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Natural Diet of Two Commercial Crab Species, *Portunus segnis* (Forskål, 1775) and *P. sanguinolentus* (Herbst, 1783), in the Coastal Waters of Karachi

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Abstract: Stomach contents of 558 *Portunus segnis* (Forskål, 1775) and 426 *P. sanguinolentus* (Herbst, 1783), from coastal waters of Karachi were examined. Crabs were collected from Korangi Creek, Karachi from January 2004 to December 2005. The frequency of occurrence and points methods were used for the stomach contents analysis. Out of 558 *P. segnis* and 426 *P. sanguinolentus*, 254 (45.52%) and 227 (53.3%) crabs had empty stomach, respectively. Mollusca and Crustacea dominated the diet of both the species. According to points method Mollusca and Crustacea scored 67.28% and 53.8% points in *P. segnis* and *P. sanguinolentus*, respectively. When analyzed by frequency of occurrence method Mollusca and Crustacea occurred in 88.37% and 71.4% stomachs in *P. segnis* and *P. sanguinolentus*, respectively. Majority of the Mollusca eaten by *P. segnis* and *P. sanguinolentus* were small soft-shelled bivalves while Crustacea included mostly small crabs. Small fish, shrimps, polychaete worms, sponges, starfishes, brittle stars, bryozoans, and plant (algae) materials were also present in some stomachs in small quantity. Results of the present study suggest that the two crab species are opportunistic predator competing for food in the natural environment.

Keywords: Stomach Content, Portunid Crabs, Pakistan

1. Introduction

Portunus segnis (Forskål, 1775) and *P. sanguinolentus* (Herbst, 1783) are commercial crabs and belong to family Portunidae. Previously *P. segnis* was reported as *P. pelagicus* (Linnaeus, 1758) from the Western Indian Ocean including Pakistan (5, 6, 9, 10, 12, 20). However, [11] revised the *P. pelagicus* species complex and recognized four species on the basis of morphology, DNA characters and geographical distribution. According to them *P. segnis* occurs from Pakistan to South Africa while *P. pelagicus* sensu stricto is found in Southeast and East Asia.

Portunus segnis and *P. sanguinolentus* posses long slim sharp-toothed chelae which are well adapted for the rapid snapping movements. They may hide in the sand and capture a passing prey with the rapid upward snatch. Their chelae are also suited for feeding burrowing bivalves which have soft shell such as species of *Mercenaria*, *Mya*, *Donax* etc. but are less able to crack large shells. They can however feed on large shell by inserting the tip of their chelae into the aperture of a gastropod or between the valves of a bivalve. They also feed on carrion but this constitutes very small part of their diet.

Stomach content of a species can provide information about its natural diet, its interaction with other organisms living sympatrically, its nutritional requirement and its potential for culture [3]. Crab's stomach has two parts, a large anterior cardiac stomach and a smaller posterior pyloric stomach. Contents in the cardiac stomach are usually identifiable as the digestion here is less advanced. The analysis of stomach contents usually involves a quantitative and qualitative determination of the kinds and amounts of

food consumed. There are several methods of analyzing and presenting the data of stomach contents (see [8, 17, 18]), but in case of crabs usually the occurrence method and point method are used [22]). In occurrence method the number of crab in which each food item occurs is recorded and expressed as a percentage of total number of crab examined. In points method the food items in each stomach are allotted points on the basis of their quantity as judge by eye or rough counts. In doing so the fullness of each stomach is also taken into account [8].

The natural diet of *P. segnis* has received much attention as compared to that of *P. sanguinolentus.* The stomach contents of *P. segnis* were studied by [1, 3, 25], as *P. pelagicus*; [7, 14, 16]. These studies indicate that *P. segnis* ingest a variety of food items and it is predominantly carnivorous. The stomach contents of *P. sanguinelentus* were studied by [19, 24] and they describe it as largely carnivores.

The stomachs content of *P. segnis* and *P. sanguinolentus* have never been studied from Pakistani waters although these crabs abound our coastal waters and are important commercially. The two species of *Portunus* share the same habitat and it is likely that they also compete for the food. The present study was therefore undertaken to examine the composition of natural diet of *P. segnis* and *P. sanguinolentus* occurring in our coastal waters.

