Growth parameters and maximum age of prawn, *Penaeus semisulcatus* (De Haan) in Bushehr waters, Persian Gulf

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Abstract: Carapace length frequency data of green tiger prawn, *Penaeus semisulcatus,* were monthly collected from 50 stations along the coastal waters of Bushehr, Persian Gulf, during January 2003 to March 2004. FiSAT program was used to analyse a total of 535 shrimps including 292 females and 243 males, for the relationships of total length, weigth and carapace length. The $L\infty$ and K for males were estimated at 38mm CL and 1.6 $year^{-1}$ and for the females were 50.40mm CL and 2.20 $year^{-1}$, respectively. Maximum age (T_{max}) were 20 months for the males and 15 months for the females. The growth of the shrimp was found to be rapid during summer and autumn and negligible during winter and spring.

Keywords: Growth parameters, Green tiger prawn, *Penaeus semisulcatus*, Bushehr waters, Persian Gulf

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Introduction

A major task of a fishery biologist is to estimate the growth parameters. The fisheries system is dynamic, and the values of these parameters may fluctuate widely, even in the absence of fishing efforts. A common approach to analyse length frequency data for describing growth is to fit the data to a mixture of a finite number of normal distribution, each of which corresponds to a different age classes. Growth rates are the widely used population parameters in shrimp stock assessment (Gulland, 1969). Knowledge of growth rate is essential to understand the population dynamics of *Penaeus semisulcatus* stock because it is related directly to the levels of total biomass (Mathews *et al.*, 1987).

The first study on the Persian Gulf shrimp resources was initiated by a special working group in April 1976. This group concluded that in some areas of the region, shrimp stocks were seriously overexploited, and suggested that management measures should be introduced (UNDP/FAO, 1982). Information on the growth parameters of *P. semisulcatus* has been reported by several authors (Thomas, 1974; Naamin & Yamamoto, 1977; van Zalinge *et al.*, 1979; FAO, 1980; Mathews, 1981; Azimi, 1985; Somers & Kirkwood, 1991; Niamaimandi, 1998).

Shrimp is an important component of the coastal fisheries resources in the Persian Gulf (UNDP/FAO,1982), and is heavily exploited due to its high commercial significance. This study is limited to the green tiger prawn, *Penaeus semisulcatus*, in Bushehr coastal waters, Persian Gulf. The purpose is to estimate growth parameters based on recent data collected in order to provide baseline information required for sound stock management.

Materials and methods

The geographical study area extends from 49° 45' E to 51° 57' E and 27° 29' N to 30° 03' N, which coincide with the total fishing grounds of *P. semisulcatus*. The depth range extended from the shore to a maximum of 50m and was stratified into 4 depth strata of 6–10m, 10-20m, 20-30m and 30-50m.

A total of 50 fixed stations were selected within the study area for monthly sampling (Fig. 1). A total of 15 monthly surveys were conducted from January

2003 to March 2004 and 14 equidistant transects of 50 sampling stations were established from Bahrekan in the north to Dayer in the south of Bushehr (Fig. 1).

Sampling was conducted by R/V LAVAR-II equipped with bottom trawl net of 28m headrope and 40mm mesh size at the cod-end and body. R/V LAVAR-II is a double rig bottom trawler with 35.5m overal length, 7m wide and 850 HP engine and equipped with GPS, radar and other navigation systems. At each sampling station, a one-hour haul was undertaken at a speed of three knots. The direction of each tow was set so as to avoid any depth change and/or deviation from a straight line. Data collected at each sampling station included time, depth, position (start and stop) of each haul. The trawl survey was carried out during daylight between 06:00 to 18:00 hours.

Captured shrimp samples were separated from other catches and weighed according to the following procedures. When more than 5kg of shrimp were caught, a random sample of almost 5kg was taken and weighed using a scale of ± 25g precision. Then the samples were sorted according to species and samples of *P. semisulcatus* were sexed. The carapace length of this species was measured from post orbital notch of the carapace to the mid-posterior dorsal margin to the nearest ±0.1mm.

In order to estimate the relationship between different body parameters, subsets of samples were periodically taken to the laboratory and precise measurements of total length (±1mm), carapace length (±0.1mm), and total weight (±0.01g) were recorded. A total of 535 shrimp including 292 females and 243 males were measured and recorded for the subsample.

