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Population Dynamics of *Macrobrachium nipponense* (De Haan, 1849) in Anzali Lagoon, Iran

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ABSTRACT

This study estimates growth parameters, length-frequency growth performance index, longevity, and total mortality of the oriental river prawn, *Macrobrachium nipponense*, from Anzali lagoon, Iran. The von Bertalanffy growth parameters were, $L\infty = 8.65$ cm, $K = 0.82\ yr^{-1}$, and $t_0 = -0.146\ yr^{-1}$. The growth performance index, Φ', was 1.78. Total mortality, Z, from the linearised length-converted catch curve was 4.89 yr^{-1}. Natural mortality M calculated from Pauly's empirical formula was 2.1 $yr^{-1,}$ and fishing mortality F calculated from Z - M was 2.74 yr^{-1}. The exploitation ratio E calculated from F/Z was 0.57. The longevity was about 3 yrs. Length-frequency showed no significant difference between the two sexes ($p>0.05$). According to the results of this study, it seems that the Anzali lagoon has a suitable environment for the life and growth of *M. nipponense*.

INTRODUCTION

The study of the distribution and biological characteristics of non-native species in lagoons is critical from a biological point of view because the invasion of non-native species in all ecosystems can significantly affect the ecology and the food chain as well as reduce the value of biodiversity. The Oriental River Prawn (*M. nipponense*) is natively distributed in east Asia (**New *et al.*, 2010**). The same species were reported in Iran's Anzali Lagoon in 2006 (**De Grave and Ghane 2006**). This species belongs to the phylum of Arthropoda (Order: Decapoda; Family: Palaemonida) (**De Haan, 1849**). The Anzali Lagoon is located on the Caspian Sea's southeast coast in the Guilan province (**Khanipour *et al.*, 2020**).

Population dynamics studies are one of the oldest human studies of fish stocks, which form the basis of stocks assessment science. Information on the species' diversity and their abundance are critical in the aquatic system. Therefore, interspecific abundance relationships depend on each species available in the aquatic system. In addition, understanding some individual parameters for species, such as growth reserves, mortality, migration, and the effect of fishing, can be helpful for management, economic, and aquatic dynamics planning (**Verberk *et al*., 2010**). Understanding the factors that determine the bioavailability and abundance of the shrimp population is one of the most critical issues in fisheries today (**Biswas, 1993**). Studying the biology and ecology of different aquatic species in an aquatic ecosystem is one of the necessities of preserving their reserves and leading to ecological knowledge and analysis of ecosystems' food chain, which is widely used in proper fisheries management practices. Knowledge of aquatic resources is essential for management, economic, and aquatic dynamics planning (**Aminisarteshnizi, 2021**). Population dynamics parameters are the basis of analysis models in the discussion of stock valuation, and by calculating them, accurate information about reserves can be obtained (**Sparre and Venema, 1998**).

The study's objective was to determine the growth and mortality parameters of the *M. nipponense*. Therefore, the present study aimed to investigate the mentioned parameters for *M. nipponense* through the year in Anzali Lagoon, Iran.

MATERIALS AND METHODS

Study area

Specimens of *M.nipponense* were collected from the Anzali Site 1 (GPS coordinates: 37° 27' 9446.43'' N and 49° 22' 9944.18'' E), Site 2 (GPS coordinates: 37° 25' 026.42'' N and 49° 27' 307.12'' E) and station 3 (GPS coordinates: 37° 25' 2998.45'' N and 49° 24' 6902.1'' E) (Fig. 1), which is a preferred habitat for the species. Nine (9) traps were randomly selected for sampling the prawn. The traps were checked every 24 hours, and the samples were collected at night for ten (10) nights per month for eleven (11) months (February to December 2015).