2. Materials and Methods

2.1. Sample Source

A total of 984 crabs, collected during January 2004 to December 2005, were examined. These crabs were collected early in the morning by local fishers and were preserved in 10% formalin on the spot. Crabs were measured and sexed in the laboratory. Food items were recorded to the lowest possible taxonomic level and later grouped under nine dietary categories: bivalves, gastropods, crabs, other crustaceans, fishes, other animals, plants materials, detritus, and unidentified food items.

2.2. Measurement and Preservation

Measurement of short carapace width (SCW) was taken from the bases of the long 9th antero-lateral teeth which form long spines. Crabs with a missing cheliped or with soft carapace were not included in the analysis of stomach contents. Dissection was performed on the day of collection and the stomachs were preserved in 5% buffered formalin. The stomach contents were examined as soon as possible and always within a week from the date of collection.

2.3. Data Analysis

Percent point and percent occurrence of each food item were calculated as given by [22]. The following percentages were calculated for each food taxa as given by [22]:

$$\text{Percentage point for i}^{th}\text{prey} = \sum_{j=1} a_{ij} \times 100/A$$

$$\text{Percentage occurrence for i}^{th}\text{ prey} = b_i \text{ X } 100 / N$$

where a_{ij} is the number of points of food taxa i in the stomach of j crabs; n is the number of crabs in the sample excluding crabs with empty stomach; $A = \sum_{i=j}^{s} \sum_{j=1}^{n} a_{ij} = total$ number of points for all crabs and all food categories in the sample; s is the number of food categories and b_i is the number of crabs whose stomach contained food category i.

3. Results

Stomach contents of 558 P. *segnis* and 426 *P. sanguinolentus* were examined. Dietary items found in the cardiac stomach were grouped into nine categories (Table 1).

Table 1. *Food categories (abbreviations in parentheses) and types of remains found in the cardiac stomach of Portunus segnis and P. sanguinolentus.*

Food categories	Types of fragments found in cardiac stomach
Bivalve (BIV)	Shell pieces (some with attached muscles, umbo, cardinal teeth); sometimes small whole animal.
Gastropod (GAS)	Opercula (complete or pieces), shell pieces (some with part of helical coil), radulae; rarely small whole animal.
Crabs (CRB)	Pieces of appendages (chelae, dactylus, etc.) carapace (orbits with or without eyes, front etc.) and abdomen.
Other Crustaceans (OCR)	Pieces of shrimp appendages (chelae, telson, uropod etc.), shrimp carapace, rostrum and abdomen. Pieces of isopods and amphipods body with appendages, barnacles (pieces of shell, tergum, scutum and appendages).
Fishes (FIS)	Scales, vertebrae, slender bones of ribs and fin-rays.
Other animals (OTH)	Chaetae (simple, compound), acicula and jaws of polychaetes. Spicules of sponges (translucent, reflecting), pieces of bryozoan, hydroids (branching, plant like structures), pieces (mostly polygonal) of brittle stars and starfishes etc.
Plant materials (PLT)	Small, chopped pieces of seaweeds.
Detritus (DET)	Organic debris, sands.
Unidentified (UNI)	Unidentified items of animals remain.

3.1. Portunus Segnis

Out of 558 crabs examined for stomach contents, only 254 (or 45.52%) crabs had empty stomach while 304 (or 54.48%) crab had food remains in their stomach (Table 2). Size of the crabs with food in stomach ranged from 23 to 148 mm SCW whereas those with empty stomach ranged from 27 to 140 mm SCW. No difference was observed between the size of the crab and the presence or absence of food in the stomach. Only 22.37% crabs (that is 68 out of 304) had 25% full stomach while remaining 77.63% had 50% to 100% full stomach (Table 2).

