Population Structure, Growth and Mortality Rates of Jinga Shrimp, *Metapenaeus affinis* in Fishing Grounds of Hormozgan Province, Iran

Mohammad Hasan Gerami¹, Seyed Yousef Paighambari², Rasool Ghorbani², Mohammad Momeni³

¹MSc Student, Department of Fisheries & Environmental Sciences, University of Agricultural Sciences and Natural Resources of Gorgan, Iran
²Assistant Professor, Department of Fisheries & Environmental Sciences, University of Agricultural Sciences and Natural Resources of Gorgan, Iran
³Research Instructor of Ecology Institute of Persian Gulf and Oman Sea, Iran

*Corresponding Author: email: m.h.gerami@gmail.com*

Monthly sampling data of *Metapenaeus affinis* was analyzed to determine the age, growth and mortality rates form January 2010 to February 2011. The asymptotic total Carapace length was estimated to be 35mm for males and 47mm for females. The growth parameter K was calculated 1.1 Y¹ for females and 1.2 Y¹ for males while the average water temperature was 26.5°C. The total mortality rate, natural mortality rate and fishing mortality rate was estimated (4.04, 1.95908 and 2.08) for males and (4.93, 1.74954 and 3.18) for females, respectively. Furthermore, the exploitation rate was 0.51 for males and 0.64 for females. Maximum age was 16-17 months and 15-16 months for females and males, respectively. According to the results, *Metapenaeus affinis* growth is rapid from summer to autumn and slight from winter to spring. Natural mortality in males and females were close together but males were more vulnerable to fishing from females. A result showed *M. affinis* was overexploited in Hormozgan fishing grounds. Fishing effort of *M. affinis* must be reduced in Hormozgan fishing grounds and nursery areas should be protected.

**Key words:** Population structure, growth, *Metapenaeus affinis*, Hormozgan province

1. INTRODUCTION

Penaeid prawns (shrimps) are widely distributed in the tropical and sub-tropical areas around the world. They are particularly abundant in Southeast Asia, India, Gulf of Mexico, Australia and the Persian Gulf (Fischer and Bianchi, 1984). Commercial exploitation of prawns began in 1959 on the Iranian side of the Persian Gulf (Boerema, 1969). Shrimp fishing in Saudi Arabia started in 1963, Bahrain in 1966 followed by Qatar in 1969. In Iran, landings reached 9600 tonnes in 1964–1965 and 3335 tonnes in Kuwait in 1966–1967, while industrial landings in Saudi Arabia and Bahrain peaked at 7400 tonnes in 1973–1974 (Van Zalinge, 1984). Now shrimp fisheries in Hormozgan waters are permitted only in fishing season that takes about two months approximately from mid-September to mid-November. The season is opened when 70% of the stock is greater than 12 cmTL, and subsequently closed when the CPUE index indicates that 20% of the shrimp stock remains (Niamaimandi et al., 2007).

Growth parameters are different between species. They may also vary from one stock to another stock in same species. Growth parameters of a particular species may take different values in different parts of its range (Sparre and Venema, 1992). Also Furthermore, mortality rates(Z, M and F) are widely used population parameters in shrimp stock assessment(Garcia, 1985; Siddeek, 1991; Siddeek et al., 2001). They provide information on the dynamics of the population(Gulland, 1969). These parameters help us to management and determining whether the species is under or over-exploitation or not and having a good vision for fishing at the future.

The Persian Gulf and Oman Sea are two of the most productive and important fishing grounds in Iran. It contains a large variety of economically important fish and crustacean species that *Metapenaeus affinis* is one of the most important shrimps after *Penaeus merguiensis* in hormozgan fishing grounds. Distribution of *M. affinis* in hormozgan fishing grounds is from Towla to the east across the Jask area (Safaei, 2001). It contains 30% of shrimp trawl catch in the fishing season in hormozgan.

