Biological Investigation of Persian Gulf blue swimmer crab (*portunus pelagicus*) In Khuzestan coasts

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Abstract

A bout 361 Million square kilometers (70.8 percent) of the totol area of the earth is covered by seas and oceans. Although this huge ecosystems always make the human curious about them, but the need for advanced equipments for approaching deep and semi-deep areas is the reason for shortage of information about these ecosystems and their inhabitants comparing to the lands. So during recent years extensive researches have performed about marine ecosystems with emphasis on recognition of biological variations and make use of aquatics in several new applications such as nutrition, health, medical and industry. Although Persian Gulf have unique specifications such as different ecosystems and different varieties but it is less investigated accurately. Certainly for protecting such a valuable ecosystem, at first we must have comprehensive information of its structure. This emphasizes the necessity of exact study in all the parts. Therefore current study, investigates blue swimmer crab (one of the valuable Persian Gulf crustaceans) in hunting zones of Khuzestan province. This variety which is spreader globally has a high economic value and is considered in growing aquatics in many countries. The results of this research show that in width parts of some carapace, male blue swimmer crabs are always heavier than female ones. Also there is a positive and meaningful correlation between weight and the parameters of carapace's length, carapace's width, propodus length of male's claws and the width of 6th band of abdomen. Sex ratio during a year of study was F: M = 56%: 44% which should be the relative frequency of females. In the investigation of females maturation during a years it is found that although there were mature female crabs at all of the month in a year but the climax of their maturation in a year and in the place of study, were march and April. Indeed according to the factor of mature carapace width, the mature width was 88 mm carapace width in females. In male crabs, the mean gonad weight in immature was 0.15g and in matures was 1.2g. Also gonad index (GSI) in male crabs was observed with minimum amount of 0.480 during Feb and maximum of 0.807 in Dec.

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1. Introduction

Persian Gulf is one of the rare ecosystems which have ecological, geographical specifications and also physicochemical, biologic specifications etc... It includes considerable numbers of known marine sensitive ecological zones such as estuary, gulfs, coral reef and stone coasts. Variation of environment in the Persian gulf area cause the presence of various species in plant and animal communities, which include phytoplankton, algae, grasses and marine plants and also animal communities including various groups of invertebrates such as sponges, corals, molluscans, crustaceans and marine vertebrates such as fish, reptiles, birds and mammals. It should be noticed that some of the mentioned species of organisms are under the protection of global protection and support and some are native and only belong to this zone. The others have migrated to this zone and choose this environment for living all their lives or they spend a part of their life cycle in this place for food, generation, spawning and growing and passing the winter.

In this study, blue crab as one of the marine crustaceans which is spreader in northern areas of Indian Ocean (Persian Gulf and Oman Sea) is investigated. Although in other countries, this variety has a special place in nutrition and includes a huge part of industrial hunting, but in our country it is treated like a incident hunting and it is eaten as a food only in limited areas of south of the country such as Khuzestan, Hormozgan and Boushehr provinces. This variety is one of the biggest crabs of tide zones of Indian and Pacific Ocean. Males of this species are blue with white dots on the shells and females are green- brown. In spite of the other crabs, this species can not survive a long time out of the water and its food, shelter and growth are dependant to estuaries. Growth speed, high reproductive power, and strength against PH and salinity changes make the blue crab a proper species for aquaculture in the world. Indeed its marketable

meat has expanded its hunting and growing. Such that the price of a kilogram of blue crab is 5-8 dollars of America per fresh hunting and 8-12 dollars per alive.

2. Material and Methods

Sampling was performed in Persian Gulf coast (Khuzestan province) including eastern coasts (Bahrekan hunting zone) with following specifications:

START LAT 2957/639 END LAT 4928/065
START LAT 2954/712 END LAT 4928/059

And in western coasts (Boseaf and lifea hunting zones) with following specifications:

START LAT 2955/184 END LAT 4906/855
START LAT 2952/199 END LAT 4903/867

It was performed monthly during a year from Oct 2007 to the end of Sep 2008. Sampling was performed with several methods such as research ship and local hunters (hunting boats) with fishing net and sampling. After hunting, samples were incubated in ice and were transferred to laboratory at maximum 24 hours. Then the crabs are washed for removing the mud and algae's and barnacles sticked to the external skeleton. After that they were dried with drying paper at first crabs were separated to male and female type according to their morphological characteristics. Male crabs were bright blue and their womb area were narrow and in a form of spear and female crabs were green – brown and their womb, area were round. Then the following parameters were measured in both groups:

