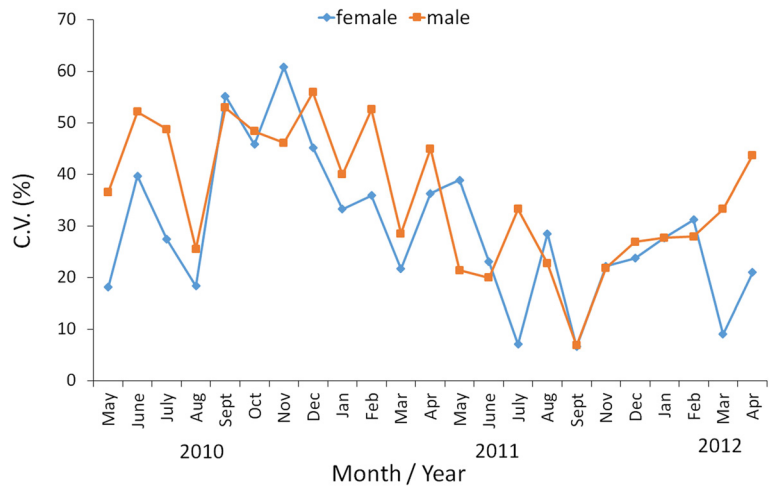

Fig. 2 Monthly fluctuation of CV index of *P. segnis* in the study area

molluscs, also small quantities of unidentifiable matter and debris. Out of the 865 stomachs examined of males, 21.50 % were 100 % full; 13.53 % were 75 % full; 13.76 % were 50 % full; 11.33 % were 25 % full; and 39.88 % were empty. For female crabs (857 stomachs examined), 28.12 % were 100 % full; 17.97 % were 75 % full; 10.85 % were 50 % full; 10.27 % were 25 % full; and 32.79 % were empty. The details by month and according to the size of the crabs are given in Tables 1 and 2.

Whenever food was found in any stomach, it always consisted of a mixture of various food groups. Upon analysis, it was found that the percentage frequency of occurrence of Crustaceans items comprised 49.47 %; Fishes 46.72 %; Molluscs 26.64 %; Miscellaneous 16.07 %; and Debris 15.64 %; (Table 3).

The points of the major food groups (by size and by season) are given in Figs. 5 and 6. In the percentage of points, Crustaceans was the most dominant food group, and was found in 39.84 % of the stomachs 'with food'. This fraction consisted primarily of decapods (parts of shrimps, like rostrum, parts of exoskeleton, appendages; and crab exoskeleton fragments, appendages, and eggs), and further contained the remains of stomatopods (like telson and raptorial claw). In different size groups of crabs, the total of crustacean remains varied between 18.3 and 56.7 %.

The second dominant food item was fish remains. These were present in 38.75 % of the stomachs. The percentage points of 'fish remains' varied between 22 and 53.5 %. Fish food dominated in the stomach contents of

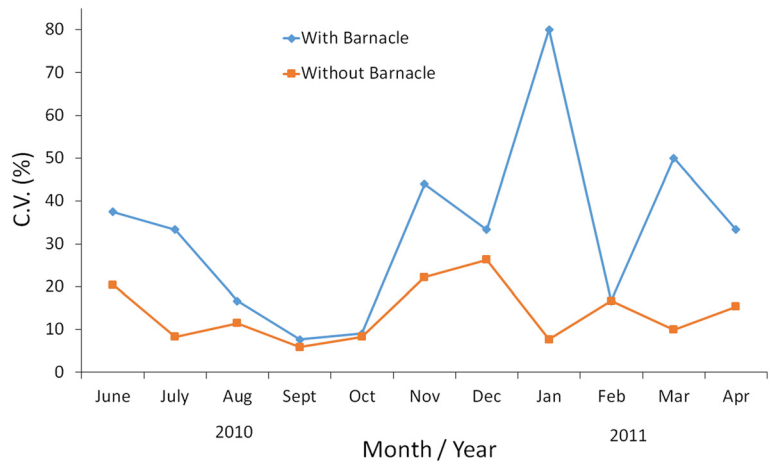

Fig. 3 Monthly effect of occurrence barnacle on CV index of *P. segnis* in the study area

