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Occurrence of Pedunculate Barnacles of the Symbiotic Genus *Octolasmis* (Cirripedia: Crustacea) in Two Species of Edible Crabs

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JM conceived and designed the study. JM supervised the study. SR executed the experimental work, analyzed the data and wrote the article.

Key words
Pedunculate, Octolasmis, Cirripeds, infestation, Portunus.

ABSTRACT

In the present study, 5356 octolasmids hosted by two *Portunus* crabs, *Potunus pelagicus* and *p. sanguinolentus*, they belong to five species; namely *Octolasmis angulata* (Aurivillius, 1894), *O. cor* (Aurivillius, 1894), *O. lowei* (Darwin, 1851), *O. tridens* (Aurivillius, 1894) and *O. warwickii* Gray, 1825. The rate of infestation was found markedly low in *P. pelagicus* (2.9 %) and *P. sanguinolentus* (10.8 %) during present investigation. Octolasmids prevalence was significantly higher in female *P. pelagicus* (81.2%) than that of male (18.8%) while in case of *P. sanguinolentus* the prevalence was significantly higher in male (60.5%) rather than female (39.5%).

INTRODUCTION

Barnacles of the genus *Octolasmis* Gray, 1825 are commonly called pedunculate barnacles or stalked barnacles. They belong to subclass Cirripedia of class Crustacea. Pedunculate barnacles of the genus *Octolasmis* are frequently found in shallow waters attached to the exoskeleton of the decapod Crustacea, including crabs. When the octolasmids inhabit branchial chambers of the crabs, they occupy space on the gills surface normally available for gaseous exchange and can severely impair host respiration (Hudson and Lester, 1994). They have bilaterally compressed body which is divided into two parts: peduncle or stalk and capitulum (Fig. 1). The base of peduncle is cemented to the substratum, which may be the exoskeleton or gills of the host, mostly decapod Crustacea. The top of the peduncle is attached with capitulum which in encased in a carapace composed of two leathery mantle folds or valves. This fleshy structure is strengthened by three to seven calcareous plates. These plates include a median dorsal carina, and on each side one to two scuta and a tergum. The scuta are posterior to the tergum, and near to peduncle. The six pairs of thoracic limbs (cirri) project from a gap between the edges of the carapace.

The genus *Octolasmis* was first described by Gray in 1825. Darwin (1851) introduced few additional species followed by Aurivillius (1892) and (1894) who described six new species. According to Jefferies *et al.* (1995) more than thirty species of *Octolasmis* have been described.

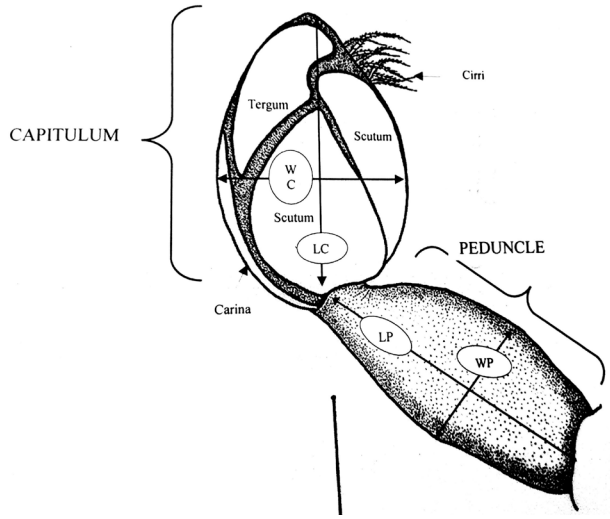

Fig. 1. Schematic drawing of a generalized octolasmid (stalked barnacle) illustrating morphological characters and measurements. LC, length of capitulum; LP, length of peduncle; WC, width of capitulum; WP, width of peduncle. Scale = 1 mm.

Octolasmids are highly modified crustaceans and distributed worldwide in tropical and temperate seas (Jeffries *et al.*, 1995). Their habitats differ from those of acorn barnacles and common goose-neck barnacles. The epizoic relationship between octolasmids and the commercially important crabs, such as *Callinectes sapidus*, *Scylla serrata* and *Portunus pelagicus*, has received much

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attention by several authors from Australia, USA, UK and Thailand (Walker, 1974, 2001; Jefferies *et al*., 1982, 1985, 1989a, b, 1991, 1992, 1995; Jefferies and Voris, 1983, 1996, 2004; Gannon, 1990; Shield, 1992; Gannon and Wheatly, 1992; Voris *et al*., 1994, 2000; Voris and Jefferies, 1997, 2001; Key *et al*., 1997; Mantelatto *et al*., 2003; Shield and Overstreet, 2003; Gaddes and Sumpton, 2004). From Tamil Nadu, India Kumaravel *et al*. (2009) have reported distribution of *Octolasmis* spp. on the gills of some edible crabs including *Portunus pelagicus* and *P. sanguinolentus*.

A survey of literature shows that only four papers have been published so far on stalked barnacles from Pakistan. First paper was published by Hashmi and Zaidi (1965) who reported stalked barnacle infestation on the gills of *Scylla* sp. (then identified as *S. serrata* - see Keenan *et al*. (1998) for revision of the genus) from Karachi waters. Hashmi and Zaidi (1965) identified stalked barnacles as *Lepas* sp. instead of *Octolasmis cor* (Moazzam and Rizvi, 1978; Mushtaq and Mustaquim, 2009, p.58). Two more papers were published by Moazzam and Rizvi (1978) and (1982) on the systematic of the pedunculate barnacles from the Pakistan coast. They described a total of twelve species: seven species of the genus *Octolasmis*, two species of *Lepas* and one species each of *Conchoderma, Poecilasma* and *Trilasmis*. Fourth paper has been published recently by Mushtaq and Mustaquim (2009) on the occurrence and distribution of *Octolasmis* on the gills of mud crab *Scylla cf. tranquebarica* (Fabricius, 1798) from Karachi. The occurrence and distribution of octolasmids on *Portunus pelagicus* and *P. sanguinolentus* have never been studied in detail from Pakistan.