Prawn is an important component of the coastal fisheries' resources in Iran, and is heavily exploited (Niamaimandi et al., 2007). Although the penaeid shrimp has the important role in Economy livelihood in South of Iran, only limited studies on this species is available in the area. The only previous work dealing with the dynamic of *Metapenaeus affinis* is (Safaei, 2003). In this study,
Gerami et al.
Population Structure, Growth and Mortality Rates of Jinga Shrimp, *Metapenaeus affinis* in Fishing Grounds of Hormozgan Province, Iran

we estimate population structure and growth parameters of M.affinis in Hormozgan fishing grounds in Persian Gulf based on collected data and mortality rates that we calculated.

2. MATERIAL AND METHODS

The study area started from Bandar-e-Abbas 27° 07’ N and 56° 06’ E to Bandar-e-Jask 26° 25’ N and 57° 07’ E, and covered the most fishing grounds of *M. affinis*. The depth was divided into 3 sections. It contains >5, 5-10 and 10-30 m.

Samples of Metapenaeus affinis were collected each month during the January 2010 to February 2011 by Trawl with 2cm stretch mesh size in the cod end in Hormozgan fishing grounds. The samples were separated by sex, and the following measurement was taken: total length (TL), Carapace length (CL) and total weight (TW).

![Study area of Metapenaeus affinis in Hormozgan fishing grounds](image)

**Fig. 1:** Study area of Metapenaeus affinis in Hormozgan fishing grounds

2.1. Growth parameters

To determine the distribution of growth parameters, Carapace length distribution was used. From the length frequency distribution of the samples, ELEFAN I in FiSAT program was used to obtain preliminary estimates of asymptotic length. A total of 5311 shrimps was collected from (L) and growth constant (K) of the von Bertalanffy Growth Function (Pauly, 1987).

In this equation: Lt: shrimp average at age t; L: the asymptotic length of the species would reach if it lived indefinitely; K: growth coefficient; to: theoretical age at zero lengths; t: age (years)

\[
L_t = L \infty \left(1 - \exp(-K(t - t_0))\right)
\]

(1)

The theoretical age at length zero \((t_0)\) be estimated by the equation:

\[
\log_{10}(-t_0) = (-0.3922) - (0.3752)\log_{10}(L \infty) - 1.038\log(K)
\]

(2)
2.2. Estimation of mortality rates

The length-converted catch curve method (Gayanilo et al., 2002) was used for estimation of the instantaneous total mortality ($Z$).

For obtaining an independent estimate of the natural mortality ($M$), Pauly’s equation (Pauly, 1980) was employed.

$$\log(M) = -0.0066 - 0.279\log(L_\infty) + 0.6543\log(K) + 0.4634\log(T)$$  \hspace{1cm} (3)

In this equation: $M$: instantaneous rate of natural mortality; $L_\infty$: the asymptotic length of the species would reach if it lived indefinitely; $K$: growth coefficient; $T$: mean annual temperature of the environment sea water surface ($^\circ$C)

Fishing mortality ($F$) was derived as the difference between $Z$ and $M$. Following the estimations of $Z$, $M$ and $F$.

$$F = Z - M$$

The exploitation rate $E = F/Z$.

To compare the growth parameters of $M$.affinis in this study from the others used Phi prime ($\phi$). Details on growth comparison using $\phi$ as an index are discussed in Pauly and Murno (1984).

$$\phi = \ln K + 2\ln L_\infty$$

3. RESULTS

The obtaining results indicated that the maximum life span of males is 15 to 16 months while that of females is 17 to 18 months. The values of $K$ obtained were 1.2 for males and 1.1 for females while max carapace length 35 cm for males and 47 cm for females.

The estimated values of $t_0$ were 0.76473 for males and 0.69319 for females.

In this study, the average of temperature in 12 months in Hormozgan waters was 26.5 $^\circ$C. The results indicate that total mortality coefficient $Z$, differed markedly between sexes. It was estimated 4.04 for males and 4.93 for females. We used $L_\infty$ and $K$ for estimating rate of natural mortality.