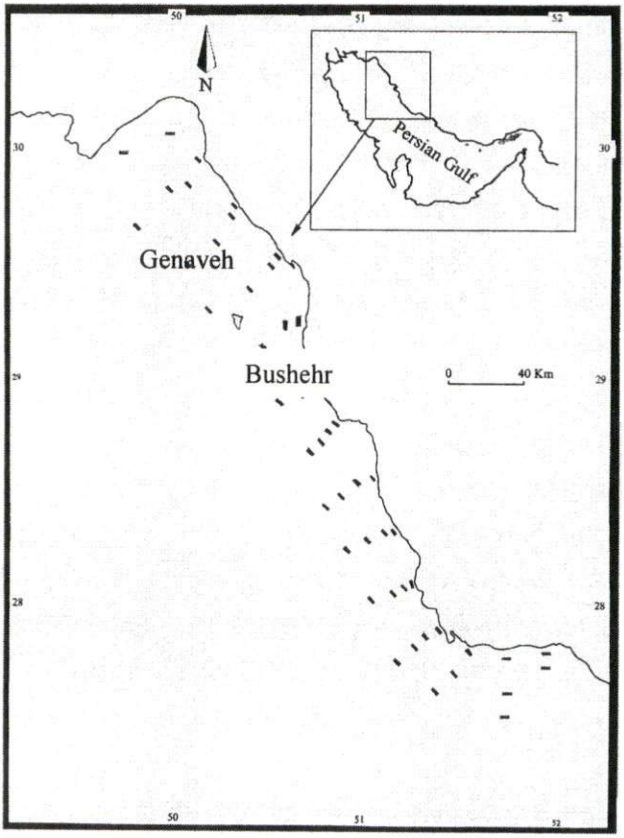


Figure 1: Location of study area and sampling Location for *P. semisulcatus* in Bushehr waters (Persian Gulf)

Growth parameters differ between species, but they may also vary from stock to stock within the same species, i.e. growth parameters of a particular species may take different values in different parts of its range (Sparre & Venema, 1992). The input data was separated by sex and the values of K and $L\infty$ were estimated for each sex by von Bertalanffy growth equation as follows:

$$L_t = L\infty\,(1-e^{-K(t-t_o)})$$

where, L_t is the length at time t, $L\infty$ is the asymptotic length, K is the growth coefficient and t_o is the hypothetical age when the size is zero.

The method used to estimate growth parameters is called ELEFAN 1 (Electronic Length Frequency Analysis) and involves the following steps (Pauly & Munro, 1984):

1- Identifying peaks and troughs, separating peaks in terms of the deviation of each length class frequency from the corresponding running average frequency (peaks are positive, troughs negative deviations). This definition involves no assumption of normality for the distribution of broods in each sample.
2- Assigning to each positive deviation a positive number point, proportionate to its derivation from the running average and similarly assign a certain number of negative points to each trough.
3- Identifying the set of growth parameters, which, by generating a growth curve which passes through a maximum number of peaks and avoiding through as much as possible accumulates the largest number of points, termed Explained Sum of Peaks or ESP, and dividing the ESP by the sum of points available in a set of length–frequency samples, i.e, by the Available Sum of Peaks (ASP) to obtain an estimator of the goodness of fit, the ESP/ASP ratio, which generally ranges between zero and one (0-1). This may be considered analogous to a coefficient of determination.

Using the input data from length frequencies and ELEFAN 1 program, asymptotic length ($L\infty$) and growth coefficient (K) were estimated for both males and females. To find the best growth curve passing through the maximum number of peaks, different starting samples and starting lengths were subjected to the goodness-of-fit tests by assessing the ratio ESP/ASP (Rn). Amplitude of oscillation (C) and winter point (WP) for both sexes were assumed equal to 0.6 and 0.2, respectively.

Using von Bertalanffy's equation, parameters of $L\infty$ and K, longevity estimates (T_{max}) were calculated for each curve by the inverse of von Bertalanffy's equations (King, 1984).

$T_{max} = t_o - (l/k) \ln [1 - (Li / L\infty)]$

Where Li is arbitrarily considered equal to 99% of the asymptotic length (King, 1995) and $t_o = 0$, or approximately $T_{max} = (3/K)$.

Finally, the following formulas were used to express the relationship between body weight, total length and carapace length.