MATERIALS AND METHODS

For the study of octolasmid infestation on the crabs, a total of 2725 specimens of the two species of *Portunus,* collected during January 2004 to December 2005, were examined. Crabs for the present study were collected from the commercial landing at Korangi Fish harbour (24° 48′ 50″ N; 67° 13′ 45″ E), Karachi. The dorsal and ventral surfaces of all crabs were examined for octolasmids with number of each species recorded. The carapace of each crab was removed and the branchial chambers and gills were visually inspected for the presence of octolasmids. Settlement was also recorded on the different part of the body like (hypobranchial gill rake, epibranchial gill rake, and scaphognathite) and the inner wall of the branchial chambers. *Octolasmis* species were identified on the basis of morphological features such as overall shape, capitular shape and capitular plate morphology as described by Daniel (1956), Newman (1960a), (1967), (1987), Moazzam and Rizvi (1978) and (1982) and Jefferies *et al*. (2005). Length and width of the peduncle and capitulum were taken under stereomicroscope with the help of an ocular micrometer. Student's *t*-test and Chi-square were calculated by Zar (1996).

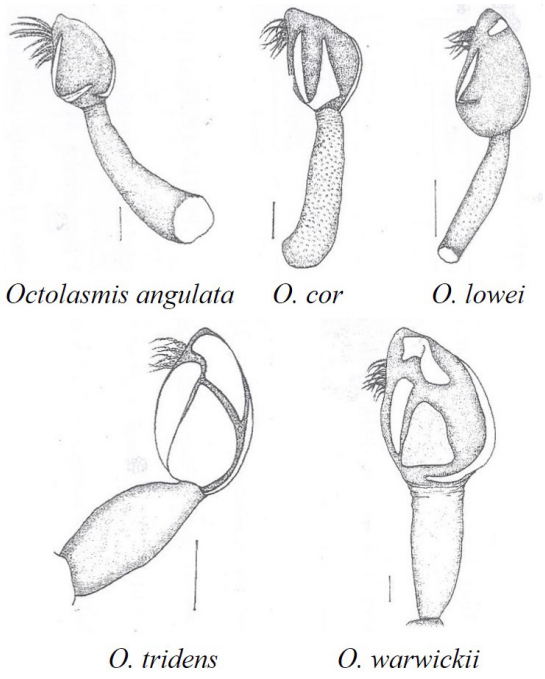

Fig. 2. Five species of *Octolasmis* found in present investigation. Scale= 1mm.

Table I.- Minimum and maximum size of the five species of *Octolasmis* found/attached on *Portunus pelagicus* and *P. sanguinolentus*.

Species	n	Peduncle		Capitulum		Total length
		Length (mm)	Width (mm)	Width (mm)	Length (mm)	(mm)
O. angulata	106	1.1 - 6.9	0.4 - 1.5	1.0 - 3.6	0.5 - 2.6	2.1 - 10.5
O. cor	23	1.3 - 6.5	0.5 - 1.7	1.2 - 3.4	0.8 - 2.5	2.5 - 9.0
O. lowei	4599	0.5 - 7.2	0.1 - 1.5	0.5 - 4.2	0.2 - 3.1	1.0 - 11.4
O. tridens	625	1.5 - 8.0	0.5 - 2.7	1.4 - 5.2	0.4 - 3.7	2.9 - 13.2
O. warwickii	3	3.5 - 8.1	1.5 - 3.0	3.5 - 6.0	2.0 - 5.0	7.0 - 14.1

RESULTS

Of 2725 specimens of the two species of *Portunus* examined for the presence or absence of octolasmids, only 162 crabs (5.94%) were found infested. The number of octolasmids hosted by these crabs was 5356 and they belong to five species; namely *Octolasmis angulata* (Aurivillius, 1894), *O. cor* (Aurivillius, 1894), *O. lowei* (Darwin, 1851), *O. tridens* (Aurivillius, 1894) and *O. warwickii* Gray, 1825 (Fig. 2). The minimum and maximum sizes of the peduncle and capitulum of these octolasmids are given in Table I.

