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Growth parameters and population dynamics of deep-sea caridean shrimp *Plesionika semilaevis* (Spence Bate, 1888) along the south-west coast of India

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Abstract

The deep-sea caridean shrimp *Plesionika semilaevis* (Spence Bate, 1888) is a significant commercial species in the deep-sea fishery on the south-west coast of India. Analysis of its population parameters is crucial for understanding variability and ensuring the sustainability of this stock. This study presents the first stock assessment of *P. semilaevis* from Indian waters, analysing its population and growth parameters in the south-eastern Arabian Sea. Both sexes showed negative allometric growth. Growth estimates using the von Bertalanffy model revealed fast growth and low longevity for males (L_∞ = 14 cm TL, K = 0.74 yr^{-1} and Φ' = 2.16) and females (L_∞ = 14.3 cm TL, K = 0.73 yr^{-1} and Φ' = 2.17). The length at first capture was estimated as 9.46 cm while the length at maturity was measured at 8.73 cm. The estimated values for natural, fishing and total mortality were 1.12 , 2.06 and 3.18±0.17 yr^{-1} respectively. The exploitation rate (E = 0.65) was almost equal to the E_{msy} value (E0.1 = 0.62), indicating the fishery as sustainable. The findings provide a baseline for stock management and conservation of Indian deep-sea fisheries.

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Introduction

Fish stock assessment plays a critical role in evaluating the health of exploited stocks and providing scientific advice essential for sustainable fisheries management. Although fishery resources have natural renewal capacity, their sustainability depends on controlling exploitation rates, fishing efforts, and catch sizes to prevent overfishing and stock depletion (Jana *et al.*, 2024). Accurate assessment of stock condition enables managers to predict sustainable yields and set appropriate fishing regulations (Beverton and Holt, 1957). Growth in crustaceans is irregular and influenced by biotic factors such as maturity, age, food quality and quantity, predator presence, moult frequency and growth increments, along with abiotic factors including salinity, dissolved oxygen, photoperiod and temperature (Dall *et al.*, 1990; Lizarraga *et al.*, 2008). Shrimps, being short-lived, have population dynamics shaped mainly by environmental variability, with regional differences attributed more to habitat diversity than genetics (Miazaki *et al.*, 2021). Direct aging is difficult due to lack of durable structures (King, 2013; Punt *et al.*, 2013); thus, population parameters are typically derived from length-frequency data. Length-weight relationships are fundamental in fisheries assessments, serving as indicators of growth condition, feeding intensity and reproductive cycles (Fagade, 1979; Welcome, 1979).

The genus *Plesionika* is one of the most abundant in the deep-sea shrimp family, comprising over 100 species (WoRMS, 2024) worldwide. *Plesionika semilaevis* and *Plesionika quasigrandis* emerged as the predominant species within the *Plesionika* genus, together contributing significantly, accounting for 21% of deep-sea shrimp fishery along the Kerala coast (Chakraborty *et al.*, 2022). *P. semilaevis*, widely distributed in tropical waters of the

Indo-Pacific and Atlantic regions, inhabits shelf edges and upper continental slopes at depths ranging from 260 to 2263 m along the south-east and south-west coasts of India (Alcock, 1901; Suseelan, 1985). Although detailed data on feeding (Sreelakshmy *et al*., 2023), reproduction (Sreelakshmy and Chakraborty, 2023), and biochemical properties (Sreelakshmy *et al*., 2024) are available from the south-eastern Arabian Sea, information on the population parameters of *P. semilaevis* in Indian waters remains lacking. The only available global information on *P. semilaevis* pertains to its length-weight parameters from Kagoshima Bay, Japan, as reported by Ohtomi (1997). Given their considerable commercial and ecological importance, there is a pressing need to thoroughly assess the stock status of these species in order to develop effective management strategies that address the intense harvesting activities along the south-west coast of India.

Available information on the growth parameters and population dynamics of other deep-sea shrimps from the south-west coast is on *Heterocarpus woodmasoni, H. gibbosus* (Radhika, 2004), *P. quasigransis* (Chakraborty *et al.,* 2014; Shanis, 2014) and *Aristeus alcocki* (Chakraborty *et al.,* 2018). This study is the first to address the population structure, growth, mortality, exploitation, and longevity of *P. semilaevis* from the south-west coast of India, providing essential information for the sustainable management of this important resource.