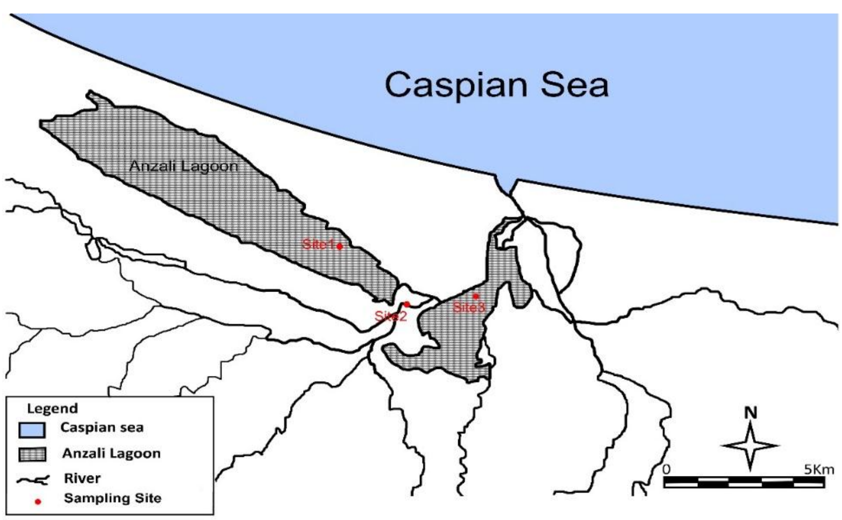

Figure 1. Sampling area for *M. nipponense* in Anzali Lagoon, Gilan Province, Iran.

Sample collection:

All collected samples were immediately placed in iceboxes and transported to the fish biology laboratory for further analyses. Samples were sorted into male and female. Total length (from the tip of the rostrum to the tip of the telson) was measured with a Vernier caliper to the nearest 0.1 mm. The prawns were then weighed with a balance to the nearest 0.1 g. Samples taken each month were measured and preserved separately.

Growth Pattern

The recorded length (total length) of the individuals of the assessed prawn species was used. In all, a total of 1200 specimens of *M. nipponense* were examined for the present study. The Sturges formula (**Sturges, 1926**) was used for length frequently.

R= (Max-Min) +1

K= 1+3.3 log n

C= R/K, where n = number of prawns, K= number of classes, C= distance between classes

Kolmogorov–Smirnov test was used to determine whether the size composition of *M.nipponense* significantly differed between males and females.

The population parameter estimates were obtained using the FAO-ICLARM Stock Assessment Tools routines, FiSAT (**Gayanilo *et al.*, 1995**). For the von Bertalanffy growth parameters' estimates, the asymptotic length ($L\infty$), and the growth coefficient (K), the ELEFAN I routine of FiSAT was used. ELEFANI routine allows the estimation of growth parameters without knowing the individuals' age. The von Bertalanffy growth in length equation is expressed as (**Pauly and David, 1981**):

$$L_t = L_\infty (1 - e^{-(t-t_0)})$$

Pauly's empirical equation for the theoretical age at length zero (t_0) was used to obtain this parameter as (Pauly 1979):

$$\text{Log}_{10} (-t_0) = -0.392 - 0.275 \text{ Log}_{10} L\infty - 1.038 \text{ Log}_{10} K$$

The $L\infty$ and K estimates were used to compute the growth performance index, Φ' of the species as follows (Moreau et al. 1986):

$$\Phi' = \text{Log}_{10} K + 2 \text{ Log}_{10} L\infty$$

and longevity (T_{max}) was estimated using the equation of Pauly (1980a) as follows.

$$T_{max} = \text{approx. } 3/K$$

Mortality

Total mortality (Z) estimates were derived from the linearized length–converted catch curve (**Pauly, 1983**), a component of ELEFAN I, by fitting a regression line through the natural logarithm (ln) of the number (N) of prawns in various length groups divided by the time (d_t) necessary for average individual prawns to grow through the length class, against their relative age, t (i.e., ln (N/dt) = a + bt). Z was estimated from the slope, b (with the sign changed) of the descending right arm of the plot (**Sparre and Venema, 1992**). The regression line was fitted to exclude the initial ascending data, points, and the rightmost point. Natural mortality (M) was derived through Pauly's (1980b) empirical equation using a mean annual surface habitat temperature of 24°C. Then,

$$\mathbf{Log_{10} M = -0.0066 - 0.279 Log_{10} L\infty + 0.6543 Log_{10} K + 0.463 Log_{10} T.}$$

The difference between (Z) and (M) gave us the fishing mortality rate, F, from the equation; F = Z – M, and the rate of exploitation (E) was calculated by the quotient between fishing and total mortality:

E = F/Z (Gulland, 1971).