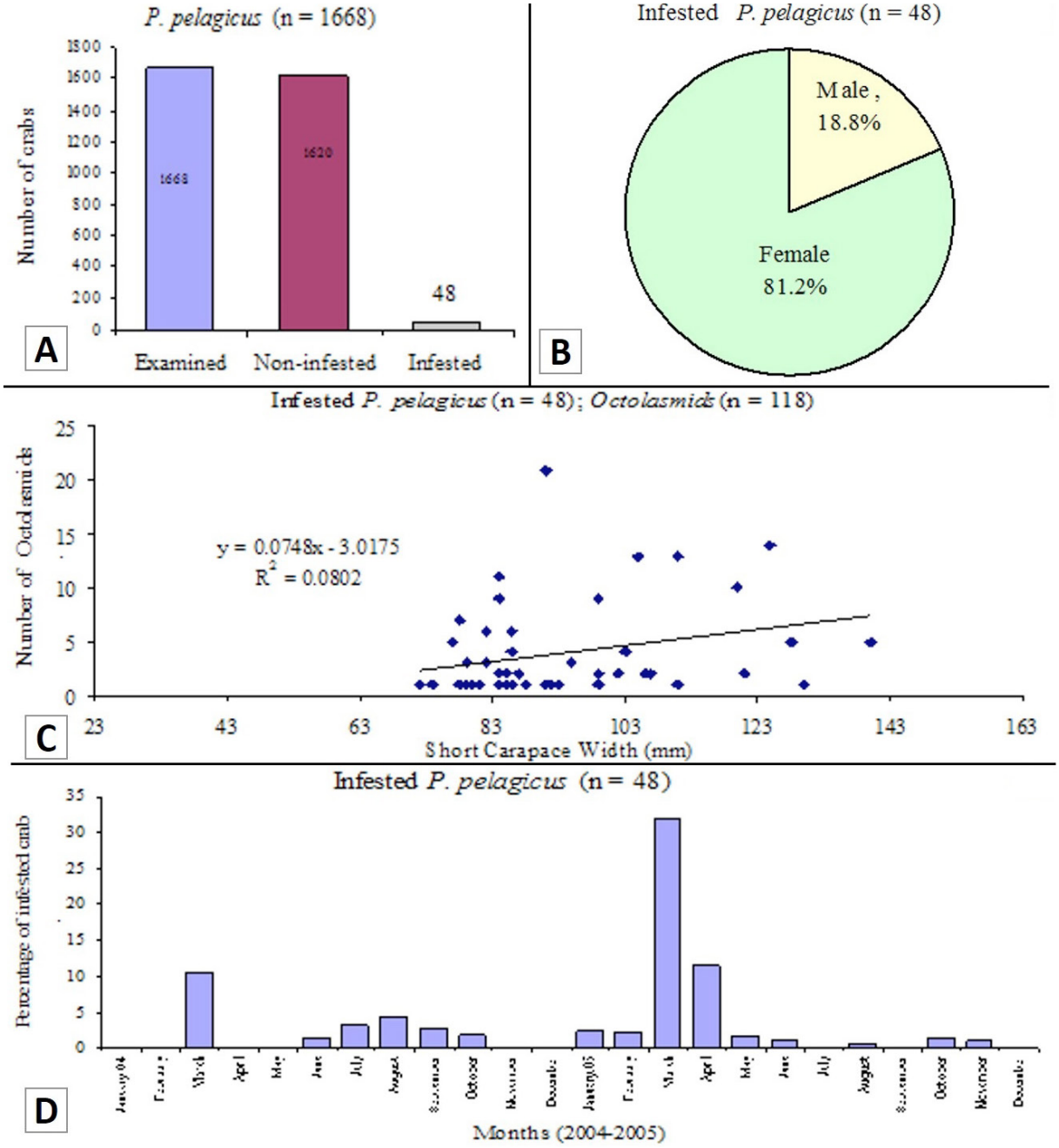

Fig. 3. *Portunus pelagicus*. (A) Bar- diagram showing number of infested and non- infested crabs. (B) Pi-diagram showing percentage of infested male and female crabs. (C) Relationship between number of the octolasmids and the size of the crab. (D) Bar-diagram showing seasonal abundance of the infested crabs.

Portunus pelagicus

Out of 2725 crabs examined, 1668 were *P. pelagicus* (789 male, 879 female including 74 berried female). The size of the male and female crabs ranged from 23-140 mm short carapace width (82.15±3.62 mm) and 26-148 mm short carapace width (83.77±3.07 mm), respectively. Number of infested *P. pelagicus* was found to be 48 (2.9% of the total *P. pelagicus* examined) (Fig. 3A). The short carapace width of infested crabs varied from 70-140 mm (70-120 mm for non-berried female, 84-107 mm for berried female and 77-140 mm for male). Total number of octolasmids hosted by these 48 *P. pelagicus* was 188 (Table II).

Table II.- Number of octolasmids hosted by *Portunus pelagicus* (n = 48).

Species	Number	Percent
O. angulata	2	1.1
O. cor	11	5.8
O. lowei	174	92.6
O. tridens	1	0.5
O. warwickii	0	0
Total	188	

Frequency of infestation

Forty four crabs out of 48 were infested by *O. lowei* only, while one crab each was infested by *O. angulata*, *O. tridens* and *O. cor*. Only one crab having 120 mm short carapace width hosted two species: *O. cor* (4 individuals) and *O. lowei* (1 individual). In other words *O. lowei* was found in 45 (44+1) crabs, *O. cor* in 2 crabs and *O. angulata* and *O. tridens* in one crab each. *Octolasmis warwickii* was not found in *P. pelagicus* during present investigation.

Octolasmids prevalence in male and female *P. pelagicus* was found significantly different as determined by chi-square test ($x^2 = 18.75$; $\alpha = 0.05$). Out of 48 infested crabs, only 9 were males (18.8%) and remaining 39 were females (81.2%) including 10 berried (25.6% of the total infested females) (Fig. 3B).

Intensity of infestation

The most heavily infested crab was a berried female having 94 mm short carapace width. This female crab harboured 21 *O. lowei* in the gill chambers (17 in the left gill chamber and 4 in the right). The next most heavily infested crab was a male, having 125 mm short carapace width, which harboured 14 *O. lowei* (7 in each gill chamber).

The mean intensity of infestation was found to be 3.92±4.44 S.D (range 1-21). The mean intensity of infestation was not found significantly different between male (mean 4.11±4.10 S.D) and female (3.87±4.57) as determined by student's *t*-test (t = 0.207; $\alpha = 0.05$). The intensity of infestation was also found insignificantly different between berried (4.4±6.3) and non-berried females (3.69±3.9) (t = 0.501; $\alpha = 0.05$).

Relationship between the number of octolasmids found in the gill chambers and size of the crab is shown in Figure 3C. Although the rate of infestation was found to increase with the increase in size of the host crab, the two variables are poorly correlated ($R^2 = 0.0802$). The regression equation was found to be y = 0.0748 x- 3.0175, where y is the number of octolasmids and x is the short carapace width of the crab.

Seasonal abundance of infested crab

Infested *P. pelagicus* was registered in all months except in January, February, April, May, November, December 2004, July, September and December 2005. The highest number of infested crab was recorded in March 2005 (32%) followed by April 2005 (11%) and March 2004 (10.6%) as shown in Figure 3D.

Table III.- Size frequency distribution of infested *Portunus pelagicus* in different size groups.

Size- group (SCW) mm	Number of crabs			No. of Octolasmid	No. of male crabs			No. of Octolasmid	No. of female crabs			No. of Octolasmid
	Exa.	Inf.	%		Exa.	Inf.	%		Exa.	Inf.	%	
23-38	27	0	0	0	12	0	0	0	15	0	0	0
39-54	112	0	0	0	60	0	0	0	52	0	0	0
55-70	320	0	0	0	160	0	0	0	160	0	0	0
71-86	580	25	4.31	72	245	4	1.63	10	335	21	6.27	62
87-102	443	11	2.48	44	227	1	0.44	2	216	10	4.63	42
103-118	131	5	3.82	35	64	0	0	0	67	6	8.95	35
119-134	42	5	11.9	32	19	3	15	20	23	2	8.69	12
135-151	13	1	7.69	5	2	1	50	5	11	0	0	0
	1668	48	2.82	188	789	9	1.14	37	879	39	4.44	151

Exa., examined; Inf., infested; SCW, short carapace width.