Table 2. *Portunus segnis: feeding intensity in different months from January 2004 to December 2005 (N= number of crab examined).*

Months	N	Crabs with Empty stomach		Crabs with food in stomach		Fullness of Stomach							
		No.	%	No.	%	100% Full		75% Full		50% Full		25% Full	
						No.	%	No.	%	No.	%	No.	%
January, 04	28	10	35.7	18	64.3	10	55.5	2	11.1	3	16.7	3	16.7
February, 04	81	16	19.8	65	80.2	17	26.2	15	23.1	23	35.4	10	15.4
March, 04	18	11	61.1	7	38.9	5	71.4	0	0	0	0	2	28.6
April, 04	22	15	68.2	7	31.8	4	57.1	2	28.6	0	0	1	14.3
May, 04	28	13	46.4	15	53.6	3	20.0	3	20.0	6	40.0	3	20.0
June, 04	18	9	50	9	50	0	0	0	0	4	44.4	5	55.6
July, 04	12	6	50	6	50	4	66.6	1	16.7	0	0	1	16.7
August, 04	7	4	57.2	3	42.9	1	33.3	1	33.3	1	33.3	0	0
September, 04	17	11	64.7	6	35.3	3	50.0	0	0	1	16.7	2	33.3
October, 04	29	13	44.8	16	55.2	5	31.3	3	18.6	6	37.5	2	12.5
November, 04	27	14	51.9	13	48.1	3	23.1	1	7.7	4	30.8	5	38.5
December, 04	19	9	47.4	10	52.6	1	10.0	3	30.0	5	50.0	1	10.0
January, 05	15	5	33.3	10	66.7	5	50.0	1	10.0	2	20.0	2	20.0
February, 05	25	5	72.4	20	27.6	2	10.0	8	40.0	10	50.0	0	0
March, 05	29	21	20	8	80	2	25.0	0	0	2	25.0	4	50.0
April, 05	21	17	80.9	4	19.0	2	50.0	1	25.0	1	25.0	0	0
May, 05	28	15	53.6	13	46.4	5	38.5	1	7.7	7	53.9	0	0
June, 05	24	10	41.7	14	58.3	3	21.4	2	14.3	6	42.9	3	21.4
July, 05	18	12	66.7	6	33.3	2	33.3	1	16.7	0	0	3	50.0
August, 05	15	7	43.7	8	53.3	1	12.5	3	37.5	3	37.5	1	12.5
September, 05	13	5	38.5	8	61.5	2	25.0	1	12.5	2	25.0	3	37.5
October, 05	25	9	80.9	16	19.1	5	31.3	2	12.5	3	18.8	6	37.5
November, 05	22	10	45.5	12	54.5	2	16.7	3	25.0	2	16.7	5	41.7
December, 05	17	7	41.2	10	58.8	0	0	0	0	4	40.0	6	60.0
Total	558	254	45.5	304	55.5	87	28.6	54	17.8	95	31.3	68	22.4

Analysis of food items according to percent point and percent occurrence methods are given below.

3.1.1. Percent Point

According to this method, bivalves were found as the most commonly ingested food items occupying the score of 27.6% (Figure 1). Crustacean (crabs, shrimps etc.) was the next highest ingested food item with a score of 27.01% (18.29+8.72 = 27.01%). This was followed by gastropod (12.6%) and fishes (5.10%). Plant materials were ingested in small quantities (3.84%).

