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Reproductive season, maturation size (LM_{50}) and sex ratio of *Metapenaeus affinis* (Decapoda: Penaeidae) in Hormozgan shrimp fishing grounds, south of Iran

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Abstract: This study aimed to investigate the spawning season, length at first maturity (LM_{50}) and sex ratio of *Metapenaeus affinis* in the shrimp fishing grounds of Hormozgan Province, west of the Persian Gulf, Iran. Samples were taken by the swept area method and trawl net with 2 cm mesh size in the cod end from January 2010 to February 2011. Results showed that the sex ratio deviated from 1:1 and female's number were significantly higher than males. *Metapenaeus affinis* females had continuous spawning in all seasons but the peak spawning season was found in spring, and stage 3 of maturity was observed in all seasons. Length at maturity (LM_{50}) for females was estimated at 27.12 mm based on carapace length. Our finding showed that LM_{50} of *M. affinis* do not change with sex ratio deviates from equal ratio.

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Introduction

Metapenaeus affinis is considered to be one of the important commercial species which is caught by fishermen in shrimp fishing season in the coastal waters of the Hormozgan Province on the Persian Gulf, Iran (from early October to December) (Kamrani et al., 2003). The maximum width of the Persian Gulf is 640 km and its average depth is 35m (Reynolds, 1993; Valinassab et al., 2006). Therefore, this gulf provides an important habitant for a number of Penaeid shrimp species. *Metapenaeus affinis* can be found in Hormozgan fishing grounds from Towla in the west to the Jask area in the east (Safaei, 2001). In recent years, several studies have been conducted on this species in Iran. Between 2000 and 2002, Safaie and Kamrani (2003) studied the population structure of *M. affinis* in the coastal waters of the Hormozgan Province. Safaie (2009) investigated ovarian tissue sections of *M. affinis* in the coastal waters of the Hormozgan Province. Furthermore, several studies have been carried out on *M. affinis* spawning periods in other locations. Ayub and Ahmed (1992) investigated the population structure, length at maturity (LM_{50}; the length at which 50% of specimens reach the stage 3 or 4 of maturation and can be inseminated), sex ratio and spawning season of some Penaeid shrimps *Penaeus pencillatus*, *P. merguiensis* and *Metapenaeus affinis* in the waters of Pakistan. Mathews (1989) studied the biology and management of the *M. affinis* stock in Kuwait.

Pinheiro and Fransozo (2002) stated that the breeding season in decapods may be restricted to a few months (discontinuous pattern) or may be year-round (continuous pattern) due to thermal conditions in winter (Sastry, 1983). The spawning cycle periodicity is affected by endogenous and environmental factors (Wenner et al., 1974; Batoy et al., 1987), like temperature (Heasman et al., 1985; Campbell and Fielder, 1986) and photoperiod

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(Knudsen, 1964; Little, 1968; Saigusa, 1992; Flores and Negreiros-Fransozo, 1998).

The present study aimed to present an update of information on sex ratio, LM_{50} and reproductive season of *M. affinis* in the waters of Hormozgan Province, west of the Persian Gulf, Iran. The present study, particularly, the length at first maturity, may help the sustainable fishery of the species through saving the juveniles from the catch (Paighambari et al., 2004). Furthermore, information on the species spawning season is necessary for setting the fishing seasons, and determining the effectiveness of the environmental factors (Momeni and Kamrani, 2006).

Material and methods

Samples were collected from Bandar-e-Abbas 27° 07' N in the west of Hormozgan Province and 56° 06' E to Bandar-e-Jask 26° 25' N and 57° 07' E in the east, and covered most of the fishing grounds of *M. affinis*. The sampling were performed in three depths: >5, 5-10 and 10-30 m using a trawl with a 2 cm mesh size at the cod end with a 450 hp vessel. The swept area method was used for sampling (Gerami, 2011). The netting operation was 5 days a month, 6 to 8 times a day. Each netting operation lasted one hour. The samples were treated by 10% formalin and transferred to the laboratory. In the laboratory, species were separated by gender. The following biometric data were obtained: total length and carapace length in cm and mm, respectively (to the nearest to 0.1 cm and mm), total weight in g (nearest to 0.01 g) and the ovarian developmental stage of females, which was classified into four stages (Lim et al.,1987; Primavera, 1985; Ausbon Brown and Patalan, 1974): stage one, undeveloped (transparent, small ovaries); stage two, developing (larger, yellowish. with increasing pigmentation); stage three, early ripe (light green color); stage four, ripe stages (intense green color with a further increase in size). In addition, stage five is the spawning stage and similar to stage one but the ovary is more clear than stage one. All reproduction stages were identified based on visual selection.