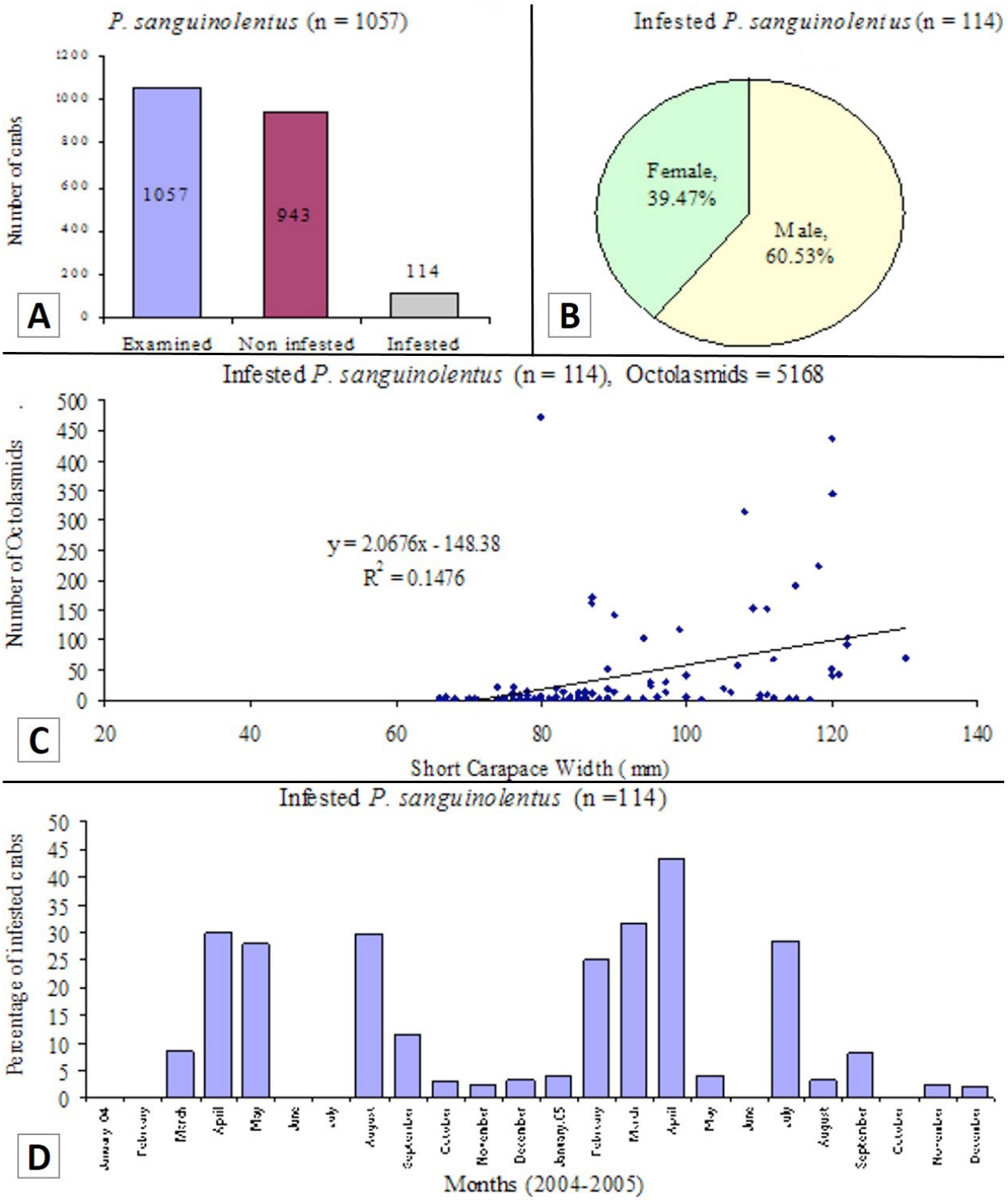

Fig. 4. *Portunus sanguinolentus*. (A) Bar- diagram showing number of infested and non- infested crabs. (B) Pi-diagram showing percentage of infested male and female crabs. (C) Relationship between number of the octolasmids and the size of the crab. (D) Bar-diagram showing seasonal abundance of the infested crabs.

Size frequency distribution of infested crab

Table III shows size frequency distribution of infested *P. pelagicus*. The three smallest size groups (23 mm to 70 mm) had no infested crab at all, although a total of 459 crabs belonging to these size-groups were carefully examined for the presence of octolasmids. The highest percentage of infested crabs was found in size-group 119-134 mm, where 11.9% crabs harboured octolasmids. The next highest percentage of infested crabs was found in size group 135-151 mm followed by size group 71-86 mm. Crabs belonging to size-group 87-102 mm had the least percentage of infested crab (2.48%).

Portunus sanguinolentus

The number of *P. sanguinolentus* examined was 1057 (635 male, 442 female including 128 berried female). The size of the male and female crabs ranged from 24-122 mm short carapace width (80.3±7.4mm) and 28-130 mm short carapace width (76.9±6.42 mm), respectively. Number of infested *P. sanguinolentus* (Fig. 4A) was 114 (10.8% of the total *P. sanguinolentus* examined). Out of which 69 (60.53%) were male and 45 (39.47%) were female including 10 berried female. The short carapace width of infested crabs varied from 67-130 mm (67-117 mm for berried female, 68-122 mm for male and 70-130 mm for non- berried female). Total number of octolasmids hosted by these 114 *P. sanguinolentus* was 5168 (Table IV).

Table IV.- Number of octolasmids hosted by *Portunus sanguinolentus*.