Materials and methods

Length-weight relationship

The length-weight relationship was analysed for samples collected bimonthly between 2016 to 2022 from the Saktikulangara landing centre, Kollam, Kerala (Fig. 1). Males and females were separated and total length (TL) and body weight (W) were measured with precisions of 0.1 mm and 0.01 g, respectively (Fig. 2).

The length-weight relationship was determined using the formula, $W = aL^b$ (Le Cren, 1951), which is logarithmically expressed as:

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

where W is the wet body weight in g; L is the total length of the shrimp in cm and a and b are the length-weight parameters.

The coefficient 'b' offers insights into the condition of shrimp and aids in discerning whether somatic growth is isometric (b=3) or allometric (b<3; negative allometric and b>3; positive allometric) (Ricker, 1973; Spiegel, 1991).

Analysis of covariance (ANCOVA) was employed to test the homogeneity (equality) of regression slopes between male and female individuals.

Fulton's condition factor (K) of the shrimps was determined from the relationship:

$K = 100\ W/L^3$ (Fulton, 1902)

Growth parameters

Using the von Bertalanffy growth function (VBGF), growth parameters such as asymptotic length (L_∞), growth rate (*K*) and the theoretical age of a shrimp at which length is zero (t_0), were calculated for male, female and pooled data employing the electronic length frequency analysis (ELEFAN) programming available in the TropFishR package (von Bertalanffy, 1938; Mildenberger *et al.,* 2017). L_∞ and *K* values calculated for the pooled data were used as inputs for further stock assessment studies. ELEFAN was applied to restructured length–frequency data, generated by a moving average technique

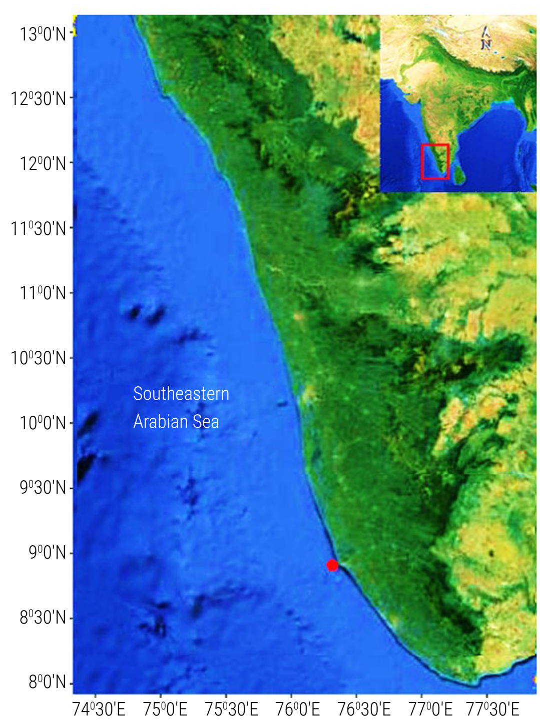

Fig. 1. Geographical location of the fishing area in southeastern Arabian Sea (Red dot indicates deep-sea landing centre, Saktikulangara)

Fig. 2. (a) Female and (b) male specimens of *P. semilaevis*

to enhance modal progression detection. To evaluate parameter uncertainty, bootstrapped ELEFAN (1000 iterations) was performed, providing confidence intervals and improved robustness of growth estimates.

$Lt = L_\infty (1- e^{-K(t-t0)})$ (Pauly, 1984)

where L_t represents the length of the shrimp at age t, L_∞ stands for the asymptotic length measured in cm, *K* represents the growth rate coefficient in yr^{-1} and t_0 denotes the theoretical age of the shrimp at which its length is zero.

An initial seed value for L_∞ was established by utilising L_{max}, derived from the mean of the largest 1% individuals in the sample and computed using Pauly's (1984) formula:

$L_\infty = L_{max}/0.95$

The estimation of species longevity (T_{max}) was done using the equation:

$T_{max} = 3/K$ (Pauly, 1979)

The growth performance index (Φ') was determined employing the formula:

$\Phi' = 2\log L_\infty + \log K$ (Pauly and Munro, 1984)

Mortality parameters and exploitation rate

Total mortality (Z) for the pooled data was calculated by the linearised length-converted catch curve method (Pauly and David, 1981; Sparre and Venema, 1992)

The natural mortality rate (M) was determined using the equation:

$M = 4.118 \times K^{0.73} \times L_\infty^{-0.333}$ (Then *et al.*, 2015)

This estimator was chosen because it has been shown to perform well across diverse taxa and is particularly suitable for short-lived, fast-growing species such as shrimps.