The values of $M$ were obtained 1.95 for males and 1.74 for females. The values obtained for $F$ were 2.08 for males and 3.18 for females. From the estimates of the instantaneous of fishing and total mortalities, the exploitation rate ($E$) was calculated, for both sexes:

$E = 0.51$ for males; $E = 0.64$ for females. The results of $\phi$ for both sexes are as follows:

$\phi = 7.79$ for females

$\phi = 7.29$ for males

Fig. 2: The length-converted Catch curve of Female Metapenaeus affinis in Hormozgan waters

Fig. 3: The length-converted Catch curve of Male Metapenaeus affinis in Hormozgan waters
4. DISCUSSION

In this study, the numbers of 2917 shrimps were studied; which 1116 of them were male and 1799 were female. The difference of maximum carapace length (CL∞) between males and females was 12 that indicate there are some differences between growth rates in males and females. To prove this claim the annual growth rate (K) also can be another reason. The coefficients which are 1.2 for males and 1.1 for females confirm different growth rates in males and females. Short-lived animals like shrimp reach their asymptotic length in first or second years of their lives span and are characterized by a high K-value (Beverton and Holt 1993 and Garcia and Le Reste 1981). Rates of growth for both males and females, are highest in summer and autumn (Niamaimandi et al., 2007) (October-March for females and July-December). The population of M. affinis almost composed of two-year classes. There are two cohorts during most months in males, while females have three cohorts in the most months (Fig IV and V). Growth Growth analyses based on length-frequency data are most suitable for species which recruitment occurs over a short time period, and for which growth rates are relatively high (King, 1984). If both conditions are satisfied, a single length-frequency sample may show several widely-spaced year-aged size classes, and a time series of length-frequency samples is likely to produce narrow cohorts with modes that rapidly progress along the length axes (Niamaimandi et al., 2007).

Figure 3 and 4 shows that the slope of the Females curve is more than the males' curve. This means that females reach their maximum length faster than males.

The K-value was nearly same in both sexes; however, in females were higher than in males.
Nevertheless, \( CL_\infty \) was varying in both sexes. Spare said that \( CL_\infty \) was interpreted as the average length of the ten oldest specimens in the population that found in catch samples (Sparre and Venema, 1992).

The K-value in this investigation is nearly same with the results by other studies, e.g., (Pauly and Munro, 1984) found that the K-value for penaeid shrimps between 0.39 to 1.6, and (Mathews et al, 1987) that obtained the K-value and \( CL_\infty \) for \textit{Metapenaeus affinis} in Kuwait waters for both males and females, 1.09, 37/7 and 1.22, 48 respectively. That was similar to the finding in the present study which suggesting that our estimates of the von Bertalanfy growth parameters are reliable. Jayawardane et al (2003) said it is, however, a general phenomenon that short-lived species such as shrimps will have high growth rate constants because K is a curvature parameter of the growth curve which determines how fast the shrimp approaches its asymptotic length (Sparre & Venema 1992).

There are several reasons why the size of the shrimps in the catches might differ between gears. One concerns the influence of the gear itself (gear selectivity) and where it operates. Another might be the migration of shrimps as they grow larger (Jayawardane et al, 2003).

Many factors in the marine environment act to reduce the survival of individuals in a population (King, 1984). These factors include incompatible conditions, lack of food, competition and predation. Due to Environmental conditions and Presence or absence of predators, natural mortality rates will vary each year.

Natural mortality based on the empirical equation Pauly (Pauly, 1980) (the result of research on natural mortality of 175 aquatic) were obtained.

The estimated values of \( Z \) (4.04 for males and 4.39 for females) using the cumulated catch curve of Jones and Van Zalinge (1981) is in the acceptable range. Most of the penaeid fisheries around the world have high fishing mortalities and thus show high Z values, e.g., \( Z = 9.2 \) for males and 8.8 for females in Kuwait (Jones and Van Zalinge 1981) and \( Z = 6.7 \) for combined sexes in Kuwait (Van Zalinge et al. 1981). The size distribution in catches will also be affected, ultimately, by mortality rates. Thus, fewer individuals will reach large sizes when mortality (from fishing and natural causes) is high (Jayawardane et al, 2003).