$\text{Log } W = \log a + b \log TL$

$\text{Log } W = \log a + b \log CL$

$W = a\, TL^b$

$W = a\, CL^b$

Where W is weight (g), TL is total length (cm), CL is carapace length (mm) and, a and b are constants to be estimated from length/weight data pairs.

Results

The growth parameters of $L\infty$ and K in males were obtained for the best fit with $L\infty = 38$mm and $K = 1.6^{-1}$ (Fig. 2). For females, these parameters were estimated with $L\infty = 50.4$mm and $K = 2.2^{-1}$ (Fig. 3).

In females, the results showed that K ranged from 2.0 to 3.0 per year and in males from 1.5 to 2.6 per year. The $L\infty$ ranged in values from 49.9 to 51.0mm in females, and 36.4 to 38.1mm in males.

The relationship between total length and carapace length was obtained by linear regression (Figs. 4 and 5). The results for both sexes are as follows:

$CL = 2.32\, TL - 2.66$ Males

$CL = 2.55\, TL - 5.14$ Females

The relationships of total length, carapace length and weight were determined using exponential regression. The results for both sexes are as follow (Figs. 6, 7, 8, 9):

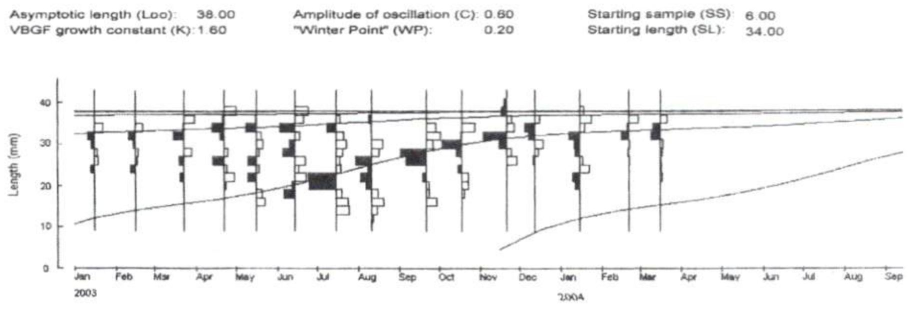
$W = 0.0015\, TL^{3.6089}$ Males

$W = 0.0027\, TL^{3.4004}$ Females

$W = 0.0005\, CL^{3.146}$ Males

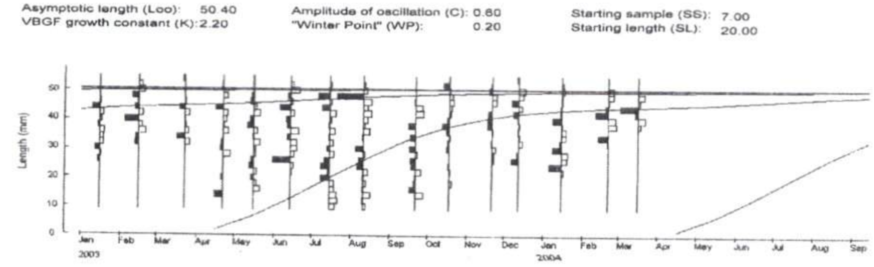
$W = 0.0012\, CL^{2.8643}$ Females

where, W is the weight (g), TL is the total length in cm and CL is the carapace length in mm, a and b are units of exponential regression.



Month

Figure 2: Length-frequency curve of male *P. semisulcatus* in Bushehr waters, Persian Gulf (2003-2004).



Month

Figure 3: Length-frequency curve of female *P. semisulcatus* in Bushehr waters, Persian Gulf (2003-2004).

The average carapace lengths for males and females were calculated (Fig. 10). The average minimum carapace length for males occurs in July (21.5±2.2mm), while the maximum occurs in December (32.9±2.1mm). For females, the minimum and maximum average of carapace length was calculated (25.8±4.1mm in July and 43.5±2.1mm in March, respectively). Both sexes exhibit a minimum point in July and a similar growth pattern during most of the year, with a difference only in March to May 2003 (Fig. 10).