Fishing mortality (F) was computed using the following formula:

Z – M (Qamar *et al.,* 2016)

The exploitation rate (E) was calculated using the equation:

E = F/Z (Georgiev and Kolarov, 1962)

Length at first capture (LC_{50}) and size at sexual maturity (TL_{50})

The lengths at 50, 75 and 95% capture were obtained from the ascending data points of the selectivity curve, derived through linear regression analysis (Pauly, 1979; Pauly, 1987; Gayanilo *et al.*, 2005). The length at first capture was taken as LC_{50}. The optimum length of exploitation (L_{opt}) was computed from the equation:

$L_{opt} = (3/ (3 + M/K)) * L_\infty$ (Froese and Binohlan, 2000)

Size at sexual maturity (TL_{50}) was determined based on the TL at which 50% of females are berried (TL_{50}), estimated *via* a logistic equation as described by King (1995):

$P = 1/ [1 + \exp (a + b * CL)]$

Virtual population analysis (VPA)

VPA is a technique enabling the reconstruction of population dynamics using total catch data categorised by age or length (Sparre and Venema, 1998). The inputs required for length-based VPA estimation encompass the exploitation rate, length-weight parameters (pooled data), mortality parameters and catches.

Catch trends of *P. semilaevis*

The fishery of *P. semilaevis* along the south-west coast of India from 2007 to 2022 was analysed using data from the Fishery Resources Assessment, Economics and Extension Division (FRAEED) of ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi. The data were estimated employing the Multistage Stratified Random Sampling design (Srinath *et al.,* 2005; Somy and Mini, 2024). This catch and effort data was then utilised to determine the catch per unit effort (CPUE).

Data analysis

The length-frequency data were aggregated into intervals of 1 cm in length. Subsequently, the data were analysed by the TropFishR package within the R statistical tool to evaluate the population parameters.

Results

Length frequency distribution

The length-frequency composition, based on 1411 males and 1712 females collected from 2016-2022 indicates that male specimens ranged from 65 to 140 mm, while female specimens ranged from 70 to 135 mm. The size distribution demonstrates that the average length of the sampled specimens is 102.1±13.44 mm for males and 101.9±11.31 mm for females (Fig. 3)

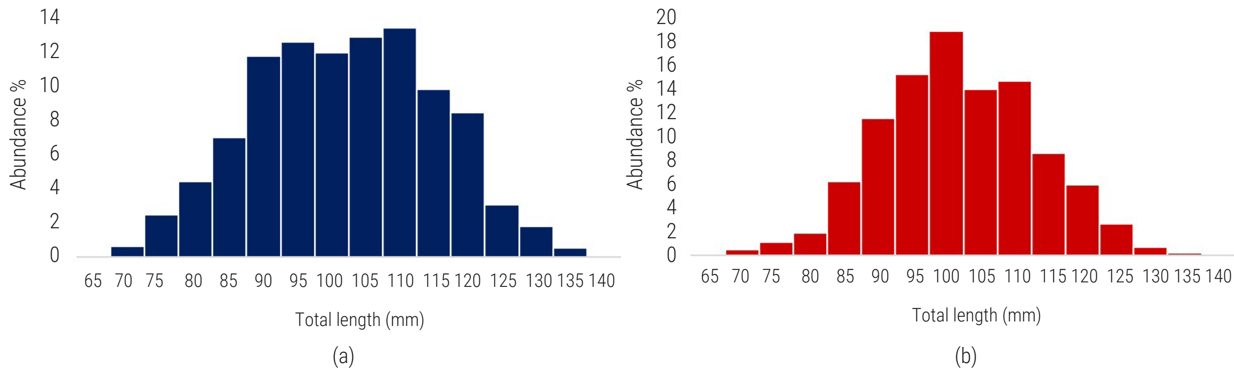

Fig. 3. Length frequency distribution in males and females of *P. semilaevis*

Length-weight relationship

The relationship between weight (W) and length (L) was expressed by the formula $W=0.005L^{2.75}$ (R^2=0.79) in males and $W=0.0045L^{2.84}$ (R^2=0.85) in females (Fig. 4). This indicates a negative allometric relationship between total length and body wet weight for both males (b=2.75) and females (b=2.84). The a and b parameters for the pooled data were 0.0042 and 2.86 respectively and were used as input parameters for estimating yield per recruit in TropFishR. ANCOVA of length and weight variables revealed a highly significant difference between sexes ($p<0.001$) in *P. semilaevis* indicating sexual dimorphism in length and weight. Fulton's condition factor (K) ranged from 0.16 to 0.75 in females with an average of 0.32±0.05. In males K ranged from 0.2 to 0.68 with an average of 0.30±0.05.