- Wet weight (ww)
- Gonad weight in males (GW)
- Carapace length (CL)
- Carapace width(CW)
- Propodus length of claw in males (PL)
- Wide of sixth band of womb in females (All of the items were measured by a coils with accuracy of 1 millimeter)

In mature females (from maturation stage 4 to next) the eggs were investigated for calculating the fecundity .for determining the gonad maturation, an index key is used. Different sex stages in female crabs include:

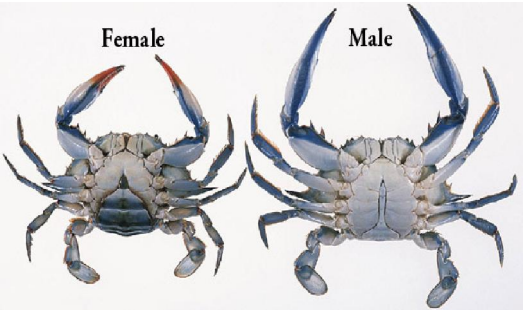

Fig1.Male and female blue crab (24)

- Immature stage (1), white narrow ovary is observed in young and immature crabs
- Rudimentary stage (11), light yellow ovary which shows a considerable volume
- Developing stage (111), light orange ovary. From this stage, ovary is considered to be mature.
- Intermediate stage (IV), The size of ovary increases and occupies 25% of carapace
- Advanced stage (V), Bright dark orange ovary which is dotted and besides carapace it occupies the front side of the belly
- Resting stage (VI), Eggs are settled below the womb feet and ovary shows one of the 2-5 stages

After identifying the gonad developing stages in female crabs, they were classified in groups of 10 millimeter width and the percent of the samples of each stage were calculated. Based on the percent of maturation during the seasons of a year (different months of each season), the maturation peak and hatch were identified. Female crabs which has the maturation stage of more than 4, were selected and their fecundity were calculated in this way (sukumaran 1996).

At first the ovary was separated by a scalpel after drying with drying paper it was weighted with a sensitive scale (with accuracy of 0/001 grams) (G) Then a small part of ovary were separated and weighted again (about 1 gram) (g) The small sample of ovary were kept in dish containing distilled water with detergent and eggs were isolative slowly by shaker .Then the eggs were counted with a binuclear with magnification of 16x. (For decreasing the error a colony counter was used) After that fecundity was calculated with this formula:

$$F=n\times G/g$$

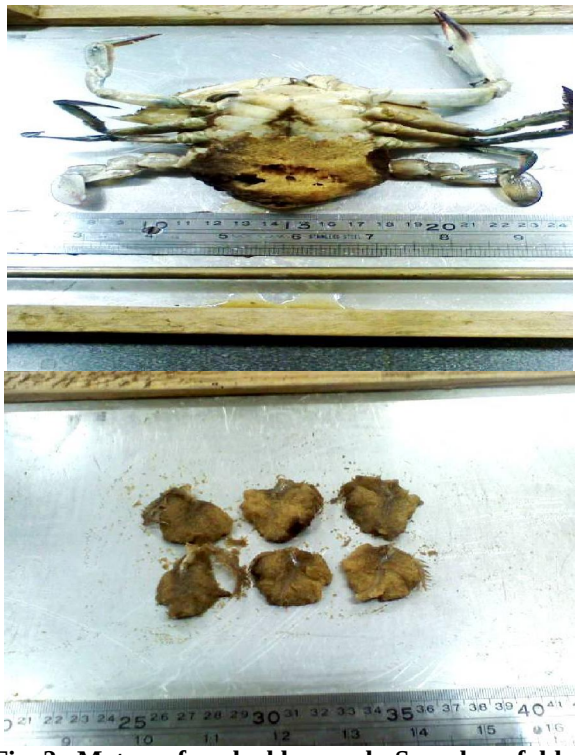

Fig 2. Mature female blue crab Samples of blue crab eggs

For calculating the gonad index in male crabs, gonads were removed carefully after analyzing the womb plate and immediately were weighted with sensitive scale then gonad index was calculated with a formula: $GSI = \frac{Gonal\ \text{weight}}{body\ \text{weight}} \times 100$

In this study for determining maturation in males of blue crab, after identifying the male crabs and their weighting, the parameters of length and width of the carapace and length of propodus were measured carefully. Then besides analyzing the womb protective plate, gonads were separated and weighted (by an electric scale 0.001 gr). considering that gonad weights in matures are 10 times more than gonad weight in young and immature males (kogous and ettal 2001), based on the mean weight of gonad, male crabs were divided to two groups of mature (mean weight of gonad 1.2 gr) and immature (mean weight of gonad 0.15 gr). Then width classification was performed based on carapace width. At each of the classes, which include minimum 50 percent of mature samples, that class was introduced as the maturation class of male crabs (carapace width of maturation).