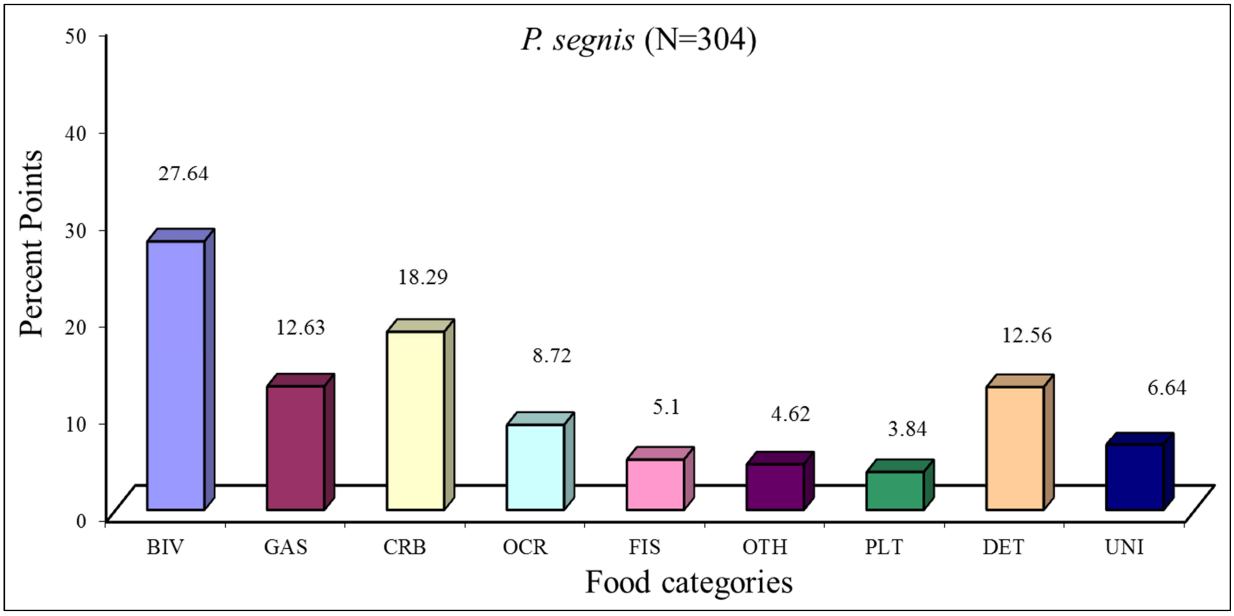

Figure 1. *Portunus segnis: relative composition of food categories by Percent Points method.*

(BIV: bivalves; GAS: gastropods; CRB: crabs; OCR: other crustaceans; FIS: fishes; OTH: other animals; PLT: plant materials; DET: detritus; UNI: unidentified).

3.1.2. Percent Occurrence

In terms of frequency of occurrence the order of relative importance of bivalves, crustaceans and gastropods was the same as that found with the Percent Points method. Bivalves occurred in 34.5% stomachs while crustaceans (crabs, shrimps etc.) occurred in 29.86% stomachs. The next food category was gastropods, which had a frequency of occurrence of 24.01% (Figure 2).