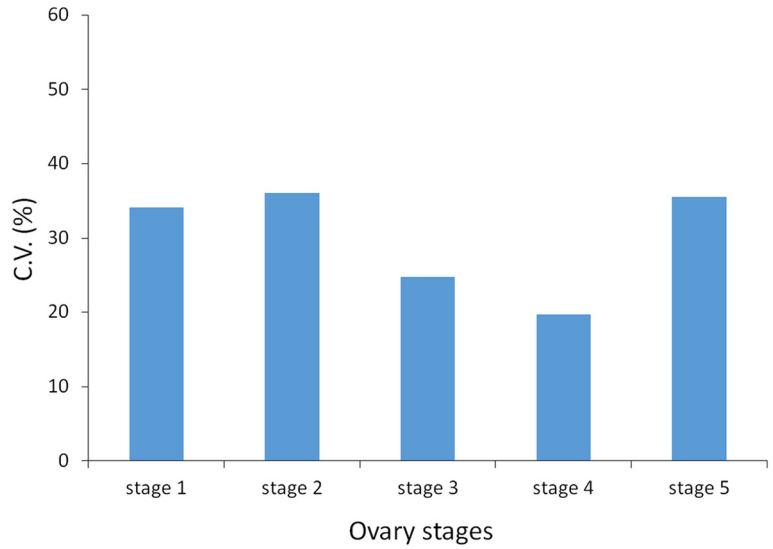

Fig. 4 Relation between CV index and gonad maturity stage of P.segnis in the study area

the larger size groups of the crab (115–144 and 145–174 carapace width in mm). Mollusca formed the third most important food item, mainly comprising shell fragments of bivalves and gastropods. It ranged between 11.6 and 26.8 % in the various size groups and the maximum percentage was observed in the larger size groups (115–144 and 145–174 mm).

The 'miscellaneous' group mainly comprised crushed plant material originating from seaweeds and sea grasses, etc. This group was present in the majority of the stomachs and varied between 1.2 and 9.5 %. Detritus was present in 3.19 % of the stomachs.

Their percentages of points in the different size groups varied between 0.2 and 56.7 %. In Juvenile crabs (<85 mm CW) appeared to prefer crustaceans (56.7 %) followed by fish (22 %), Mollusca (11.6 %) and miscellaneous items (8.7 %). In the sub adult group (86–115 mm CW), crustaceans (45.1 %) were the major food item followed by fish (31 %), Mollusca (13.5 %), miscellaneous and debris items (9.5 %) and (0.9 %) respectively. In adult groups (116–145 and 146–175 mm), fish were the principal food item, however in the larger size group of adults (141–180 mm), Mollusca formed the second most important food item.

The points of major food groups by season (Fig. 6), crustaceans was the most dominant in summer, and was found in 56 % of the stomachs with food, Whereas the other large quantities, the fish items and Mollusca were the most dominant in autumn (67 %) and winter (45 %) respectively. The other food items include miscellaneous and detritus, were the most abundant in spring (15.5 %) and winter (15 %) respectively. There were no significant differences in the preference for food items in the different season of the crab ($P > 0.05$).

Discussion

Knowledge of feeding regimes of species is of great importance in understanding their ecological interaction. Understanding crab feeding habits requires extensive field and laboratory studies to infer the main sources of nutrition for a species. Even then, feeding studies can identify the prevalence of food items but it is not possible to assess the diet preferences of crab without detailed complementary studies to estimate the range and abundance of potential food items available in their natural environment (Biswass 1993).

In this research, the C.V. index for the whole study period was ranged between 6.9–56 % and 16.5–48 % for male and female respectively. Also the means of vacuity varied significantly in both sex, implying a high feeding rate or a slow digestion rate in this species.

The result showed that *P. segnis* is an omnivorous species; this conforms with the findings of several respects to the diet of other portunid crabs. Pazooki et al. (2012) and Josileen (2011) were reported for similar species and *P.pelagicus* respectively, that those species have similar diet component. The research results showed that they are all opportunistic omnivores with a preference for animal prey, but within that framework only rarely feed on more mobile prey such as fish and prawns (Patel et al. 1979; Williams 1982). In the present study, it is observed that crustaceans constitute the most favored item in this species' diet, followed by fish and molluscs. This conforms to