In order to compare the growth of *P. semisulcatus* from the study area with those from other studies, ∅ (an index for comparison of growth performance in marine animals with the von Bertalanffy type of growth) was used. Details on growth comparison using ∅ as an index are discussed in Pauly and Munro (1984). The results for both sexes are as follow:

$\varnothing = \ln k + 2 \ln L_\infty$

$\varnothing = \ln 1.6 + 2 \ln 38 = 7.73$ Males

$\varnothing = \ln 2.2 + 2 \ln 50.4 = 8.6$ Females

The maximum age (T_{max}) was calculated for both sexes. In these calculations, t_o is unknown; however, it should be low and was fixed at zero. The results for both sexes are as follow:

Tmax = 3/1.6 = 1.8 year Male

Tmax= 3/2.2 = 1.3 year Female

Growth parameters of *P. semisulcatus* estimated in other studies are summarised in Table 1.

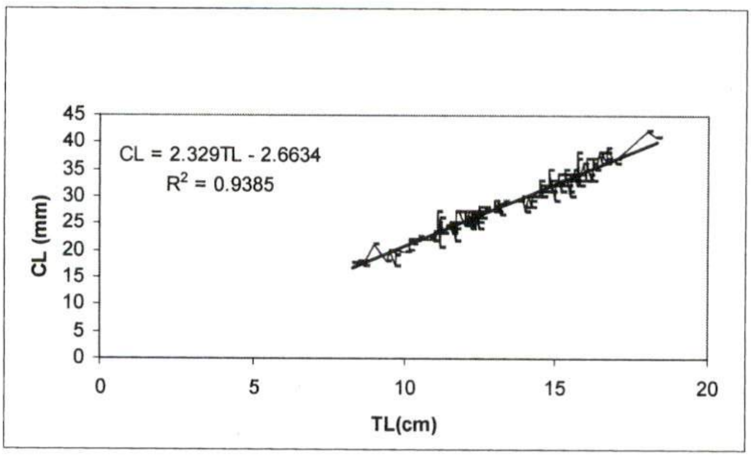


Figure 4: Relationship of total length and carapace length in males of *P. semisulcatus* in Bushehr waters, Persian Gulf (2003-2004).

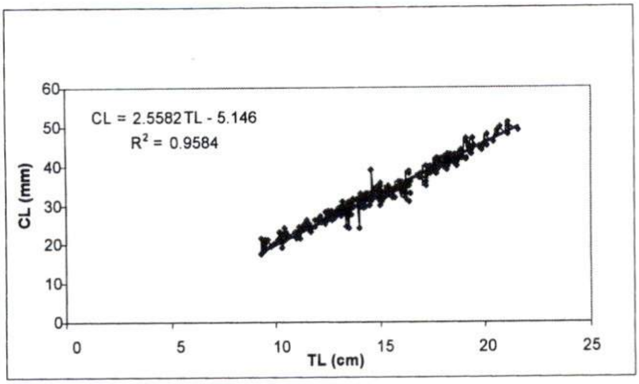


Figure 5: Relationship of total length and carapace length in females of *P. semisulcatus* in Bushehr waters, Persian Gulf (2003-2004).

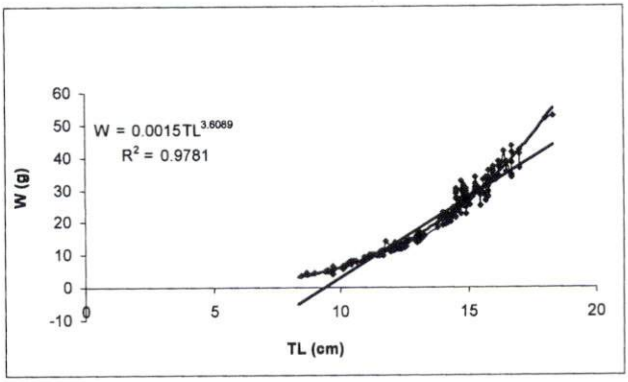


Figure 6: Relationship of total length and weight in males of *P. semisulcatus* in Bushehr waters, Persian Gulf (2003-2004).

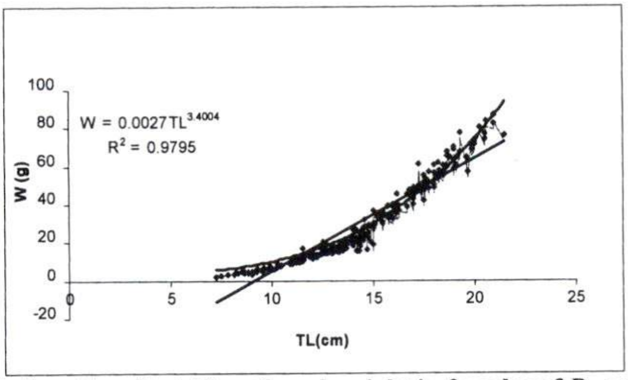


Figure 7: Relationship of total length and weight in females of *P. semisulcatus* in Bushehr waters, Persian Gulf (2003-2004).