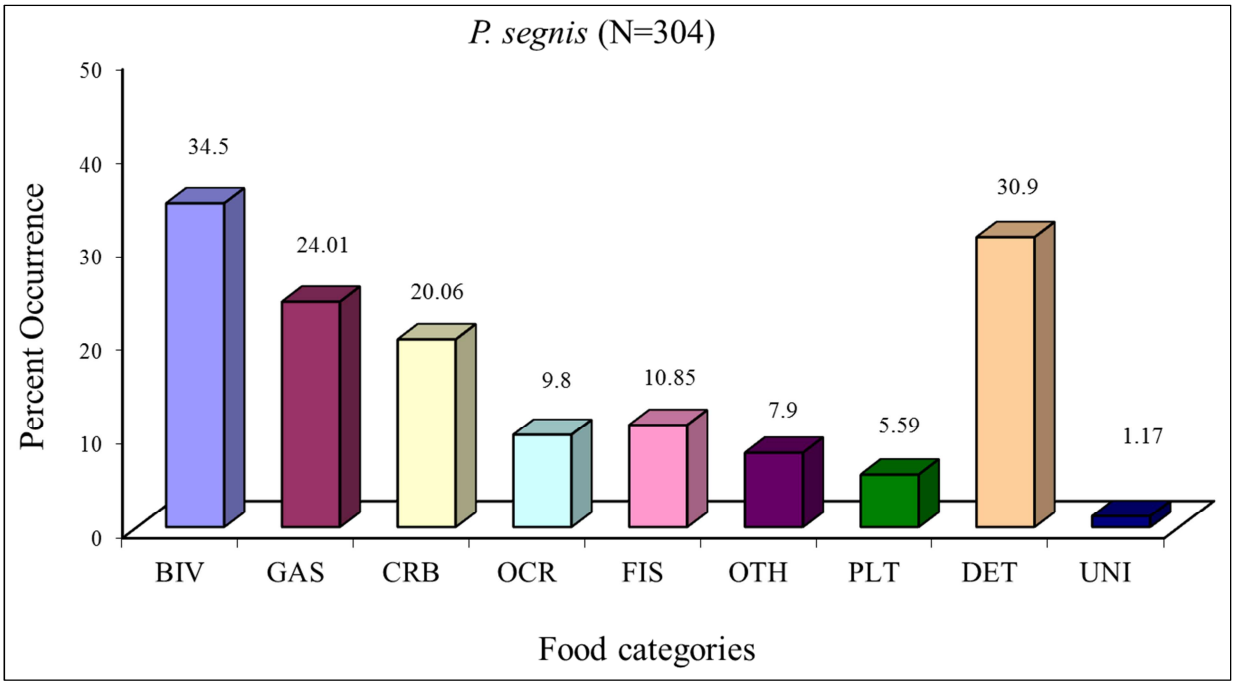

Figure 2. *Portunus segnis: relative composition of food categories by Percent Occurrence method.*

(BIV: bivalves; GAS: gastropods; CRB: crabs; OCR: other crustaceans; FIS: fishes; OTH: other animals; PLT: plant materials; DET: detritus; UNI: unidentified).

3.2. Portunus sanguinolentus

A total of 426 *P. sanguinolentus* were examined for stomach contents from January 2004 to December 2005. The stomachs of 227 crabs (53.3%) were found empty while 199 crabs (46.7%) had food remains in their stomachs (Table 3). The size of the crabs with food in the stomach varied from 24 to 130 mm SCW while those with empty stomach ranged from 26 to 134 mm SCW, there being no difference between the size of the crab and the presence or absence of food in the stomach. Only 22.61% crabs (45 out of 199) had 25% full stomach while remaining 77.38% (154 out of 199) had 50% to 100% full stomach (Table 3).

Table 3. *Portunus sanguinolentus: feeding intensity in different months from January 2004 to December 2005 (N=number of crab examined).*

Months	N	Crabs with Empty stomach		Crabs with food in stomach		Fullness of Stomach							
		No.	%	No.	%	100% Full		75% Full		50% Full		25% Full	
						No.	%	No.	%	No.	%	No.	%
January, 04	19	9	47.4	10	52.6	5	50.0	1	10.0	2	20.0	2	20.0
February, 04	0	0	0	0	0	0	0	0	0	0	0	0	0
March, 04	24	16	66.7	8	33.3	2	25.0	0	0	2	25.0	4	50.0
April, 04	33	29	87.9	4	12.1	2	50.0	1	25.0	1	25.0	0	0
May, 04	25	12	48.0	13	52.0	5	38.5	1	7.7	7	53.8	0	0
June, 04	0	0	0	0	0	0	0	0	0	0	0	0	0
July, 04	8	5	62.5	3	37.5	1	33.3	1	33.3	0	0	1	33.3
August, 04	12	4	33.3	8	66.7	1	12.5	3	37.5	3	37.5	1	12.5
September, 04	17	9	52.9	8	47.05	2	25.0	1	12.5	2	25.0	3	37.5
October, 04	28	12	42.9	16	57.1	5	31.3	2	12.5	3	18.7	6	37.5
November, 04	26	14	53.9	12	46.1	2	16.7	3	25.0	2	16.7	5	41.7
December, 05	18	8	44.4	10	55.6	1	10.0	0	0	2	20.0	7	70.0
January, 05	13	6	46.1	7	53.8	4	57.1	1	14.3	2	28.6	0	0
February, 05	28	8	28.6	20	71.4	2	10.0	8	40.0	10	50.0	0	0
March, 05	20	17	85.0	3	15.0	0	0	1	33.3	0	0	2	66.7
April, 05	23	11	47.8	12	52.2	8	66.8	0	0	1	8.33	3	25.0