Table 1 Stomach fullness during various months in *Portunus segnis*

Year/ Month		Male						Female					
		Percentage (%)					Total crab	Percentage (%)					Total crab
		Empty	25 %	50 %	75 %	Full		Empty	25 %	50 %	75 %	Full	
2010	May	36.6	4.9	22.0	9.8	26.8	41	18.2	0.0	31.8	36.4	13.6	22
	June	52.2	2.9	29.0	2.9	13.0	69	39.7	17.5	3.2	14.3	25.4	63
	July	48.8	0.0	7.3	15.9	28.0	82	27.5	7.8	15.7	13.7	35.3	102
	Aug	25.6	1.1	8.9	18.9	45.6	90	18.4	0.0	4.6	11.5	65.5	87
	Sept	53.0	4.3	6.0	9.4	27.4	117	55.2	0.0	2.1	13.5	29.2	96
	Oct	48.4	8.1	29.0	9.7	4.8	62	45.9	0.0	9.4	36.5	8.2	85
	Nov	46.2	23.1	0.0	15.4	15.4	13	60.9	26.1	4.3	8.7	0.0	23
	Dec	56.0	22.0	4.0	12.0	6.0	50	45.2	23.8	11.9	14.3	4.8	42
2011	Jan	40.0	30.0	0.0	10.0	20.0	10	33.3	26.7	13.3	0.0	26.7	15
	Feb	52.6	26.3	5.3	5.3	10.5	19	36.0	16.0	20.0	8.0	20.0	25
	Mar	28.6	14.3	7.1	21.4	28.6	14	21.7	17.4	21.7	30.4	8.7	23
	Apr	45.0	30.0	8.3	11.7	5.0	60	36.4	24.2	9.1	6.1	24.2	33
	May	21.4	42.9	14.3	21.4	0.0	14	38.9	16.7	22.2	16.7	5.6	18
	June	20.0	16.0	12.0	24.0	28.0	25	23.1	7.7	11.5	17.3	40.4	52
	July	33.3	0.0	33.3	8.3	25.0	12	0.0	0.0	7.7	15.4	76.9	13
	Aug	22.7	31.8	18.2	4.5	22.7	22	28.6	17.1	8.6	20.0	25.7	35
	Sept	6.9	6.9	20.7	20.7	44.8	29	6.7	0.0	13.3	30.0	50.0	30
	Oct												
	Nov	21.9	3.1	9.4	31.3	34.4	32	22.2	11.1	33.3	11.1	22.2	9
	Dec	26.9	11.5	15.4	26.9	19.2	26	23.8	38.1	0.0	23.8	14.3	21
2012	Jan	27.8	22.2	16.7	16.7	16.7	18	27.8	16.7	22.2	16.7	16.7	18
	Feb	28.0	12.0	32.0	20.0	8.0	25	31.3	31.3	18.8	12.5	6.3	16
	Mar	33.3	0.0	0.0	33.3	33.3	3	0.0	0.0	0.0	30.0	70.0	10
	Apr	43.8	34.4	15.6	3.1	3.1	32	21.1	15.8	26.3	31.6	5.3	19
Total		39.9	11.3	13.8	13.5	21.5	865	32.8	10.3	10.9	17.8	28.1	857

Table 2 Stomach fullness in different size groups (Carapace width in mm) of *Portunus segnis*

Size class	Male						Female					
	Percentage (%)					Total crab	Percentage (%)					Total crab
	Empty	25 %	50 %	75 %	Full		Empty	25 %	50 %	75 %	Full	
36 – 55	28.6	7.1	14.3	14.3	35.7	14	60.0	0.0	0.0	40.0	0.0	11
56 – 75	52.1	6.3	8.3	16.7	16.7	48	52.9	13.7	9.8	9.8	13.7	49
76 – 95	37.7	10.4	15.6	13.0	23.4	154	31.5	6.5	13.7	16.9	31.5	124
96 – 115	41.9	10.5	14.3	11.2	22.1	256	32.7	8.9	7.3	21.4	29.8	246
116 – 135	38.4	11.0	13.9	15.2	21.5	236	35.1	10.3	9.5	14.5	30.5	263
136 – 155	36.3	16.9	12.9	15.3	18.5	123	26.8	17.0	13.4	19.6	23.2	112
156 – 175	44.1	11.8	8.8	11.8	23.5	34	17.3	7.7	23.1	25.0	26.9	52
Total	40.0	11.3	13.8	13.6	21.7	865	32.8	10.2	10.7	18.0	28.0	857

Table 3 Percentage of points and frequency of occurrence of major food groups in *Portunus segnis*

Items	Points	% of Points	% of frequency of occurrence
Crustacean	9979	39.84	49.47
Fish	9706	38.75	46.72
Mollusscan	3460	13.81	26.64
Miscellanous	1103	4.40	16.07
Debris	800	3.19	15.64

the findings of Patel et al. (1979) and Sukumaran and Neelakantan (1997) for *P.pelagicus*, while also Pazooki et al. (2012) reported the crustaceans constitute the most favored item, followed by molluscs and fish in Boushehr coastal waters for *P.segnis.* Chande and Mgaya (2004) reported that molluscs, particularly the bivalve *Arcuatula arcuatula* (Hanley, 1843), were the most important food items in the stomachs of *P. pelagicus* along the coast of Dar es Salaam, Tanzania. Al-Behbehani (2007), also reported that molluscs and crustaceans were the dominant food items in the stomachs of *P. pelagicus* from Kuwait waters.