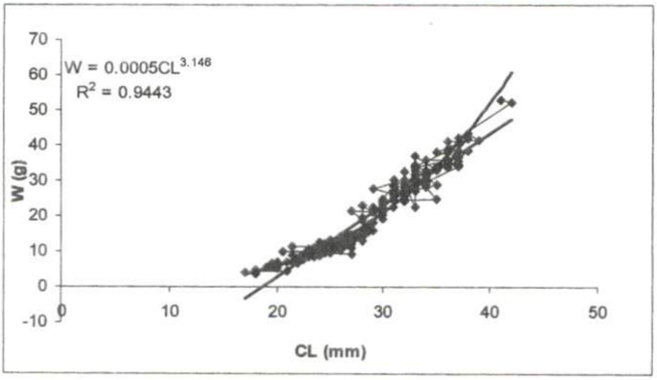


Figure 8: Relationship of carapace length and weight in males of *P. semisulcatus* in Bushehr waters, Persian Gulf (2003-2004).

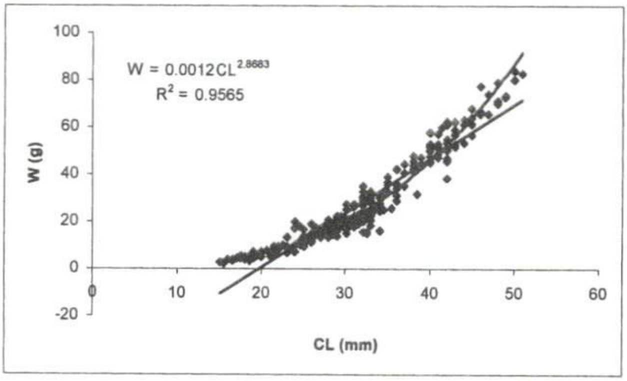


Figure 9: Relationship of carapace length and weight in females of *P. semisulcatus* in Bushehr waters, Persian Gulf (2003-2004).

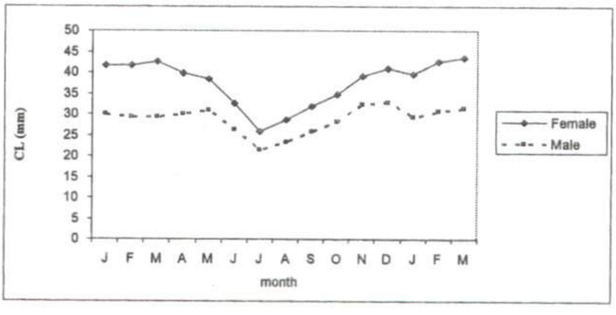


Figure 10: Average carapace length of male and female *P. semisulcatus* in Bushehr waters, Persian Gulf (2003-2004).

Table 1: Comparison of growth estimates for *P. semisulcatus* from different areas of the Persian Gulf

K (year^{-1})	L_∞ (mm)	Ø	Sex	Area	Source
0.93 1.09	48.2 53.2	7.68 7.76	Male Female	Persian Gulf (Kuwait)	Mathews *et al.* (1987)
2.2 3.2	-- --	-- --	Male Female	Persian Gulf (Kuwait)	FAO (1982)
2.6 2	48.2 47.7	8.7 8.41	Male Female	Persian Gulf (Kuwait)	Jones & van Zalinge (1981)
1.44–1.56 2.11–2.15	33.9–33.5 54.9–56.3	-- --	Male Female	Persian Gulf (Kuwait)	van Zalinge *et al.* (1979)
1.7 2.4	-- --	-- --	Male Female	Persian Gulf (Kuwait)	FAO (1978)
2.8 2.6	47.7 48.2	8.45 8.7	Male Female	Persian Gulf (Kuwait)	van Zalinge (1984)
1.3 3.2	38.1 62.2	-- --	Male Female	Australia	Somers & Kirkwood (1984)
1.7 2.4	18 22	7.45 8.7	Male Female	Persian Gulf (Iran)*	Ghasemi & Niamaimandi (1993)
1.8 2.6	37 49	7.8 8.73	Male Female	Persian Gulf (Iran)	Niamaimandi (1998)
1.6 2.2	38 50.4	7.74 8.54	Male Female	Persian Gulf (Iran)	Present study