RESULTS

The maximum and minimum length for *M. nipponense* was 82 mm and 11.9 mm, respectively. Length-frequently between females and males was no significant difference (p>0.05) (Fig. 2).

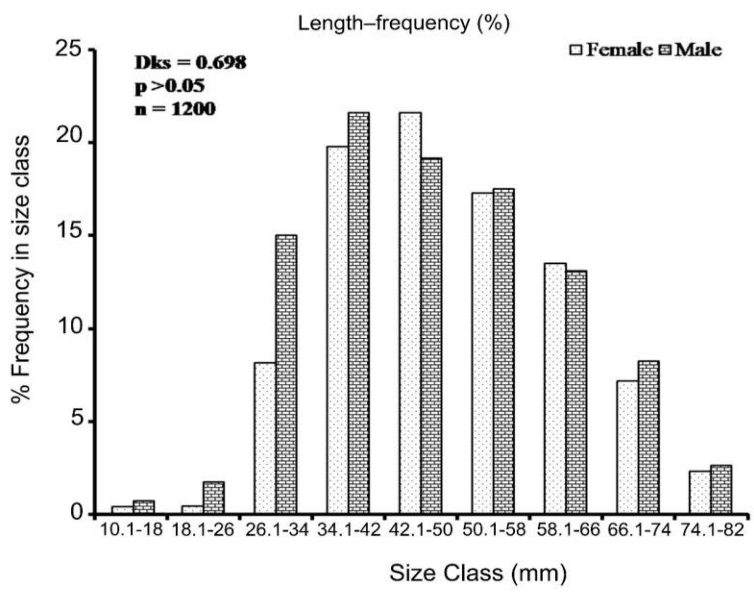

Figure 2. Percentage length-frequency distributions of *M. nipponense* for males and females.

The von Bertalanffy growth model for *M. nipponense* in the Anzali lagoon was described as: $L_t = 86.5\ (1\text{-}e^{-0.82(t+0.146)})$. The length-frequency distribution output from ELEFAN 1 of FiSAT was shown for *M. niponenses* (Fig. 3).

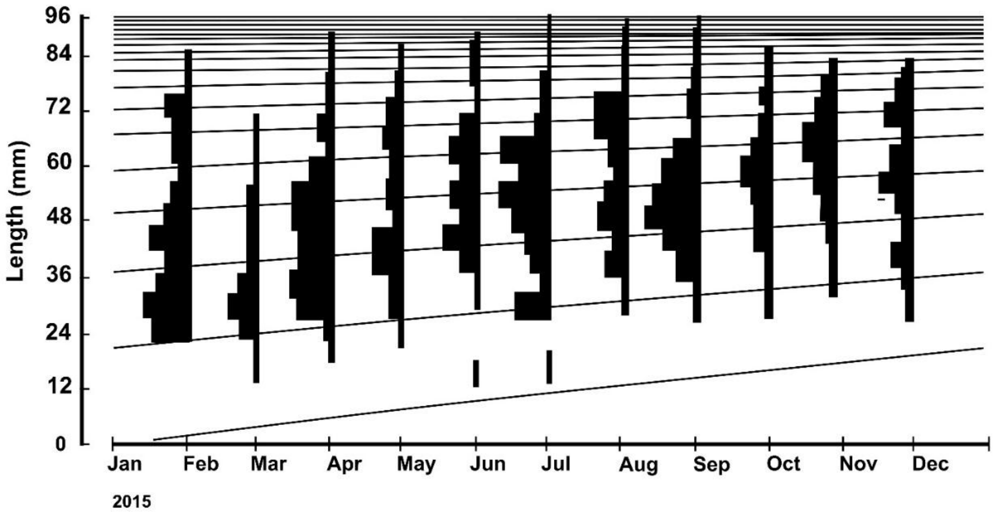

Figure 3. Length-frequency distribution output from FiSAT with growth curve for *M. nipponense* from Anzali lagoon.