The wide foraging strategy of *P. segnis* is also typical of other portunid crabs. All species studied so far have been reported to consume mixed diets of crustaceans, fishes and molluscs, similar to *P. segnis* (e.g., *Scylla serrata*: Hill 1976; *Callinectes sapidus*: Laughlin 1982; *Scylla tranquebarica* and *S. serrata*: Joel and Raj 1986; *S. serrata*: Prasad and Neelakantan 1988; *Thalamita crenata*: Cannicci et al. 1996).

The considerable amount of detritus in their guts has shown that *P. segnis* is also an opportunistic deposit feeder, just as reported by Prasad and Neelakantan (1988) for *Scylla serrata* and for *P.pelagicus* (Josileen 2011). The detrital energy assimilated by the crab population is thus converted partly into body tissues (Macintosh 1984). Many portunids also consume small quantities of macrophytes. The adults of *Necora puber* (Linnaeus, 1767) are found to consume plant material (brown algae) even by preference (Choy 1986). Grapsid, xanthoid, majid, potamid, and portunid crabs (in portunids particularly juveniles) have also been reported to consume plant material (Hill 1976; Paul 1981; Jewett and Feder 1982; Williams 1982; Rosas et al. 1994). In the present study, the stomach contents of juveniles and of sub-adult crabs contained semi-digested plant material, like remains of seaweeds and sea grasses mixed with sand, mud and gravel. Josileen (2011) and Patel et al. (1979) have reported the presence of fair amounts of organic matter mixed with sand, mud, gravel, and other bottom particles, which indicates the species' bottom feeding habits in its bottom habitat.

There was no difference observed in the quantity of the food consumed by males and females of *P.segnis* in this study, as also reported earlier by Williams (1981), Jewett and Feder (1982), Sumpton and Smith (1990), Wieczorek and Hooper (1995) and josileen (2011) for *P.pelagicus*.

The majority of crabs with empty stomachs encountered during the study were either in berried condition.