Then with identifying the minimum of maturation carapace width, the minimum of propodus length in males were identified. During sampling in each month, beside counting the female and male crabs and calculating the sex percentage, the sex proportion (M: F) for each month, each season and finally each year of sampling for that zone, were calculated. Also minimum width of carapace in maturation (LM 50) was calculated and stated for female and male mature crabs. In such a way that after dividation of crab to width groups of 10mm in each width group, if 50 percent of the sample were mature, that width became the maturation width. In male crabs, after measuring the propodus lenght of the claw, the relation between propodus length and carapace width and length were determined with statistical methods (determining equations and correlation coefficient).

3. Results

Statistical test results for comparing mean weights of female and male blue crab showed that there was a meaningful difference between 2 groups at the level of %1 and males were heavier than females. Indeed males were always heavier than females in width classes of carapace. The highest weight difference was observed in carapace width (170- 179 mm) and the least weigh difference (100-109mm) was observed in carapace width.

Table 1. Statistical relation of weight with Morph metric in weight classes (1)

Females weight group	x	Y	R^2	Correlation equation
ww <50 gr	Cl	ww	0.96	Y=1.278 x - 29.93
	CW	ww	0.85	Y=0.529 x - 63.15
	AW6	ww	0.91	Y=1.1 x + 150.09
ww 50-100gr	CL	ww	0.90	Y=2.565 x - 77.5
	CW	ww	0.73	Y=0.640 x - 59.30
	AW6	ww	0.91	Y=3.28 x - 32.70
ww>100gr	CL	ww	0.97	Y=3.423 x - 62.54
	CW	ww	0.94	Y=3.249 x - 297.3
	AW6	ww	0.74	Y=0.749 x +134.7

Table 2. Statistical relation of weight with Morph metric in weight classes (2)

males weight group	x	y	R^2	Correlation equation
ww <50 gr	Cl	ww	0.94	Y=1.095 x + 9.088
	CW	ww	0.85	Y=0.157 x + 28.52
	PL	ww	0.93	Y=1.474 x + 19.36
ww 50-100gr	CL	ww	0.97	Y=1.237 x + 33.56
	CW	ww	0.97	Y=0.716 x + 1.225
	PL	ww	0.94	Y=4.197 x + 2.135
ww>100gr	CL	ww	0.75	Y=4.433 x – 88.32
	CW	ww	0.95	Y=3.948 x – 386.8
	PL	ww	0.96	Y=14.80 x + 238.8

Table 3. Freq percent of gonad weight in carapace weight

/Freq percent carapace width	(gr)gonad weight		
	< 0.75	0.75 - 1.5	> ١.5
80 -89	90	10	---
90 -99	32	40	28
100 -109	10	44	46
110 -119	0	35	65
120 -129	0	13	87
130 -139	0	5	95
140 -149	0	1	99
150 -159	0	0	100
160 -169	0	0	100
170 -179	0	0	100

The results of the relationship of weight with Morphometric factors in blue crab in two sex classes and three weight classes, showed the statistical relation of carapace length, carapace width, and width of sixth womb band with weight, and the equation and correlation coefficient were obtained between weight and all other factors.

Based on sex frequency percentage of blue crab in Persian gulf coasts (Khuzestan province) the total sex proportion during a year of sampling were estimated as F: M= 56%: 44% Which showed that female blue swimmer crab has the larger part of the population Results show that in the Oct and Sep months, sex proportion was balance, in Nov and Dec, the percentage of males was higher. And in other Months of the year females has the higher percentage of the population. Indeed, the maximum frequencies of males were observed in Nov and maximum frequencies of females were observed in Mar.

Considering that blue crabs in stages 1 and 2 are immature and in other stages are mature, results showed that in all of the months of a year, there were mature female crabs in addition, during the seasons of fall and summer, the frequency percent of immature crabs were more than immature, and the frequency of maturation stage 5 was observed in Mar and Apr. Stage 5 existing in all of months in the year (except summer months) showed the possibility of spawning of this type during the year.

Determining the percentage of female crabs mutation stages with width classes dividation showed that females with carapace width less than 80 mm were immature considering that in 80-89 mm width class, minimum of 50 percent of the samples were mature, physiologically so the minimum physiological maturation with for females of this type, were calculated 85 mm. indeed the smallest mature female blue crab had 82 mm carapace width, in other words minimum size if the maturation carapace width in the females of this type was 82 mm.