The growth parameters were $L\infty = 86.5$ mm, $K = 0.82 yr^{-1}$ and to = -0.146 years. The growth performance index Φ' was 1.78, while the longevity $t_{max} = 3.65$ years. The instantaneous total mortality, $Z = 4.89\ yr^{-1}$, natural mortality, $M = 2.1\ yr^{-1}$, and fishing mortality, $F = 2.79\ yr^{-1}$ (Fig. 4). The rate of exploitation, E = 0.57, while the M/K ratio values were 2.56.

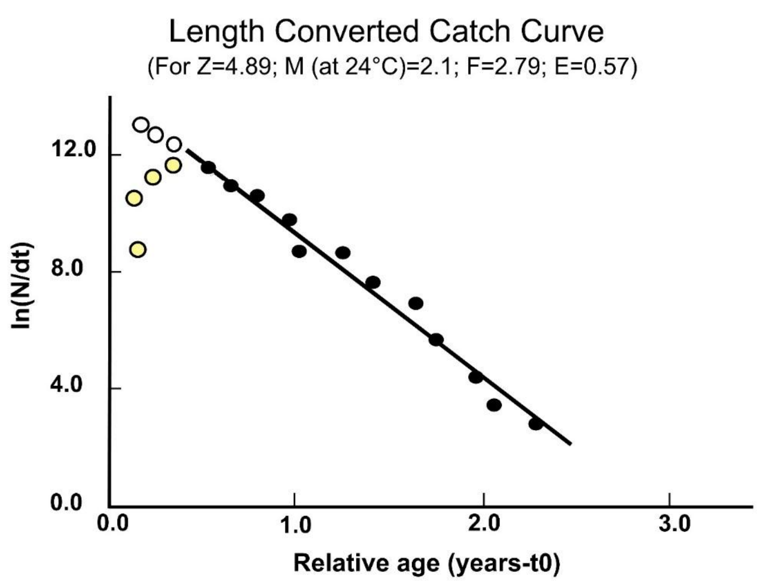

Figure 4. Length-converted catch curve for *M. nipponense* from the Anzali lagoon.

Water quality parameters in the Anzli lagoon were within acceptable limits for the growth and development of *M. nipponense*. The water temperature was 24°C, dissolved oxygen was 4.5 mg/L, and pH was 8.1 during the sampling period.

DISCUSSION

The monthly abundance of *M. nipponense* during a year differed in the Anzali lagoon. In July, the number of *M. nipponense* was high (water temperature was 30.1), and the lowest number was in December (water temperature was 10.4). According to the temperature, *M. nipponense* had a high abundance in the best temperature range. **New et al. (2010)** reported that temperature significantly influenced growth patterns. *Macrobrachium* species required water temperatures from 26 to 31◦C for profitable growth. The most frequent length class for females was 45-53 mm and for males was 36-44 mm. In the highest-sized class, we had just males, so the result showed males were bigger than females. The parameters that can describe growth in length ($L\infty$= 8.65 cm and K = 0.82 yr^{-1}) of *M. nipponense* in this study differed from those observed by other researchers.

Raeisi *et al.* (2018) recorded the total $L\infty$ of 73 mm and K of 0.95 yr^{-1} for *M. nipponense* from Boustan Dam Lake in 2016. Fore separated the species into sexes; they obtained $L\infty$ of 86.63 mm and 76 mm, K values of 1 yr^{-1} and 0.79 yr^{-1} for males and females, respectively. The average size of adult *M. nipponense* in this study was bigger than Boustan Dam. The mentioned authors have reported the mean total length as 40.97 mm. At the same time, the maximum and minimum total lengths were 74.94 mm and 11.7 mm, respectively. Many ecological reasons affect the growing pattern for *M. nipponense*, but the main reasons are temperature and food availability. In Anzali lagoon, the water temperature was higher than in Boustan Dam Lake. According to **Khanipour *et al*. (2020)**, food available in the Anzali lagoon for *M. nipponense* was high.