*** In this study L_∞ is based on total length (cm).**

Discussion

In the present study, *P. semisulcatus* exhibited sexually dimorphic growth rates throughout the year. The lowest growth rate occurred in January, February and March, which represents the coldest months in the study area (Figs. 2 & 3). The highest growth rates occurred during the months of summer and autumn (July-December). At the beginning of July, the newly recruited *P. semisulcatus* population exhibits length modes of ~20mm CL for both males and females. By January small shrimps again began to appear and by August-September they became the major component of the population.

The length-frequency histograms for both sexes indicated that the population at any one time was composed of, at most, two-year classes. In males, there are two cohorts during most months and only one cohort presented during February and March (Fig. 2). In contrast, females exhibit three cohorts in some months (Fig. 3). Both sexes exhibited new recruitment in July. This was particularly clear in the growth curve of males (Fig. 2).

The mean carapace lengths have to be estimated for each cohort from the length–frequency data. A cohort of large and older shrimps was visible in the first several months (Fig. 10), and for both sexes, males and females the smaller newly recruited shrimps appeared as a new cohort in July.

Growth analyses based on length-frequency data work best on species in which the recruitment occurs over a short time period, and in which growth rates are relatively high (King, 1984). If both of these conditions applied, a single length-frequency sample may show several widely spaced year classes, and a time series of length-frequency samples is likely to produce narrow cohorts with modes that rapidly progress along the length axes. Molting in penaeids is relatively frequent (about 20 moults per year) and is apparently not synchronous for a population as a whole (Garcia, 1988). Therefore, although individual prawns may grow in a step-wise fashion, continuous growth models are generally considered the most appropriate means of describing growth at the population level (Garcia, 1985).

Pauly and Munro (1984) developed simple methodologies (ELEFAN) for comparing growth that, when applied to shrimp, can be useful tool for growth analysis. It is particularly helpful when the seasonal changes in growth are suspected and the seasonal temperature cycle consists of a single annual oscillation (Garcia, 1985).

K and $L\infty$ are different in both sexes. $L\infty$ is interpreted as the average length of the oldest specimens in the population, and its value may be approximated as the mean of the ten largest individuals found in catch samples (Sparre & Venema, 1992).

Various growth parameters estimates have been reported for *P. semisulcatus* from different areas (Table 1). The estimations ranged from 33.9 to 62.2mm CL for $L\infty$, while K ranged from 0.93 to 3.2 per year (Siddeek & Abdul-Ghafar, 1989; Dall *et al.*, 1990; Xu *et al.*, 1995). Growth parameters findings from other *P. semisulcatus* studies are summarized in Table 1. The estimates of K and L_∞ obtained from the studies in the Persian Gulf cover a very wide range of values, where K values ranged between 0.93 and 2.6 for males and 1.09 to 3.2 for females, and $L\infty$ values between 33.9mm and 62.3mm CL for males and females, respectively. The values obtained in this study were similar to those reported from Kuwait (van Zalinge *et al.*, 1979) and Bahrain (FAO, 1978). The mean ∅ values for the Kuwait and Bahrain studies were 7.68-8.7 for both sexes and are similar to 7.70-8.54 for the present study; therefore, suggesting that the estimates of the von Bertalanfty growth parameters in the present study are reliable. The present study values also agree with the earlier estimates of K and $L\infty$ reported from the same area (Ghasemi and Niamaimandi, 1993; Niamaimandi, 1998).

The latest survey from the Arabian side of the Persian Gulf (Kuwait, Saudi Arabia, Bahrain and Qatar) showed that $L\infty$ ranged from 38.32 to 51.27mm CL for females, and from 26.15 to 36.57mm CL for males (Ye *et al.*, 2003). Among the survey areas, Kuwait's shrimp exhibited the largest female $L\infty$ (51.27mm CL), while records from Saudi Arabia had the smallest (38.32mm CL). The largest males approached 36.57 mm CL in Kuwait waters and the smallest was 26.15mm CL in Qatar. In this study, K value was estimated to be from 1.64 per year (Kuwaiti area) to 3.63 per year (Saudi Arabia) for the males and from 1.94 (Kuwait) to 3.53 (Bahrain) for the females.