Table 4. Frequency percent of female crabs sex maturation with width group's dividation of percent of maturation stages

(mm) width groups	I	II	III	IV	V	VI
80-89	**35**	**10**	**45**	**10**	---	---
90-99	**25**	**20**	**40**	**10**	**5**	---
100-109	**7**	**43**	**13**	**7**	**30**	---
110-119	**13**	**30**	**13**	**10**	**30**	**4**
120-129	**4**	**44**	**15**	**11**	**18**	**8**
130-139	---	**17**	**38**	**7**	**37**	**1**
140-149	**6**	**37**	---	**48**	**6**	**1**
150-159	---	---	**38**	**15**	**42**	**5**
160-169	---	---	**33**	**23**	**8**	**36**
170-179	---	---	**25**	**25**	**50**	---

Results of statistical comparison for determining crabs morphological maturation in two groups of mature and immature (isolated based on the size of the width of womb 6th band) showed that, there was always a meaningful relationship between weight

and width of womb 6th band at the level of %1 and with increasing the weight, the width of womb 6th bund also increased. Minimum width of womb 6th band in mature females (with carapace width more than 85 mm) was 22 mm and maximum width of womb 6th band in female crabs was 46 mm. investigating the gonad weight in groups of mature and immature male crabs showed that mean weight of gonad in mature group was 1.2 gr and mean weight of gonad in young and immature male group was 0.15 gr. Regression analysis of gonad weight and total weight factors, carapace length and carapace width showed a meaningful relationship between then at the level of %1 which this relationship was observable in triple weight groups.

Gonad weight less than %75gr was considered immature and more than that was mature. So because in the 90-99 mm width class, more than 50 percent of male samples were mature considering gonad, so 95 mm carapace width (above class width mean) was stated as male crab maturation carapace width. With regard to minimum width of maturation carapace in male crabs (95 mm), minimum length of maturation propodus was specified as 20mm. in other words all of the male crabs whose propodus length were less than 20 mm, were immature. The maximum length of observed propodus in male pelagian crabs was 29mm.

Results of gonad index calculations in male types of blue crab showed that minimum GSI in Feb was 0.420 and maximum GSI was 0.801 in Dec. (Table) Also it have been observed that maximum GSI was in Nov, Dec, May and Jun. Investigating absolute generation in female crabs showed that minimum amount of generation was 150496 and its maximum was 1106215 generation in blue crab was observed as 815249. the results of variance analysis showed that there was a meaningful correlation between weight and generation, carapace width and generation and carapace length and generation at the level of %1 Based on that , with increasing the weight, generation increased and also with increasing carapace length and width , generation amount increased.

Discussion

Growth is caused by consumption, assimilation and food participation in constructing the body of organisms (vastenso 1979). Growth is a special adapting property which is supplied by the continuity of the species with its environment. Strategy of r.selection property shows the adaptation of this species with its environment. (Considering the changeable and in consistency of ecologic situations of the zones under tide (main ecosystem of swimmer crab) this species has short life time (3-5 years), rapid growth, early maturation and abundant generation, as a seizing species. Based on the results of this study in Persian Gulf coasts (Khuzestan province), the mean weight of male blue crabs were always more than females. Performed studies in Boshehr, and Bandar abas coast had the same results (sharafy 1377, Ghorbani 1380) with changing the latitude and longitude and in various ecological situations in other places in the world, changing some parameters such as temperature, salinity, food diet and available food, etc, caves that in some zones, mean weight in male and female blue crab be in favor of males. In Australian coasts, mean weight of males, was reported considerably more than females potter and co-workers 1993).

Investigating the relations of carapace length and width with weight showed that there is a linear relation between those parameters which has a positive and high correlation coefficient. Also results of this study showed that there is a positive correlation between weight and carapace length and width of blue crab and in same carapace width, males are always heavier than females, in biological and ecological studies of populations, one of the considerable characteristics Is the sex ration in the population of that species, which a sex ratio of 50 :50 is expected in the normal situation and without any external stresses such as private hunting, sudden change of temperature and decreasing available food sources. Such a situation cause consisting and constancy of this species. Because it increases the chance and possibility of successful mating and generation. If any factor causes this ratio to change considerably in favor of one of theses sexes (dominance of males or females in a population), so the chance of finding proper mate and successful mating decreases, and also it endanger the constancy and survival of this population. (Naybaken 2005). The results of current study showed that during a year of research in investigated zone, the sex ratio of blue crab population was as F: M= 56% : 44% which this ratio shows the female proportional frequency to males in the population of this species. Same researches in Australian coasts showed a double ratio of females to males of this species. (Kangas and ettal 2000). Generally, hunting method (e.g. hunting with cage) season situation and sudden changes of the weather and migration patterns can affect the sex ratio in the population of this species (nicolsky 1997). Among blue crabs when female crabs migrate to estuary areas for spawning (for reaching to food and enough oxygen for larvas) male crabs prefer living in sweet waters. Vice versa in spring migration, mature males of this type migrate to upper areas of estuary. (Sukumaran 1992).