Similar results were presented by **Danayi *et al*. (2019),** who reported the average size of adult values of $L\infty$ 86.63 mm and K 0.8 yr^{-1} for *M. nipponense* from Golestan Dam Lake in 2016. On the other hand, they separated the species into sexes and obtained $L\infty$ for each sex was 87.5 mm, K values of 0.9 yr^{-1} and 0.85 yr^{-1} for males and females, respectively. In addition, they have reported a mean of the total length as 41.7 mm. The maximum and minimum total lengths were 85 mm and 16 mm, respectively.

Isaac (1990) showed that growth parameters estimated from ELEFAN 1 routine could be biased due to individual growth variation, seasonal oscillations in growth, the restructuring procedure, size-dependent selection, variable recruitment period, and large size-class interval. Although, the reliability of this routine remains on the following assumptions: first, the sample(s) used represents the population investigated; second, the growth pattern in the population from year to year is the same; third, the von Bertalanffy

Growth Function (VBGF) describes the average growth of the studied stock; forth, all fishes in the (set of) sample(s) have the same length at the same age; therefore, differences in length can be showed to different ages. The assumptions above show a sampling problem since the decision on soak time, and the local fishermen made the sampling place of the study with expertise in prawn fishing. Although, the fourth of these assumptions does not use since it is known that fishes may have different lengths at the same age. However, simulations show that this assumption, essential to the routine's operation, does not generate a marked bias (**Dwiponggo *et al.*, 1986**). Estimating mortality and growth is fundamental in fisheries because the management and stock assessment depend on these population parameters. Therefore, length-frequency-based methods have become an important method. While aging techniques are either impossible or very expensive (**Wang and Ellis, 2005**).

Using the growth performance index or phi prime (Φ'), which is the basis for comparing growth parameters, the species grows according to the von Bertalanffy model. Similar values of Φ', for related species are present, and each taxon may have a particular distribution of values different from another taxon (**Pauly and Munro, 1984; Pauly, 1991**). The results in this study fall within an acceptable range (Φ'= 1.78) are comparable with those for *M. nipponense* (1.7) (**Raeisi *et al*., 2018**), *M. nipponense* (1.6) (**Danayi *et al*., 2019**), and *M. vollenhovenii* (2.3) (**Alhassan and Armah, 2011**). Low Φ' values in water bodies were in the low rainfall, and high Φ' values were in high rainfall zones (**Alhassan and Armah, 2011**). **Nwosu and Wolfi (2006)** showed the range of the Φ' values for species was the same, but their estimated longevity varied widely.

The fishing mortality, F, total mortality, Z, and natural mortality, M, obtained in this study were 2.79 yr^{-1}, 4.89 yr^{-1}, 2.1 yr^{-1}, respectively. At the same time, **Raeisi *et al*. (2018)** obtained M of 1.17 and 1.08 for males and females, respectively, for *M. nipponense*. **Danayi *et al.* (2019)** for *M. nipponense* showed M of 2.17 and 2.09 for males and females, respectively. **Alhassan and Armah (2011)** reported Z, M, F for *M. vollenhovenii* was 5.36 yr^{-1}, 2.2 $yr^{-1,}$ and 3.16 yr^{-1}, respectively. They said that a high natural mortality rate was probably due to emigration because emigration sometimes appears as seeming mortality; however, it may be compensated by immigration (**Laevastu and Favorite, 1988; Alhassan and Armah, 2011**). **Fallah and Zamani-Ahmadmahmoodi (2017)** reported water quality of the Anzali lagoon is classified into the "medium" and "bad" classes based on the season. They showed that the wastewater produced by farming activity during the rainy season is one of the reasons for polluting the water. Therefore, increasing water pollution causes increasing the natural mortality of *M. nipponense*.