Species of *Octolasmis*	Number	Percent
O. angulata	104	2.01
O. cor	12	0.23
O. lowei	4425	85.62
O. tridens	624	12.07
O. warwickii	3	0.06
Total	5168	

Frequency of infestation

Table V shows number of *P. sanguinolentus* infested by different species of *Octolasmis*. Forty four crabs out of 48 were infested by *O. lowei* only, while one crab each was infested by *O. angulata*, *O. tridens* and *O. cor*. Only one crab having 120 mm short carapace width hosted two species: *O. cor* (4 individuals) and *O. lowei* (1 individual). In other words *O. lowei* was found in 45 (44+1) crabs, *O. cor* in 2 crabs and *O. angulata* and *O. tridens* in one crab each. *Octolasmis warwickii* was not found in *P. pelagicus* during present investigation.

Octolasmids prevalence in male and female *P. pelagicus* was found significantly different as determined by chi-square test ($x^2 = 18.75$; $\alpha = 0.05$). Out of 48 infested crabs, only 9 were males (18.8%) and remaining 39 were females (81.2%) including 10 berried (25.6% of the total infested females) (Fig. 4B).

Table V.- Number of *Portunus sanguinolentus* infested by different species of *Octolasmis*.

No. of crabs	Infested by *Octolasmis* species (No. of octolasmids)
78	*O. lowei* (751)
24	*O. lowei* (2567) + *O. tridens* (280)
3	*O. lowei* (89) + *O. cor* (11)
2	*O. lowei* (750) + *O. tridens* (155) + *O. warwickii* (2)
1	*O. angulata* (6)
1	*O. cor* (1)
1	*O. tridens* (1)
1	*O. lowei* (15) + *O. angulata* (1)
1	*O. angulata* (94) + *O. tridens* (6)
1	*O. lowei* (154) + *O. tridens* (165) + *O. angulata* (1)
1	*O. lowei* (99) + *O. tridens* (17) + *O. angulata* (2) + *O. warwickii* (1)
114	*O. lowei* (4425) + *O. tridens* (624) + *O. angulata* (104) + *O. cor* (12) + *O. warwickii* (3) = (5168)

Intensity of infestation

The most heavily infested crab was a female (non-berried) having 80 mm short carapace width. This female crab harboured 537 octolasmids (473 *O. lowei* + 64 *O. tridens*) in the gill chambers. The right gill chamber had 301 octolasmids (246 *O. lowei* + 55 *O. tridens*) while the left gill chamber had 236 octolasmids (227 *O. lowei* + 9 *O. tridens*). The only specimen of *O. warwickii* found in male crab was attached to fifth swimming leg (Fig. 5A, B). The second most heavily infested crab was a male of 120 mm short carapace width and was found infested with 471 octolasmids (436 *O. lowei* + 34 *O. tridens* + 1 *O. warwickii*). The right gill chamber of this particular crab harboured 175 octolasmids (155 *O. lowei* + 20 *O. tridens*) whereas the left gill chamber had 295 octolasmids (281 *O. lowei* + 14 *O. tridens*). *O. warwickii* found in this crab was attached on the carapace (Fig. 5C).

The mean intensity of infestation was found to be 34±74.16 (range 1-537). The mean intensity of infestation was not found significantly different between male (29.68±68.74) and female (40.52±81.73) as determined by student's *t*-test ($t = 0.692$: $\alpha = 0.05$). The intensity of infestation was also found insignificantly different between berried (37.5±59.25) and non-berried female (40.62±86.88) ($t = 0.0935$: $\alpha = 0.05$).

Table VI.- Size frequency distribution of infested *Portunus sanguinolentus* in different size-groups.

Size-group (SCW) mm	Number of crabs			No. of Octolasmid	No. of male crabs			No. of Octolasmid	No. of female crabs			No. of Octolasmid
	Exa.	Inf.	%		Exa.	Inf.	%		Exa.	Inf.	%	
23-38	7	0	0	0	4	0	0	0	3	0	0	0
39-54	8	0	0	0	5	0	0	0	3	0	0	0
55-70	81	7	8.64	16	22	1	4.54	2	59	6	10.2	14
71-86	479	46	9.6	809	280	29	10.36	123	199	17	8.54	686
87-102	394	29	7.36	1167	267	18	6.74	464	127	11	8.66	703
103-118	76	24	31.58	1890	50	15	30	863	26	9	34.6	1027
119-134	12	8	66.66	1286	7	6	85.71	1160	5	2	40	126
	1057	114	10.78	5168	635	69	10.86	2612	422	45	10.7	2556

Exa., examined; Inf., infested; SCW, short carapace width.

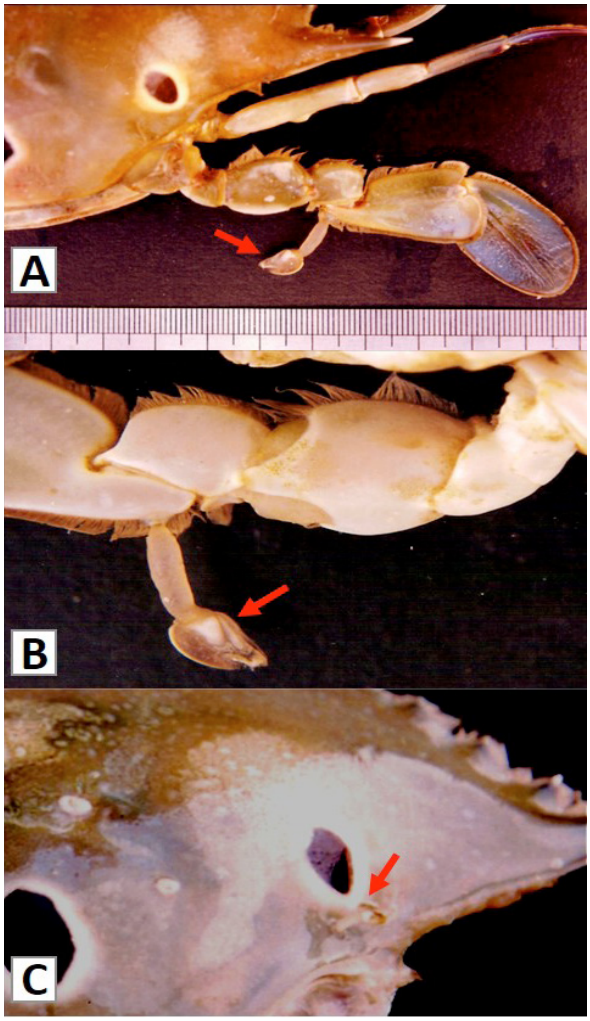

Fig. 5. *Octolasmis warwickii* (A) dorsal view: attached to the fifth walking (swimming leg) of a male *P. sanguinolentus* (scale: one smallest division = 1mm) (B) enlarged and ventral view of the same and (C) attached on the surface of the carapace of a female *Portunus sanguinolentus*.