Like other aquatics we can use either of two methods for determining the morphological maturation,

size of 50 percent of matures and mean size of twin matures group. in all of the studied the mean size of twin matures group in female blue crab was large than 50 percent of matures size. (Korgus and ettal 2006). Because in first width class of carapace width (20-29 mm) of 50 percent of samples were mature, so maturation carapace width in blue crab was stated as 850mm. indeed minimum of maturation width was 82mm it means that all of the female crabs with carapace width larger than 22 mm were mature. Same researches in other areas show the changes of maturation width in this species which it proves the dependency of growth and generation of the species on the ecologic situation and position. For example in Indian coasts, maturation width of this species is stated as 110 mm (Kumar 2003). In Southern Australia estuaries, the minimum maturation carapace in blue crabs is states 94 mm (lestang 2001). We expect that in same ecological situation and ecosystem adjacency, the maturation size of the variety shows a quiet same result. (Filder 1999) in a same research which is performed in Hormozgan coasts, maturation carapace width of blue crab was stated as 90mm. (valinasab 1380). Where as this parameter shows 108 mm in Boushehr coasts. (Ghorbani 1380).

Results showed that there was a meaningful linear correlation between width of womb 6th band and carapace width in female pelagian crabs (at the %1 level). It means that with increasing the weigh of female crab, the width of womb 6th band increased so the parameter of womb 6th band with can be used as an index for determining maturation or maturation stage of the female types with regard to physiologic and morphologic changes of female crab after maturation, mating and specially during spawning. in same researches in Malaysia (kampel and ettal 2001) beside studying reproductive biology of blue swimmer crab, they use the parameter of womb 6th band width for determining the sex maturation in female types. Those researchers stated that, female crabs with mean womb 6th band width of (21 mm) are considered as mature. Considering that aquatic generation cycles are affected by several ecological, biological, chemical and physical factors, increasing the surface temperature of water or increasing the available food will accelerate the generation activity and maturation process. Indeed, photo periods or light- dark cycles has an important role on regulating seasonal reproductive activities in aquatics with direct effect on pineal gonads and hypothalamus. (Bon 1996).

In the family of portunidae and blue crab the situation of along day, accelerates the maturation process and as a result, gonad weight and index increases. (Shimizo 1995). Results of this research showed that gonad index (GSI) of blue crab has little fluctuations during the seasons of a year. The maximum gonad index was observed in the middle to the end of fall and from the middle to the end of spring. Which is not consistent with the season of spawning peak of female crabs (the time of maturation peak)? This shows a time gap about 3 months between mating to Spawning in this variety. Indeed mean gonad index during the seasons of the year .shows the male readiness for repeated mating. in spite of female types which mate only one time in their life cycle (Alono 1998), same studies in the Mexican gulf zone on the reproductive biology of blue crab showed that males of this rarely have considerable gonad index at the most months of the year so they can mate several times (kampel 1994)

Considering the reproductive strategy of blue crab this species has high fecundity like other members of portunidae family. This amount of power is always affected by biological, chemical and physical parameters. (Shield 1998). Based on that under the environmental situations, in the seasons which there is enough available food, generation shows higher amounts. (potter 1996): same results in Australian estuaries showed that when nutrition stress have impact on variety population of blue crab, energy reserves will decrease in the animals liver and after that fecundity of females decreases severely. Considering this reality that increasing the body size (increasing the carapace width and length) provide a proper and enough space for length and volume growth of ovary and as a result cause more eggs settles in the womb plate area, (sukumaran 1995), results of this study showed that there is a positive and meaningful relation and correlation between reproductive power of female blue crabs with wet weight and carapace width and length. So increasing the body dimensions (carapace width and length) and increasing the weight of female crab, fecundity increases. Researches in the north of Australia have same results, so they observed a high correlation between fecundity and carapace width in female blue crab at the level of 5% (potter and ettal).

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