According to **Beverton and Holt (1957)**, the validity of the estimated natural mortality, M, is ascertained using the M/K ratio within the ranges of 1.12 to 2.5 for most fishes. The M/K ratio of 2.5 obtained in the present study was within this range. The longevity was found to be three years (36 months). This confirms **Garcia's (1988)** findings, which suggested that tropical prawns are generally fast-growing and short-lived, with a maximum life range of 2 to 3 years. **Nwosu and Wolfi (2006)** reported longevity of 29 months (males) and 28.8 months (females), while **Alhassan and Armah (2011)** estimated longevity of 36 months. **Nwosu (2007)** reported longevity for *M. equidens* was 28.8 months.

CONCLUSION

In conclusion, *M. nipponense* in the Anzali lagoon had a better situation than the other part of Iran. Total length and length-frequency showed a bigger size of *M. nipponense* in the Anzali lagoon. Furthermore, because of the emigration to the Caspian Sea for spawning, the natural mortality rate was 2.1. The result showed Anzali lagoon has a good potential for growing and living *M. nipponense.* Besides, because *M. nipponense* is invasive species, the management of this fishery will enhance the conservation of this ecosystem's biological diversity.

REFERENCES

Alhassan, E.H. and Armah, A.K. (2011). Population Dynamics of the African River Prawn, *Macrobrachium vollenhovenii*, in Dawhenya Impoundment. Turkish Journal of Fisheries and Aquatic Sciences, 11: 113-119.

Aminisarteshnizi, M. (2021). Length-Weight Relationship and Fulton's Condition Factor of *Macrobrachium nipponense* (De Haan, 1849) in Siah Darvishan River, Iran. Egyptian Journal of Aquatic Biology & Fisheries, 25(2): 551 – 560.

Beverton, R.J.H. and Holt, S.J. (1957). On the Dynamics of Exploited Fish Populations. Fisheries Investment Ministry, Agriculture Fish Food. Series II, Vol. 19. HMSO, London, 533 pp.

Biswas, S.P. (1993). Manual of methods in fish biology. Palemonid prawns of Myanmar Crustacea: Decapoda: Caridea. Hydrobiologia, 487: 59-83.

Danayi, A.; Patimar, R. and Raeisi, H. (2019). Population dynamic of the oriental river prawn (*Macrobrachium nipponense*) from Golestan Dam Lake-Golestan Province. Jornal of Aquatic Ecology, 9(3): 14-30.

De Grave, S. and Ghane, A. (2006). The Establishment of the Oriental River Prawn, *Macrobrachium nipponense* (de Haan), in Anzali Lagoon. Iran. Aquatic Invasions**,** 4: 204-208.

De Haan,W. (1833-1850). Crustacea. In: von Siebold PF Fauna Japonica sive description animalium, quae in itenere per Japoniam, jussu et auspiciis superiorum, qui summum in India Batava imperium tenent, suscepto, annis 1823-1830 collegit, notis, observationibus et admumbrationibus illustravit. Lugduni-Batavorum, i-xvii, ix-xvi, 1-243, [244], I-xxxi, Plates A-J, L-Q, 1-55.

Dwiponggo, A.; Hariati, T.; Banon, S.; Palomares, M.L. and Pauly, D. (1986). Growth, mortality and recruitment of commercially important fishes and penaed shrimps in Indonesian waters. ICLARM Technical Reports**.** 17: 91.

Fallah, M. and Zamani-Ahmadmahmoodi, R. (2017). Assessment of water quality in Iran's Anzali Wetland, using qualitative indices from 1985, 2007, and 2014. *Wetlands Ecology Management.* **25**: 597–605. DOI: 10.1007/s11273-017-9538-y

Garcia, S. (1988). Tropical panaed prawns. In: J.A. Gulland (Ed.), Fish population dynamics (2nd Edn). John Wiley& Sons, London, 219-249.

Gayanilo, Jr F.C.; Sparre, P. and Pauly, D. (1995). FAO – ICLARM stock assessment tools (FiSAT) user's manual. FAO Computerized Information Series (Fisheries)**,** 8:126.

Gulland J. A. (1971). The fish resources of the ocean. West Byfleet, Surrrey. *Fishing News Books Ltd, FAO*. 255 pp.

Isaac V.J. (1990). The accuracy of some length-based methods for fish population studies. ICLARM Tech. Rep**,** 27: 81.