The $L\infty$ and K values of males in the present study were smaller than those reported from Kuwait (van Zalinge, 1984), although for females there was a difference between the values of K and $L\infty$ (K was larger and $L\infty$ was smaller). In Australia, the $L\infty$ and K values in males were very close to the present study but in females these parameters were very different in two locations (Somers & Kirkwood, 1989).

The growth parameters of *P. semisulcatus* may thus vary with geographical locations and environmental changes from year to year. A wide variation in the observed growth parameter estimates are possible due to a number of reasons:

inaccurate earlier estimates, varying environmental conditions, and high correlation between L∞ and K.

The six sets of estimated parameters and related Ø are presented in Table 1. The main objective of pointing out this aspect is that Ø has a different role to play. If the Ø value of a family of species is known, then the value of one growth parameter can be determined if the other is known for a particular species of that family. Apparently, there is good agreement among different results obtained in the Persian Gulf waters. Therefore, one could conclude that the Ø obtained from this study is either contradicting or supporting the Ø values found in the other parts of the Persian Gulf.

The maximum age for males (20 months) and females (15 months) and the L∞ for both sexes in the present study, along with the estimates of longevity, are similar to the results of the Somers and Kirkwood (1991) in the Gulf of Carpentaria but lower than the results of Tom *et al.* (1984) in the Mediterranean.

In the northwestern Gulf of Carpentaria (Australia), the longevity of *P. semisulcatus* must be at least 18 months, by this time males had reached about 39mm CL and females about 50mm CL (Somers & Kirkwood, 1991). Along the southeastern coast of the Mediterranean, Tom *et al.* (1984) found that the highest mean total length attained for the age group was 17.5 cm for males and 21.5cm for females, and they estimated that the shrimp's life span was about 25 months, having recruited at about 6 months of age. These body lengths correspond to carapace lengths of approximately 37mm for males and 50mm for females. Morgan (1995) also noted that the life span of *P. semisulcatus* was 12-18 months.

Fishing mortality, natural mortality and environmental factors all affect longevity. In long life span species, the application of fishing pressure over long periods reduces longevity. However, for shrimp it seems that the effects of predators and environmental factors become more important factors in regulating longevity.

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References

Azimi, A., 1985. [Final report on shrimp resources survey project in Bushehr coast of the Persian Gulf. Persian Gulf Fisheries Research Center Press, Bushehr, Iran]. 56P. (In Persian).

Dall, W., Hill, B.J., Rothlisberg, P.C. and Staples, D.J., 1990. Advances in Marine Biology. The biology of penaeidae. Academic Press. London, Uk. Vol. 27, pp.282-306.

FAO, 1978. Fisheries biologist shrimp report prepared for the government of Bahrain. 14P.

FAO, 1980. Report to the government of Kuwait on shrimp resources evaluation and management. FAO/UTFN/KUW/006/KUW: 10P.

FAO, 1982. Report on the workshop on assessment of the shrimp stocks of the west coast of the Gulf between Iran and Arabian peninsula (Kuwait, 17-22 October 1981): FI/DP/RAB/80/015. 13P.

Garcia, S., 1985. Reproduction, stock models and population parameters in exploited penaeid shrimp population. Second Australian National Prawn Seminar. NPS2 Cleveland Australia. pp.139-158.

Garcia, S., 1988. Tropical penaeid prawns. Fish Population Dynamics. (ed. J.A. Guland). pp.219-249.

Ghasemi, S. and Niamaimandi, N., 1993. [Final report of stock assessment of four species of fishes and shrimp, *Penaeus semisulcatus* by trawl survey in the Persian Gulf]. Iranian Fisheries Research Organization Press. 53P. (In Persian).

Guland, J.A., 1969. Manual of methods for fish stock assessment. Part 1. Fish population analysis. FAO Marine Fisheries Science 4. FAO Press. Rome, Italy. 154P.

Jones, R. and Van Zalinge, N.P., 1981. Estimates of mortality rates and population size for shrimp in Kuwait waters. Kuwait Bulletin of Marine Science. pp.273-288.

King, M., 1984. A study of the reproductive organs of the common marine shrimp, *Penaeus setiferus* (Linnaeus). Marine shrimp culture, principles and practices. pp.99-104.