Relationship between the number of octolasmids found in the gill chambers and size of the crab is shown in Figure 4C. The regression analysis revealed that the two variables are not strongly correlated (R^2 = 0.1372), although the rate of infestation was found to increase with the increase in size of the host crab. The regression equation was found to be y= 1.9492x -139.51, where y is the number of octolasmids and x is the short carapace width of the crab.

Seasonal abundance of infested crab

Infested *P. sanguinolentus* was registered in all months except in January, February, April, May, November, December 2004, July, September and December 2005. The highest number of infested crab was recorded in March 2005 (32%) followed by April 2005 (11%) and March 2004 (10.6%) as shown in Figure 4D.

Size frequency distribution of infested crabs

Table VI shows size frequency distribution of infested *P. sanguinolentus*. The two smallest size groups (23mm to 54 mm) had no infested crab, although a total of 15 crabs belonging to these size groups were carefully examined for the presence of octolasmids. The highest infestation was found in size group 119-134 mm, where 66.66% crabs harboured octolasmids. The next highest infestation (31.58%) was found in size-group 103-118 mm. These two size groups (that is 103-118 and 119-134 mm) contained 98.24 % of the total octolasmids. Crabs belonging to size group 87-102 mm had least percentage (7.36%) of infested crabs (n = 394).

DISCUSSION

The rate of infestation was found markedly low in *P. pelagicus* (2.9%) and *P. sanguinolentus* (10.8%) during present investigation than the rates reported by Gaddes and Sumpton (2004) for *P. pelagicus* (92%) from Australia

and Jefferies *et al*. (1982) for *P. pelagicus* (89%) and *P. sanguinolentus* (57%) from the seas adjacent to Singapore. On the other hand the rate of infestation found in the present study is close to rates reported by Kumaravel *et al*. (2009) for *P. pelagicus* (11.1%) and *P. sanguinolentus* (14.1%) from India. It is well documented in the literature that the infection by rhizocephalan parasite inhabits moulting in crabs which makes infected crab an ideal host for epizoic barnacles (Phillips and Cannon, 1978). Gaddes and Sumpton (2004) reported 92% infestation rate as mentioned above, found 12.3% *P. pelagicus* infested with rhizocephalan parasites *Sacculina granifera* Boschma, 1973 and reported that only the female *P. pelagicus* infected by *S. granifera* exhibited higher barnacle abundances. They attributed this higher infestation rate to the different habitat preferences of females (Sumpton *et al*., 1989) rather than rhizocephalan parasitization. However, Walker (2001) from Australia reported that the branchial chambers of rhizocephalan parasitized crab *Charybdis callianasa* had the greatest number of barnacle *O. angulata*. During present study not a single crab (out of 1668 *P. pelagicus* and 1057 *P. sanguinolentus*) was found parasitized by rhizocephalan. Parasitisation of *P. pelagicus* by rhizocephalan has never been reported from Pakistan so far. Recently Moazzam and Moazzam (2004) reported *Hetrosaccus ruginosus* Boshma, 1931 – a rhizocephalan parasite – from two specimens of *P. sanguinolentus* obtained from Karachi Fish Harbour (commercial landing) in November 1998. Some other species of anomuran crabs like *Petrolisthes boscii* Audouin 1826, and *P. rufescens* Heller, 1861 and brachyuran crabs such as *Leptodius exartus* (H.M. Edward, 1834) occurring in the coastal waters of Pakistan were found infested with rhizocephalan parasites (Ahmed and Mustaquim, 1974; Siddiqui and Ahmed, 1994). These parasitized crabs were not studied for epizoic infestation, so the effect of the parasite on epizoic cannot be gauged from these studies.

Octolasmids prevalence in male and female crabs was found significantly different in this study which contrasts the finding of Gaddes and Sumpton (2004) for *P. pelagicus* from Australia, who reported insignificant difference in the prevalence of octolasmids between male and female. In the present study it was found that octolasmids prevalence was significantly higher in female *P. pelagicus* (81.2%) than that of male (18.8%) while in case of *P. sanguinolentus* the prevalence was significantly higher in male (60.5%) rather than female (39.5%). This finding of present study – as far as *P. pelagicus* is concerned – supports the observation of Shields (1992) from Australia who found significantly more *Octolasmis* spp. in female *P. pelagicus*. Shield (1992) stated several factors that may help to explain the differences in the prevalence of epizoites between the sexes. These factors include slower growth rate (that is longer intermoults period) in female crabs and possible differences in the feeding and migratory habits between the sexes that may result in different prevalence of epizoites.

Size of the crab was found positively correlated with the number of octolasmids in the present study, although the relationship was not found strongly correlated. Similar observations have been reported earlier by Jefferies *et al*. (1992) for *Scylla serrata* from Thailand, Santos and Bueno (2002) for *Callinectes danae* from Brazil, Mantelatto *et al*. (2003) for ten species of brachyuran crabs from Brazil, Yan *et al*. (2004) for *Charybdis feriatus* from China, Kumaravel *et al*. (2009) for five species of crabs including *P. pelagicus* and *P. sanguinolentus* from India and Mushtaq and Mustaquim (2009) for *Scylla cf. tranquebarica* from Pakistan.