Khanipour, A.A.; Noori, A.; Amini, M. and Kamrani, E. (2020). Length-weight relationship and Fulton's condition factor of *Macrobrachium nipponense* (De Haan, 1849) in Anzali lagoon of Iran. Iranian Journal of Fisheries Sciences, 19(1): 496-500.

Laevastu, T. and Favorite, F. (1988). Fishing and Stock Fluactuations. Farham, Survey, Fishing News Books, London, 240 pp.

Moreau, J.; Bambino, C. and Pauly, D. (1986). A comparison of four indices of overall growth performance, based on 100 tilapia populations (Cichlidae). In: J.L. Maclean, L.B. Dizon and L.V. Hosillos (Eds.), The first Asian fisheries forum. Asian Fisheries Society, Manila, Philippines, 201- 206.

New, M.B.; Valenti, W.C.; Tidwell, J.H.; DAbramo, L.R. and Kutty, M.N. (2010). Fresh water prawn's biology and farming. Wiley-Blackwell publishing, 542 PP.

Nwosu, F.M. (2008). Growth and mortality of the rough river prawn Macrobrachium equidens Dana, 1852 (Crustacea, Palaemonidae) in Cross River Estuary, Southeast Nigeria. Journal of Food, Agriculture & Environment, 6 (1): 1 8 6 - 1 8 9.

Nwosu, F.M. and Wolfi, M. (2006). Population Dynamics of the Giant African River Prawn Macrobrachium vollenhovenii Herklots 1857 (Crustacea, Palaemonidae) in the Cross-River Estuary, Nigeria. West Africa Journal of Applied Ecology (WAJAE), 9: 11-18.

Pauly, D. (1979). Theory and management of tropical multispecies stocks: a review with emphasis on the Southeast Asian demersal fisheries. ICLARM Study Review, 1: 35.

Pauly, D. (1980a). A selection of simple methods for the assessment of tropical fish stocks. FAO Fisheries Circular, 729: 54.

Pauly, D. (1980b). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. Journal du Conseil International pour l' Explorationde la Mer, 39: 175-192.

Pauly, D. (1983). Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM Study Review**,** 8: 325.

Pauly, D. (1990). Length-converted catch curves and the seasonal growth of fishes. Fishbyte**,** 8: 33-38.

Pauly, D. (1991). Growth performance in fishes: rigorous description of patterns as a basis for understanding causal mechanisms. Aquabyte, 4: 3-6.

Pauly, D. and David, N. (1981). ELEFAN I: a basic programme for the objective extraction of growth parameters from length-frequencies data. Meerestorschiung, 28: 205-211.

Pauly, D. and Munro, J.L. (1984). Once more on the comparison of growth in fish and invertebrates. ICLARM fish byte, 2: 21.

Raeisi, H.; Danayi, A. and Patimar, R. (2018). Growth and mortality of the oriental river prawn (*Macrobrachium nipponense*) from Boustan Dam Lake-Southeast Caspian Sea. Journal of animal environmental, 10(4): 451-460.

Sparre, P. and Venema, S.C. (1992). Introduction to Tropical Fish Stock Assessment. Part 1. Manual. FAO Fisheries Technical Paper 306, Review 1, FAO, Rome, 376 pp.

Sparre, P. and Venema, S.C. (1998). Introduction to tropical fish stock assessment. part 1. Manual FAO Fish, Tech. Pap. 306. FAO, Rome, Italy. 407 p.

Sturges, H. A. (1926). The choice of a class interval. *Journal of the American Statistical Association*. **21 (153)**: 65–66. DOI:10.1080/01621459.1926.10502161. JSTOR 2965501

Verberk, W.C.E.P., Velde, G.V.D. and Esselink, H. (2010). Explaining abundance–occupancy relationships in specialists and generalists: a case study on aquatic macroinvertebrates in standing waters. *Journal of Animal Ecology*. **79**: 589–601. DOI: 10.1111/j.1365-2656.20

Wang, Y. and Ellis, N. (2005). Maximum likelihood estimation of mortality and growth with individual variability from multiple length-frequency data. *Fishery Bulletin* **103**: 380-391.