King, M., 1995. Fisheries Biology. Assessment and Management. Oxford Press. London, UK. 342P.

Mathews, C.P., Al-Hossaini, M., Abdul Ghaffar, A.R. and Al-Shoushni, M., 1987. Assessment of short-lived stocks with special reference to Kuwait's shrimp fisheries:

a contrast of results obtained from traditional and recent size-based techniques. (eds. D. Pauly and G.R. Morgan). ICLARM Conference Proceeding. Vol. 13, pp.147-166.

Mathews, C.P., 1981. The history of Kuwait's shrimp fisheries. UFK/KISR 1981. pp.71-75.

Morgan, G.R., 1995. Prawn. Southern Fisheries. Vol. 3, 16-19.

Naamin, N. and Yamamoto, T., 1977. Some thoughts on the conservation of shrimp resources in west Iranian waters (Arafura Sea). Paper presented at the Second National Seminar on Shrimp. 15-16 March 1977. Jakarta, Andonezy. 48P.

Niamaimandi, N., 1998. Fisheries management of *Penaeus semisulcatus* in the Persian Gulf (Iranian waters). Fourth International Crustacean Congress, 20-24 July, 1998, Amsterdam, Netherland. pp.1-13.

Pauly, D. and Munro, J.L., 1984. Once more on the growth comparison in fish and invertebrates. Fishbyte. Vol. 2, 21P.

Siddeek, M.S.M. and Abdul-Ghaffar, A.R., 1989. The effects of the one month delay in opening the shrimp fishery season of *Penaeus semisulcatus* in 1986 in Kuwait waters. Kuwait Bulletin of Marine Science. No. 10, pp.81-96.

Somers, I.F. and Kikwood, G.P., 1984. Movement of tagged tiger prawns, *Penaeus spp*., in the western Gulf of Carpentaria, Australia. Australian Journal of Marine Freshwater Resources. **35:**713-723.

Somers, I.F. and Kirkwood, G.P., 1991. Population ecology of the grooved tiger prawn, *Penaeus semisulcatus*, in the north-western Gulf of Carpentaria, Australia. On composition of growth curves: How do we test whether growth rates differ. Second Australian National Prawn Seminar. NPS2 Cleveland Australia. pp.871-878.

Sparre, P. and Venema, S.C., 1992. Introduction to tropical fish stock assessment. Part 1-manual. FAO Press, Rome, Italy. 376P.

Thomas, M.M., 1974. Reproduction fecundity and sex ratio of the green tiger prawn, *Penaeus semisulcatus* De Haan. Indian Journal of Fisheries. **21:**152-163.

Tom, M., Schlagman, A. and Lewinsohu, C., 1984. The benthic phase of the life cycle of *Penaeus semisulcatus* (De Haan*)* along the southeastern coast of the Mediterranean: Marine Ecology Progress Series 5. pp.229-241.

UNDP/FAO, 1982. Report on the workshop on assessment of the shrimp stocks of the west coast of the Gulf between Iran and the Arabian Peninsula. Rome. Kuwait 17-22 October 1981, FI: DP/RAB/80/015. 163P.

van Zalinge, N.P., 1984. The shrimp fisheries in the Gulf between Iran and Arabian

Peninsula. Penaeid shrimps-their biology and management. ICLARM Contribution No. 122, pp.71-78.

van Zalinge, N.P., El-Musa, M., El-Hossaini and El-Ghaffor, A.R., 1979. The Kuwait shrimp fishery and the shrimp resources in Kuwait waters. UTFN/ KUWAIT/006/ KUWAIT/R7. pp.59-61.

Xu, X., Mohammad, H.M.A., Al-Ghunaim, A.Y. and Al-Yamani, F., 1995. Temporal variability in natural mortality of green tiger prawns, *Penaeus semisulcatus,* in Kuwait waters. Journal of Shellfish Research, 14(**2**):337-340.

Ye, Y., Bishop, J.M., Fetta, N., Abdulqader, E., Al-Mohammadi, J., Alsaffar, A.H. and Almatar, S., 2003. Spatial variation in growth of the green tiger prawn (*Penaeus semisulcatus*) along the coastal waters of Kuwait, eastern Saudi Arabia, Bahrain and Qatar. Journal of Marine Science, **60:**806-817.