CONCLUSION

In the coastal waters of Karachi, *Portunus pelagicus* and *P. sanguinolentus* are not as heavily infested by octolasmids as reported from elsewhere. *P. sanguniolentus* is more prone to the infestation than *P. pelagicus*. Absence of rhizocephalian parasites in the two crabs species are noteworthy.

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Statement of conflict of interest

No conflict of interest.

REFERENCES

Ahmed, M. and Mustaquim, J., 1974. Population structure of four species of Porcellanid crabs (Decapoda: Anomura) occurring on the coast of Karachi. *Mar. Biol.*, **26**: 173-182. https://doi.org/10.1007/BF00388887

Daniel, A., 1956. The Cirripedia of the Madras Coast. *Bull. Madras Govt. Mus,* **6:** 1-40.

Gaddes, S.W. and Sumpton, W.D., 2004. Distribution of barnacle epizoites of the crab *Portunus pelagicus* in the Moreton Bay region, eastern Australia. *Mar. Freshw. Res.,* **55**: 241–248. https://doi.org/10.1071/MF02136

Gannon, A.T., 1990. Distribution of Octolasmis *mulleri,* an ectocommensal gill barnacle, on blue crab. *Bull.*

mar. Sci., **46**: 55-61.

Gannon, A.T. and Wheatly, M.G., 1992. Physiological effect of an ectocommensal gill barnacle, *Octolasmis mulleri*, on gas exchange in the blue crab *Callinectes sapidus. J. Crust. Biol.*, **12**: 11-18. https://doi.org/10.2307/1548714

Hashmi, S.S. and Zaidi, S.S., 1965. Incidence of *Lepas* infestation on the gills of *Scylla serrata* (Forskal) in Karachi waters. *Agric. Pak.*, **16**: 177-129.

Hudson, D.A. and Lester, R.J.G., 1994. Parasites and symbionts of wild mud crabs *Scylla serrata* (Forskak) of potential significance in aquaculture. *Aquaculture*, **120**: 183-199. https://doi.org/10.1016/0044-8486(94)90077-9

Jefferies, W.B. and Voris, H. K., 1979. Observation on the relationship between *Octolasmis grayii* (Darwin, 1851) (Cirripedia, Thoracica) and certain Marine snakes (Hydrophiidae). *Crustaceana,* **37**: 123-132. https://doi.org/10.1163/156854079X00951

Jefferies, W.B., Voris, H.K. and Yang, C.M., 1982. Diversity and distribution of the pedunculate barnacle *Octolasmis* in the seas adjacent to Singapore. *J.Crust. Biol.,* **2**: 562-569. https://doi.org/10.2307/1548096

Jefferies, W.B. and Voris, H.K., 1983. The distribution, size and reproduction of pedunculate barnacle, *Octolasmis mülleri* (*Coker, 1902), on blue crab, Callinectus sapidus* (Rathbun, 1896)". *Fieldiana (N.S.)*, **16**: 1-10.

Jefferies, W.B., Voris, H. K. and Yang, C. M., 1985. Growth of *Octolasmis cor* (Aurivillius, 1892) on the gills of *Scylla serrata* (Forskal, 1755). *Biol. Bull.,* **169**: 291-296. https://doi.org/10.2307/1541404

Jefferies, W.B., Voris, H. K. and Yang, C.M., 1989a. A new mechanism of host colonization: Pedunculate barnacles of the genus *Octolasmis* on the Mangrove crab *Scylla serrata. Ophelia*, **31**: 51-58. https://doi.org/10.1080/00785326.1989.10430850

Jefferies, W.B., Voris, H.K. and Yang, C. M., 1989b. Observation on the incidence of the pedunculate barnacle, *Octolasmis warwickii* (Gary, 1825) on horseshoe crabs (Xiphosura) in the seas adjacent to Singapore. *Raffles Bul. Zool.*, **3**: 58-62.

Jefferies, W.B., Voris, H.K. and Yang, C. M., 1991. Species recognition among the pedunculate barnacles (Cirripedia: Thoracica) on the mangrove crab, *Scylla serrata*. *Raffles Bull. Zool.*, **40**: 83-92.

Jefferies, W.B., Voris, H. K. and Poovachiranon, S., 1992. Age of the mangrove crab *Scylla serrata* colonization by stalked barnacles of the genus *Octolasmis*. *Biol. Bull.,* **182**: 182-194. https://doi.org/10.2307/1542112

Jefferies, W.B., Voris, H.K., Poovachiranon, S. and Heil, L.C., 1995. The life cycle stages of the Lepadomorph barnacle, *Octolasmis cor,* and methods for their laboratory *culture. Phuket Mar. Biol. Cen. Res.Bull.,* **60**: 29-35.

Jefferies, W.B. and Voris, H.K., 1996. A subject-indexed bibliography of the symbiotic barnacles of the Genus *Octolasmis* Gray, 1825 (Crustacea: Cirripedia: Poecilasmatidae). R*affles Bull. Zool.*, **44**: 575-592.

Jefferies, W.B. and Voris, H. K., 2004. Crustacean hosts of the pedunculate barnacle genus *Octolasmis* in the northern Gulf of Mexico. *Gulf Mex. Sci.*, **8**: 173-188.

Jefferies, W. B., Voris, H. K., Naiyanetr, P. and Panha, S., 2005. Pedunculate barnacle of the symbiotic genus *Octolasmis* (Cirripedia: Thoracica: Poecilasmatidae) from the northern Gulf of Thailand. *Nat. Hist. J. Chulalongkorn Univ.*, **5**: 9-13.

Keenan, C.P. and Davie, P.J.F. and Mann, D.L., 1998. A revision of genus *Scylla* de Haan, 1833 (Crustacea: Decapoda: Brachyura: Portunidae). *Raffles Bull. Zool.* **46**: 217-245.

Key, M.M., Volpe, J.W., Jefferies W. B. and Voris, H. K., 1997. Barnacle fouling of the blue crab *Callinectes sapidus* at Beaufort, North Carolina. *J. Crust. Biol.*, **17**: 424-439. https://doi.org/10.2307/1549437

Kumaravel, K., Ravichandran, S. And Rameshkumar, G., 2009. Distribution of barnacles *Octolasmis* on the gill region of some edible crabs. *Acad. J. Ent.,* **2**: 36-39.