Months	N	Crabs with Empty stomach		Crabs with food in stomach		Fullness of Stomach							
						100% Full		75% Full		50% Full		25% Full	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
May, 05	12	6	50.0	6	50.0	4	66.8	0	0	0	0	2	33.3
June, 05	24	10	14.7	14	58.3	3	21.4	2	14.3	6	42.9	3	21.4
July, 05	7	4	57.1	3	42.9	0	0	1	33.3	2	66.7	0	0
August, 05	13	6	46.1	7	53.9	4	57.1	0	0	1	14.3	2	28.6
September, 05	9	8	88.9	1	11.1	0	0	0	0	1	10.0	0	0
October, 05	11	6	54.5	5	45.4	3	60.0	0	0	2	40.0	0	0
November, 05	24	14	58.3	10	41.7	5	50.0	2	20.0	2	20.0	1	10.0
December, 05	32	13	40.6	19	59.4	7	36.8	2	10.5	7	36.9	3	15.8
Total	426	227	53.3	199	46.7	66	33.2	30	15.1	58	29.1	45	22.6

Following are the results of food items by percent points and percent occurrence methods.

3.2.1. Percent Points

Figure 3 depicts the percent points of different food categories ingested by the *P. sanguinolentus.* Crustaceans *(*crabs, shrimps etc.) were found as the most commonly ingested food items in the diet of *P. sanguinolentus* with a score of 28.0% (21.1 + 6.9 = 28.0%). Small crabs were the most common food item than the other eight food items. Bivalves ranked second highest food category with a score of 16.4 percent points. The food category "other animals" with 10.3% points was the third highest food category and it included mostly polychaete worms and some echinoderms such as brittle stars and star fishes. Gastropods scored only 9.4 percent points. The least common food item ingested by *P. sanguinolentus* was plant material (3.6% points) and fish (4.2% points).

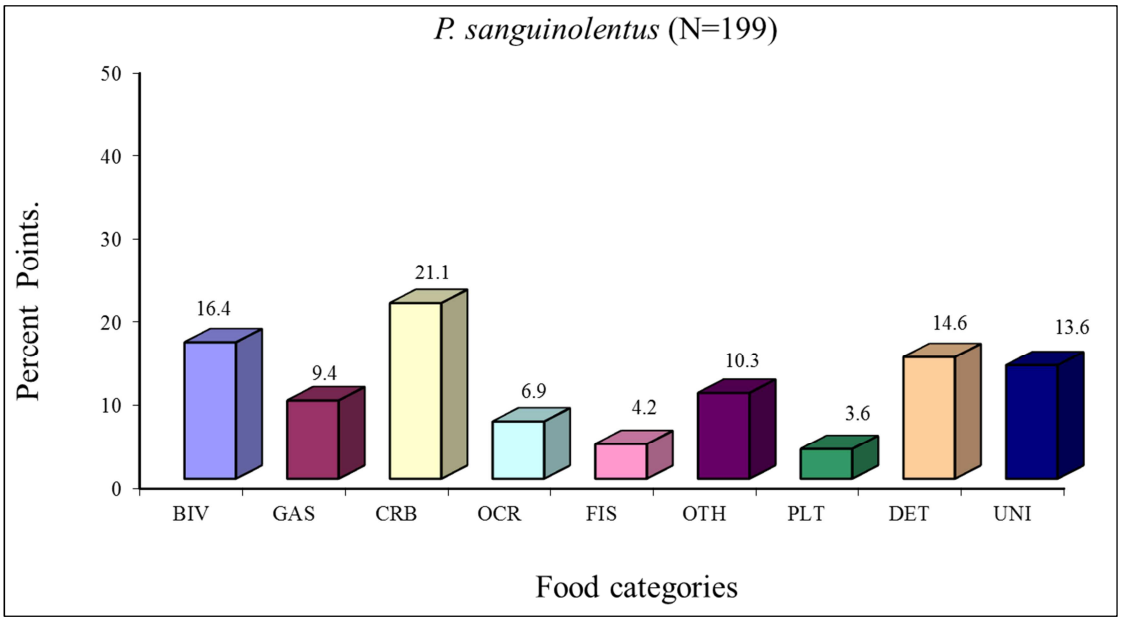

Figure 3. *Portunus sanguinolentus: relative composition of food categories by Percent Points method.*

(BIV: bivalves; GAS: gastropods; CRB: crabs; OCR: other crustaceans; FIS: fishes; OTH: other animals; PLT: plant materials; DET: detritus; UNI: unidentified).