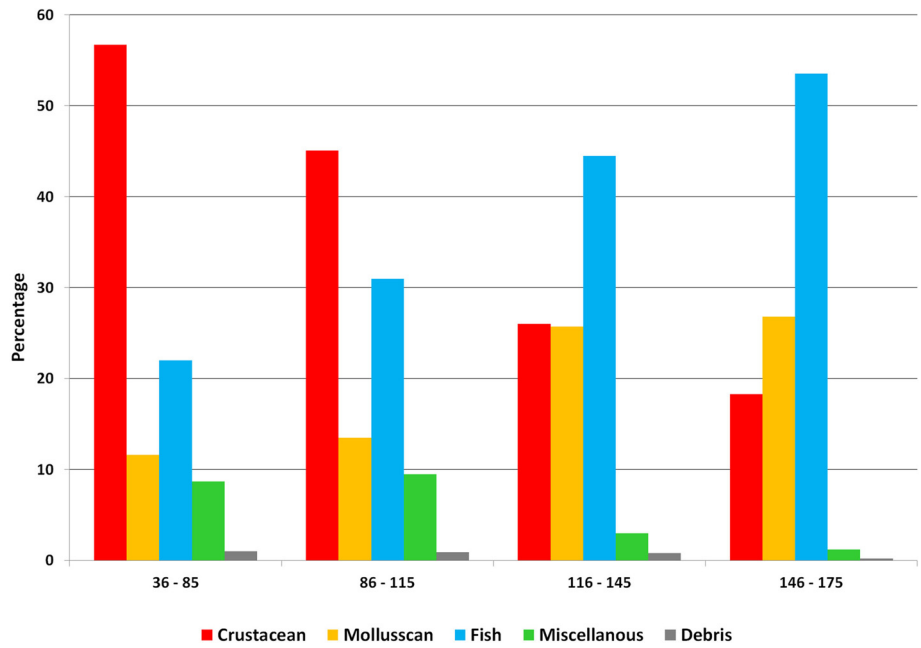

Fig. 5 Points of major food groups in various size groups of *Portunus segnis*

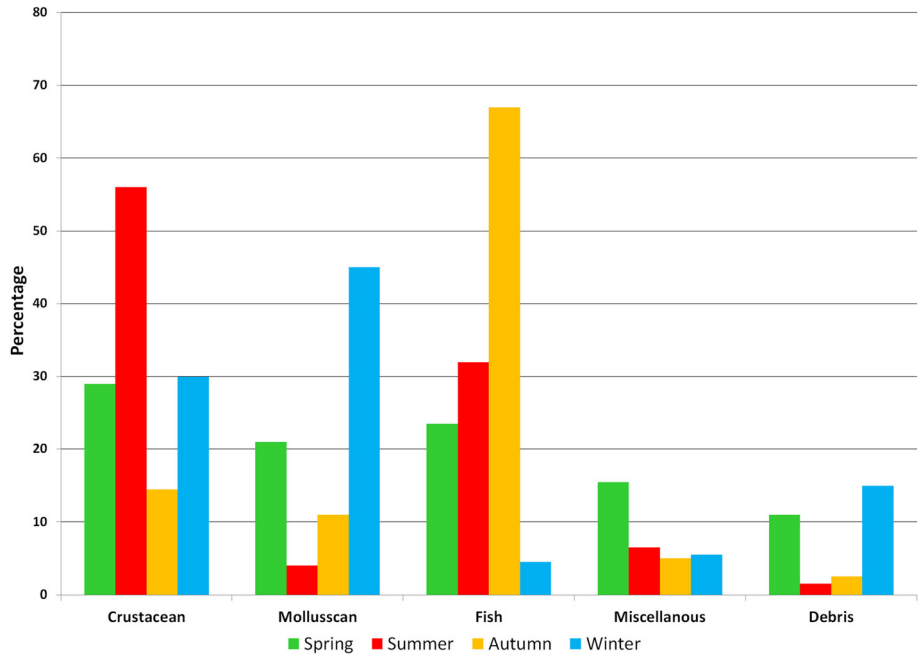

Fig. 6 Points of major food groups during various seasons in *Portunus segnis*

Choy (1986) also reported empty stomachs in ovigerous females and in parasitized crabs. Jewett and Feder (1982) reported that feeding increases during spring in the king crab, *Paralithodes camtschaticus*. However, in *Portunus segnis* no such variation was observed, as Iran is, of course, a tropical country and consequently does not have such sharp seasonal differentiation.

It is not possible to deduce from stomach contents whether a prey item was alive or not when consumed. Caine (1974) had explained a prey catching mechanism in the portunid crab, *Ovalipes guadulpensis* Rathbun, 1930, but Hill (1976) was unable to observe such a technique in *Scylla serrata*. Prasad et al. (1985) have observed mud crabs catching live prawns in a prawn culture field during harvesting seasons. Hence, the incidence of animal remains in the gut contents may indicate that the crabs might have opted for dead and decaying material by scavenging. Yet, the presence of crab exoskeleton matter in the stomach contents also shows that they are cannibalistic. Cannibalism was observed on several occasions in the rearing tanks, especially during moulting when the bodies of the newly moulted crabs are soft and vulnerable to attack by the hard-shelled crabs. In the present study, it was observed during several occasions that crabs were consuming the exuviae of other crabs. Hence there are ample chances that the crab remains recorded from the stomachs may be the result of cannibalistic consumption. Thus, the present study, as earlier related studies, suggests that, despite the diversity in crab diets and feeding habits, portunid crabs are opportunistic omnivores with a preference for animal food, also along the coast of Hormuzgan, Iran.

Conclusions

Given the results of present study and other similar studies cited above strongly suggest that crustaceans, molluscs and fishes were the most commonly ingested items throughout the study period. Thus, the present study, as earlier related studies, suggests that, despite the diversity in crab diets and feeding habits, portunid crabs are carnivores with a preference for animal food and the behavior of active predators of sessile and slow-moving macro-invertebrates. This study also shows that blue swimming crab *P. segnis* consumes a variety of food items. It is suggested that a major reduction in availability of one prey group would not have a major effect on the crab population.

Abbreviations

Not applicable.

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Authors' contributions
The author read and approved the final manuscript. Also, agree to publish my manuscript in the Marine Biodiversity records Journal.

Competing interests
The author declares that he has no competing interests.

Consent for publication
Not applicable.

Ethics approval and consent to participate
In this study all examined specimens were by catch and discard materials.

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