Mantelatto, F.L., O'Brien, J. J. and Biagi, R., 2003. Parasites and symbionts of crabs from Ubatuba Bay, São Paulo State, Brazil. *Comp. Parasit.*, **70**: 211-214. https://doi.org/10.1654/4066

Moazzam, M. and Rizvi, S.H.N., 1978. Pedunculate cirrripedes from Pakistan. *Pakistan J. Zool.,* **10**: 175-190.

Moazzam, M. and Rizvi, S.H.N., 1982. Addition to the pedunculate cirrripede fauna of Pakistan Coast. *Pakistan J. Zool.*, **14**: 234-237.

Moazzam, N. and Moazzam, M., 2004. Rhizocephalan cirripeds from Pakistan coast. *Pakistan J. Zool.*, **36**: 253-254.

Mushtaq, S. and Mustaquim, J., 2009. The occurrence and distribution of stalked barnacles of the genus *Octolasmis* on the gills of mud crab or mangrove crab, Genus *Scylla*. *Crustaceana*, **82**: 53-61. https://doi.org/10.1163/156854008X363696

Newman, W.A., 1960a. On the paucity of intertidal barnacles in the tropical western Pacific. *Veliger*, **2**:

89-94.

Newman, W.A., 1960b. *Octolasmis californiana*, spec, nov., a pedunculate barnacle from the gills of the California spiny lobster. *Veliger*, **3**: 9-11.

Newman, W.A., 1967. Shallow-water versus deep-sea Octolasmis (Cirripedia: Thoracica). *Crustaceana,* **12**: 13-32. https://doi.org/10.1163/156854067X00675

Newman, W.A., 1987. Evolution of cirripedes and their major groups. In: *Crustacean* i*ssues 5, Barnacle biology* (ed. A.J. Southward), A.A. Balkema, Rotterdam, pp. 3-42.

Phillips, W.J. and Cannon, L.R.G., 1978. Ecological observations on the commercial sand crab, *Portunus pelagicus* (L.), and its parasite, *Sacculina granifera*, Boschma 1973 (Cirripedia: Rhizocephala). *J. Fish Dis.*, **1**: 137-149. https://doi.org/10.1111/j.1365-2761.1978.tb00014.x

Rasheed, S. and Mustaquim, J., 2014. Some external abnormalities found in edible portunid crabs *Portunus pelagicus* and *P. sanguinolentus* of Pakistan. *Pakistan J. Zool.,* **46**: 541-548.

Santos, C. and Bueno, S.L.S., 2002. Infestation by *Octolasmis lowei* (Cirripedia: Poecilasmatidae) in *Callinectes danae* and *Callinectes ornatus* (Decapoda:Portunidae) from São Sebastião, Brazil. *J. Crust. Biol.*, **22**: 241-248. https://doi.org/10.1163/20021975-99990231

Shield, J.D., 1992. Parasites and symbionts of the crab *Portunus pelagicus* Moreton Bay, Eastern Australia. *J. Crust. Biol.*, **12**: 94-100. https://doi.org/10.2307/1548723

Shield, J.D. and Overstreet, R.M., 2003. Diseases, parasites and other symbionts. In: *The blue crab,* Callinectes sapidus (eds. V.S. Kennedy and L. E. Cronin). Maryland Sea Grant College. University of Maryland, College Park, Maryland, USA.

Siddiqui, G. and Ahmed, M., 1994. Population structure of the xanthid crab *Leptodius exaratus* and its rhizocephalan parasite *Sacculina* sp. from two rocky ledges near Karachi (Arabian Sea). *Mar. Res.*, **2**: 61-72.

Sumpton, W. D., Smith, G.S. and Potter, M.A., 1989. Notes on the Biology of the portunid crabs, *Portunus sanguinolentus* (Herbst) in subtropical Queensland waters. *Aust. J. Mar. Freshw. Res.*, **40**: 711-717. https://doi.org/10.1071/MF9890711

Voris, H.K. and Jeffries, W.B., 1997. Size, distribution, and significance of capitular plates in *Octolasmis* (Cirripedia: Poecilasmatidae). *J. Crust. Biol.*, **17**: 217-226. https://doi.org/10.2307/1549272

Voris, H.K. and Jeffries, W.B. 2001. Distribution and size of a stalked barnacle (*Octolasmis mülleri*) on the blue crab, *Callinectes sapidus*. *Bull. Mar. Sci.,* **68**: 181-190.

Voris, H.K., Jeffries, W.B. and Poovachiranon, S., 1994. Pattern of distribution of two barnacle species on the mangrove crab *Scylla serrata*. *Biol. Bull.*, **187**: 346-354. https://doi.org/10.2307/1542291

Voris, H.K., Jeffries, W.B. and Poovachiranon, S., 2000. Size and location of stalked barnacles of the genus *Octolasmis* on the mangrove crab *Scylla serrata*. *J. Crust. Biol.,* **20**: 483-494. https://doi.org/10.1163/20021975-99990064

Walker, G., 1974. The occurrence, distrubtion and attachement of the pedunculate barnacle *Octolasmis mulleri* (Coker) on the gills of crabs, particularly the blue crab, *Callinectes sapidus* Rathbun. *Biol. Bull.*, **147**: 678-689. https://doi.org/10.2307/1540750

Walker, G., 2001. Some observations on the epizoic barnacle *Octolasmis angulata* within the branchial chambers of an Australian swimming crab. *J. Crust. Biol.,* **21**: 450-455. https://doi.org/10.1163/20021975-99990146

Yan, Y., Huang, L. and Miao, S., 2004. Occurrence of the epizoic barnacle *Octolasmis angulata* on the crab *Charybdis feriatus* from Daya Bay, China. *J. mar. Biol. Assoc. U.K.,* **84**: 619-620. https://doi.org/10.1017/S0025315404009646h

Zar, J.H., 1996. *Biostatistical analysis*, 3rd Edition. Prentice-Hall, Upper Saddle River, New Jersey, pp. 790.