3.2.2. Percent Occurrence

According to this method, the relative importance of crustaceans (crabs, shrimps etc.), bivalves and gastropods was the same as that found with the percent point method (Figure 4). The most frequently occurred food item was found to be crustaceans (crab 24.1% + other crustacean 7.1% = 31.2%). The frequency of occurrence of small crabs in the stomach of *P. sanguinolentus* was 24.1%. Among other crustaceans, small shrimps were the most abundantly ingested. After crustaceans, the next most frequently occurred food category was bivalves (24.5%) followed by gastropods (15.6%). Detritus was found in 28.6% stomachs of *P. sanguinolentus*. Since the mouth parts and chelipeds of *P. sanguinolentus* are not morphologically adapted for deposit feeding, it is likely that the detritus found in the stomach of *P. sanguinolentus* was derived from prey food or it was consumed along with other food items. Fish and plant materials occurred only in 9.1% and 9.5% stomach while "other animals", mostly polychaetes, brittle star and star fishes, were found in 13.5% stomachs of *P. sanguinolentus.*

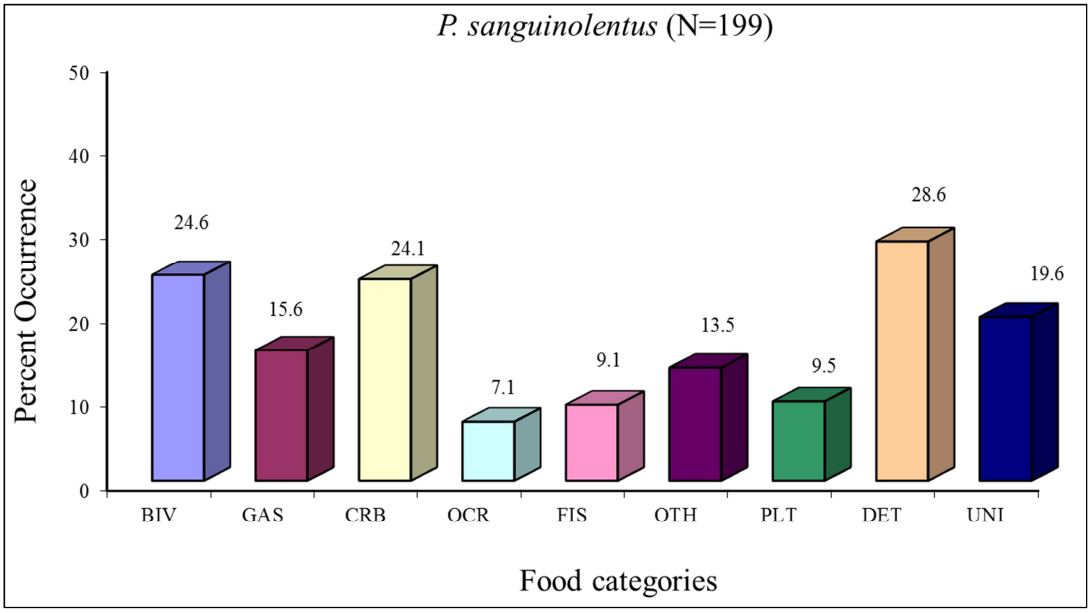

Figure 4. *Portunus sanguinolentus: relative composition of food categories by Percent Occurrence method.*

(BIV: bivalves; GAS: gastropods; CRB: crabs; OCR: other crustaceans; FIS: fishes; OTH: other animals; PLT: plant materials; DET: detritus; UNI: unidentified).

4. Discussion

The results of this study show that the major prey organisms of *Portunus segnis* and *P. sanguinolentus* are slow moving benthic invertebratess such as bivalves, crustaceans and gastropods. These findings of the present study support to those of [3], [7], [13], [14], [16] and [24].