To determine LM_{50}, length classes was specified and the abundance of each length classes was extracted from all data and the frequency of matured stages (stages 3 and 4) was compared to the total frequency of all maturation stages. Then the shrimp size at maturity was calculated by the following equation and using the least square method in Excel 2007 with data analysis Solver (king, 1995)

$$P = 1/(1 + \exp(a + b\mathrm{CL}))$$

Where P is the predicted mature proportion, a and b the estimated coefficients of the logistic equation, and CL the carapace length. Size at sexual maturity (LM_{50}), corresponding to a proportion of 0.5 sexually mature, was estimated as the negative ratio of the two coefficients [LM_{50}= - (a/b)] (Cha et al., 2004). The frequency of the reproductive stages was used to determine the spawning season of females (Biswas, 1993). The Chi-square examination was used to test the sex ratio in seasons. The SPSS 19 software was used to calculate the data with a confidence level of 5%.

Results

The weight and length characteristics of *M. affinis* are represented in Table 1. The maximum length frequency belonged to the 20 and 22 cm length class for males and females, respectively (Fig. 1 and 2). Also maximum frequency of carapace length in ripped stage belonged to 25-28 carapace length classes. The sex ratio of male and female deviated significantly from 1:1 (P<0.05) except in winter (Table 2).

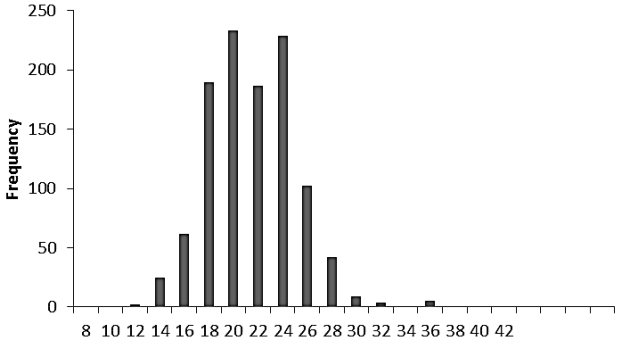

Figure 1. Males carapace length frequency of *M. affinis* (n=966).

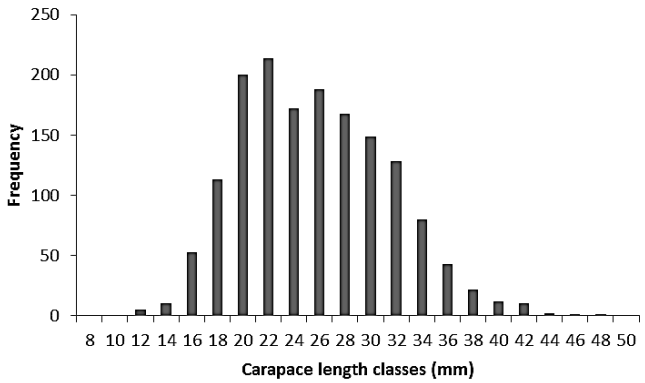

Figure 2. Females carapace length frequency of *M. affinis* (n=1445).

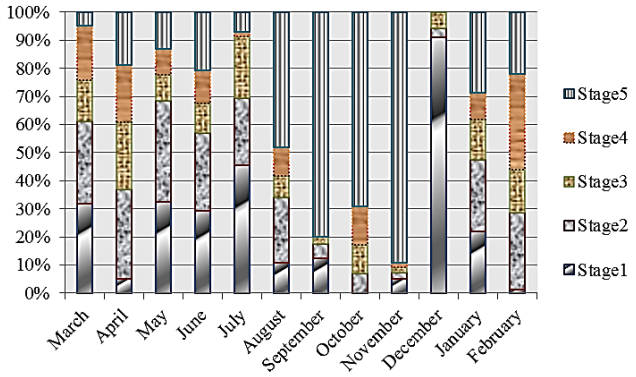

Figure 3. Frequency stages of sexual maturity of *M. affinis* in 2010-2011 (n=1445).

According to figure 3, number of *M. affinis* are in stage three of maturity in all months; but the major spawning season of this species is from late winter and last to the early spring (March and April) due to high rate of stages three and four. The most immature shrimps were found in June, July and August. LM_{50} of the *M. affinis* in the Hormozgan Province shrimp fishing grounds was 27.12 cm.

Discussion

In late winter and early spring, there was an increase in the number of mature females. Gerami (2011) stated that with increase of carapace length, the frequency of mature shrimps increased. This may be

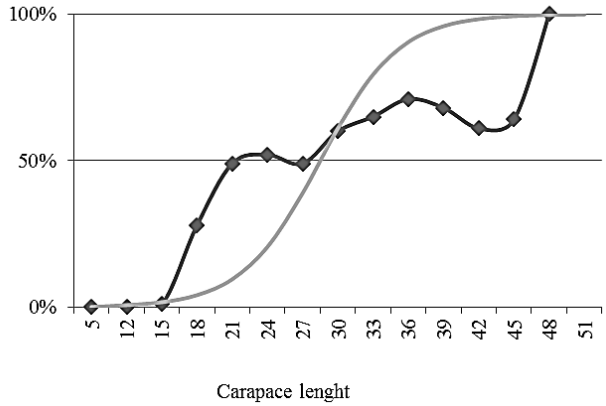

Figure 4. Percentage of ripped stages of *M. affinis* in different carapace length (n=2411).