The values of natural mortality are 2.52 for males and 2.20 for females. These values are in the acceptable range given by Pauly et al (1984) and Mathews et al (1987) (table 1).

There is a good agreement in \( \Theta \) value in result that shown in table 2. Beverton and Holt (1959) found that fish with high growth rates had high values of natural mortality; this is also observed in shrimp populations.

### Table 1: The range of values for shrimp mortality Penaide

<table>
<thead>
<tr>
<th>Values</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.46-7.07</td>
<td>Pauly et al.,(1984)</td>
</tr>
<tr>
<td>0.77-3.12</td>
<td>M</td>
</tr>
<tr>
<td>0.55-4.68</td>
<td>F</td>
</tr>
<tr>
<td>3.33-7.08</td>
<td>Mathews et al.,(1987)</td>
</tr>
<tr>
<td>0.77-2.71</td>
<td>M</td>
</tr>
<tr>
<td>0.55-4.72</td>
<td>F</td>
</tr>
</tbody>
</table>

### Table 2: Comparison of the growth parameters for \textit{Metapenaeus affinis} in 2 areas

<table>
<thead>
<tr>
<th>Area and Source</th>
<th>Sex</th>
<th>( CL_\infty )</th>
<th>( K )</th>
<th>( \Theta' )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathews et al., 1987</td>
<td>Male</td>
<td>37.7</td>
<td>1.09</td>
<td>7.34</td>
</tr>
<tr>
<td>Kuwait waters</td>
<td>Female</td>
<td>48</td>
<td>1.22</td>
<td>7.94</td>
</tr>
<tr>
<td>This study</td>
<td>Male</td>
<td>35</td>
<td>1.2</td>
<td>7.29</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>47</td>
<td>1.1</td>
<td>7.79</td>
</tr>
</tbody>
</table>
The values of \( E \) are higher than optimum levels, particularly in females (0.51 for males 0.64 for females) that represent over-fishing in this species (overfishing occurs if \( M = <F \) or \( E > 0.5 \), Gulland, 1969). On the other hand, over-fishing occurs due to illegal catch in the closure seasons, or also in the nursery areas. The study of Jayawardane et al. (2003) showed that 65 and 75% of the catch of males and females of *Metapenaeus dobsoni*, respectively, comprised under-sized individuals. The fishing gears operating inside the estuarine environment (drag nets and stake nets) particularly exploited substantial amounts of under-sized individuals.

The obtaining results indicated that the maximum life span of males is 15 to 16 months while that of females is 17 to 18 months. Tom et al. (1984) found that the highest mean total length attained for age group was 17.5 cm for males and 21.5 cm for females, and they estimated that the prawn’s life span was \( \sim 25 \) months, having recruited at about six months of age. These body lengths correspond to carapace lengths of approximately 37mm for males and 50mm for females. Morgan (1995) noted that the life span of *P. semisulcatus* is 12–18 months (Niamaimandi et al., 2007).

Short lived species such as shrimps with high fecundity, have the capacity to produce large numbers of pre-recruits when environmental conditions are suitable (King, 1995). At this situation, if we have caught season for shrimp harvest, maybe increase in fishing mortality (\( F \)) at the catch season but fishing mortality shows low at year. So it is not important to establish \( E=0.5 \) at catch season. But it is important to limit fishing in a catch season and/or custom area.

5. CONCLUSION

From these results, it is most likely that the shrimp stocks in the Persian Gulf are in a situation of economic over-fishing, and the savings from reduced fishing effort would be much greater than any revenue that was forgone. In fact, if the average shrimp size increases, with reducing fishing mortality, revenues could increase because of increased stock.

REFERENCES


Kuwait. Kuwait the Bulletin of marine science, 10: 3-636.