In their study on the stomach contents of *P. segnis* (as *P. pelagicus*), caught in stake nets off Sikka, India, [13] reported pieces of small crabs, gastropods and bivalves as the major food items found in the cardiac stomach of the crab. [24] investigated natural diet of three species of portunid crabs including *P. sanguinolentus* from Tolo Harbour, Hong Kong. Their results show that the major diets of *P. sanguinolentus* was small bivalves, although a large amount of algae and fish were also found in the stomach of the crabs. From the coast of Dar-es-Salaam, Tanzania, [3] reported molluscs and crustaceans as the main food items ingested by *P. segnis* (as *P. pelagicus*). They found *Areuatula arcutula* Hanley, 1844 – a bivalve – as the dominant food items while other molluscs included the gastropods genera *Nassarius, Littoraria* and *Conus sp*. All these studies indicate that the two species of *Portunus* are predators on slow moving benthic invertebrates.

Fish was found as a minor food item in the diet of *P. segnis* and *P. sanguinolentus* during present study. Similar observation had been reported by [3] for *P. segnis* from Tanzania. However, [25] and [16], from Bahrain and Iran respectively, found fish as one of the major food items for *P. segnis* [14] and [7], who studied dietary composition and biology, respectively, of *P. segnis* from Persian Gulf, found crustaceans, molluscs and fishes as major food items. It is however debatable whether the fish consumed by *Portunus spp*. were carrion or live fish. [24] stated that the fish remains found in the stomach of *Portunus spp* may be carrion since it is doubtful if *P. pelagicus* (closely related to *P. segnis* and has same structure of chelipede and mouth parts) could be able to capture live swimming fish for food in its natural environment. [21], who studied feeding by *P. pelagicus* on material discarded from prawn trawlers in Moreton Bay, Australia, showed that *P. pelagicus* was the most common scavenger attracted to a fish bait in the trawl grounds. Hence the few occurrences of fish in the stomachs of *P. segnis* and *P. sanguinolentus* during present investigation may be due to scavenging activity on dead individuals rather than the active predation.

[21] also reported that *P. pelagicus* can fill its foregut in about 8 minutes and clear it completely of tissues in about 6 hours except for fish bone which requires about 24 hours. [22] discussed in detail about the bias towards foods which are digested slowly and have a long residency time in the gut. She recommended that a correction for degree of fullness of gut and for occurrence method only those stomachs should be analyzed which are at least half (50%) full. She also recommended that a sample size of about 30 stomachs is necessary to include most food taxa and to stabilize percentage occurrence and percentage points score for common food types. These recommendations were followed during present investigation and the similar ranks of importance are given each major food category regardless of which method of scoring is used. This agrees with those of [8], [15] and [22] who compared different scoring methods for describing natural diet. The congruence of result from the two methods of scoring may be attributed to the fact that those food items which are ingested most often by crabs are also eaten in the greatest quantities.

Results of the present study also show that the plant material (algae) was found in some stomachs, though in small quantity. Similar findings were also reported by [23] who studied natural diet of *P. pelagicus* from Moreton Bay, Australia. She observed that the plants were of minor importance in the diet of the crab although *Zostrea* and other macroscopic algae abound the area from where *P. pelagicus* were collected. She stated that the plant material may be ingested accidentally by *P. pelagicus* as prey is gleaned from among algae and seagrass. [4], who studied *P. pelagicus* diet from Cliff Head, Western Australia, reported that the crab with intact chelae had consumed large quantities of molluscs whereas those two crabs that lacked chelae had consumed large quantities of algae and were herbivore rather than carnivore. This shows that *P. pelagicus* can consume algae in the absence of chelae which are used for capturing prey. This could be a subject for future research as during present investigation only those crabs were used which had intact chelae.

5. Conclusion

Portunus segnis and *P. sanguinolentus* appear to be opportunistic predators whose diet depends on local availability of sluggish benthic invertebrates and dead animals. Absence of a prey group would not affect the population size of the two crab species. The chelipeds and the mouthparts of *P. segnis* and *P. sanguinolentus* are morphologically similar and they may occupy the same habitat, hence inter-specific competition for food may occur.

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Authors Contribution

Javed Mustaquim conceived the idea, supervised the research and checked the manuscript. Shazia Imran collected specimens, performs stomach contents analysis, statistical analysis and write the manuscript.

Conflict of Interest

No conflict of interest

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