related to the presence of adult shrimps in the stock and the consequent increase of the average carapace length (Safaie and Kamrani, 2003). In the present study, there was significant deviation from 1:1 sex ratios in most seasons of the year (Table 2). Our study is consistent with Safaie (2004) who found that there was a significant difference between sex ratio in *Penaeus merguiensis* in the Hormozgan Province. Such deviation has been reported in other studies. For example, studies on the sex ratio of shrimp by Kamrani et al. (2005). Kim (2005) suggested that differences in sex ratio may be due to differences in mortality rates between the two sexes or because of differences in behavioral characteristics such as migration. Gerami et al. (2012) suggested that the higher natural mortality of males may deviate in favor of females in most years, which agrees with Cha et al. (2002) and Kim (1977). Da Costa et al. (2010) suggested that the sex ratio of females may be related to the greater vulnerability of females to fishing due to their size.

A complex interaction between endogenous and exogenous factors influences breeding periods causing intra and interspecific variation in the duration of the reproductive season (Sastry, 1983;

Table 1. Weight and length characteristic of *M. affinis* in Hormozgan coasts (2010-2011).

Sexes	Max total length (cm)		Max total weight		Mean carapace length (mm)
	Max	Min	Max	Min	
Male	5.5	13.7	1	19.3	21.04 ± 3.5
Female	3.5	17.8	1.3	45.3	24.86 ± 5.8

Table 2. Sex ratios of *M. affinis* in Hormozgan coasts (2010-2011).

		Season				Yearly
		Spring	Summer	Autumn	Winter	
NO. of observation	Male	248	365	191	162	966
	Female	416	594	243	192	1445
Ratio	Male	0.59	0.61	0.78	0.84	0.66
	Female	1	1	1	1	1
P_{value}		0.000	0.000	0.013	0.709	0.000
Chi-square		42.06	111.516	6.230	0.139	58.504

Henmi and Koga, 2009). Many biotic and abiotic factors such as photoperiod, food availability, temperature, and salinity have been identified as major modulators of reproduction in crustaceans (Aiken, 1969; Pillay and Nair, 1971; Snowden et al., 1991; Henmi, 1993; Emmerson, 1994; Company and Sarda, 1997; Litulo, 2005) and genotypic response to these environmental variations may maximize reproductive success under favourable conditions (Henmi and Koga, 2009). For example, higher temperature in late winter and early spring makes environmental factors well-defined for breeding seasons for *M. affinis* (Mathews, 1989; Safaie, 2008).

Our results show that the peak spawning season of *M. affinis* occurs in late winter and early spring when reproduction stages 3 and 4 are the dominant stages. Notably, the stage 3 was found over the year. This indicates that *M. affinis* has continuous spawning over the year as stage 1 and 2 were observed in the study duration. *Metapenaeus affinis* have resilient ovarian and is capable to prepare and fertilize itself for re-spawning (Safaie, 2008). In this study, the highest frequency of stage 1 was found in December. This is due to the spawning of shrimp species from August to November. After spawning, shrimps are in stage 1. From February to April, with the beginning of spring, stage 3 and 4 reach their peaks. Mathews (1989) reported two peaks of spawning seasons in spring and autumn for this species in Kuwaiti waters and Pillary and Nair (1971) found that the period of the breeding of this species of shrimp along the south-west coast of India were from August to April, with major and minor peaks in December in April, respectively. He explained that juveniles from the spring spawning season mature and ripen during the summer and spawn in autumn, and their descendants spawn in the upcoming spring. According to our results, stages 1 and 2 were mostly observed in summer indicating that *M. affinis* spawn in autumn. Cha et al. (2002) found that *Penaeus chinensis* recruited in August continued to grow in summer and spawn in April–June. It has been found that species of Penaeidae are able to have one or two peaks of spawning their its life (Garcia, 1977, 1985; O'Connor, 1979) and that *M. affinis* had at least two spawning seasons in life (Treece, 2001).

Studies on mean carapace length, when 50% of female shrimps were matured, indicated that the ovaries of *M. affinis* reach stage 3 and 4 of sexual maturation in the carapace length of 20-35 mm (Mathews, 1989). Garcia (1985) noted that the percentage of mature females is a biased index of population reproduction. Kamrani et al. (2005) reported the mean carapace length of *M. affinis* females, when 50% had stage 4 fertility, to be 27.16 mm carapace length in Hormozgan coastal waters. Also, Asadi (2000) observed that the LM_{50} of *M. affinis* occurs in 25.4 mm carapace length in the north of the Persian Gulf.

In conclusion, according to previous studies; LM_{50} of this species did not change significantly while sex ratio tends to predominance by females in this region. Kamrani et al. (2005) declared that sex ratio for this species was 1 to 0.87 in favour of females in this region, while our result showed a ratio of 1 to 0.66. This suggests that males is declining and managerial measures need to be considered.

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