Growth parameters

The growth parameters were estimated using the von Bertalanffy growth equation applied through Electronic Length Frequency Analysis (ELEFAN) within the TropFishR package in R (Fig. 5). For males, the estimated growth parameters were 14.0 cm for L_∞ and 0.74 yr^{-1} for the growth coefficient *K*, while for females, the values were 14.3 cm for L_∞ and 0.73 yr^{-1} for *K*. Theoretical age at length zero (t_0) was estimated as -0.0032 for both sexes while longevity (T_{max}) was estimated at 4.07 years for males and 4.12 years for females. The growth performance index (Φ') was 2.16 for males and 2.17 for females. L_∞ and *K* values calculated for the pooled data were 14.3 cm and 0.73 yr^{-1} (Table 1) and were used as inputs for further stock assessment studies.

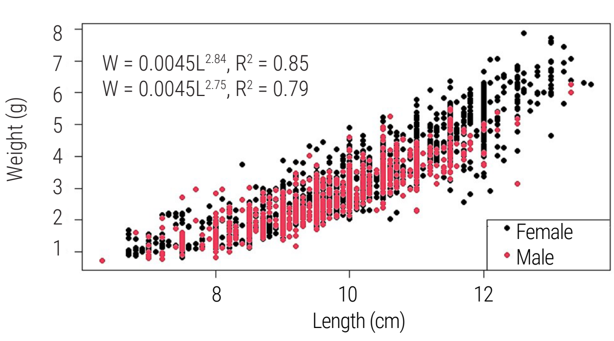

Fig. 4. Length-weight relationship of *P. semilaevis* in the south-eastern Arabian Sea

Exploitation rate and mortality parameters

From the linearised length-converted catch curve, total mortality (Z) was estimated to be 3.18±0.1 yr^{-1} for *P. semilaevis* (Fig. 6a). Natural mortality (M) was estimated at 1.12 yr^{-1} and fishing mortality (F) was calculated as 2.06 yr^{-1}. The current fishing mortality ($F_{current}$ = 2.06 yr^{-1}) is higher than the estimated F_{msy}, fishing mortality that produces the maximum sustainable yield ($F_{0.1}$ = 1.8 yr^{-1}) and lower than the maximum reference fishing mortality (F_{max} = 2.2 yr^{-1}) (Fig. 6c) (Table 1). The estimated current exploitation rate ($E_{current}$ =0.65) was close to the current exploitation rate that yields the maximum sustainable yield (E0.1 = 0.62) and slightly lower than the maximum exploitation rate (E_{max} = 0.66).

Length at first capture (LC_{50}) and size at sexual maturity (TL_{50})

Fig. 6b shows the age at probability of capture (t_{50}) for *P. semilaevis.* The age at t_{50} was 1.37 years while the ages at 75 and 95% probabilities of capture were t_{75} = 1.48 years and t_{95} = 1.67 years, respectively. Concurrently, the lengths associated with these ages were L_{C50} = 9.46 cm, L_{c75} = 9.9 cm and L_{c95} = 10.56 cm. The L_{opt} was estimated as 9.46 cm. The length at first maturity (TL_{50}) for females was calculated as 8.73 cm (Fig. 7).

Virtual population analysis

The virtual population analysis of *P. semilaevis* is illustrated in Fig. 8, depicting a sequential decline in the number of survivors with increasing individual length. Fishing mortality was highest among individuals in the mid-length range of 13.5 cm. The results indicate that individuals up to the mid-length group of 9.5 cm were primarily affected by natural mortality while beyond this size they became increasingly vulnerable to fishing gear resulting in a steady increase in fishing mortality. Specimens within the mid-length range of 9-11 cm were most exposed to fishing gear.

Catch trends of *P. semilaevis*

Analysis of *P. semilaevis* catch data from 2007 to 2022 reveals significant variations in both total shrimp catch weight (in tons) and catch per unit effort (CPUE), as shown in Fig. 9. Notable fluctuations were observed in the total catch of *P. semilaevis* throughout the survey period ranging from 25.37 t in 2017 to 386.99 t in 2019, with an average of 169.94±121.09 t. CPUE values varied from 0.0071 in 2017 to 0.1170 in 2019, with a mean of 0.0501±0.0331.

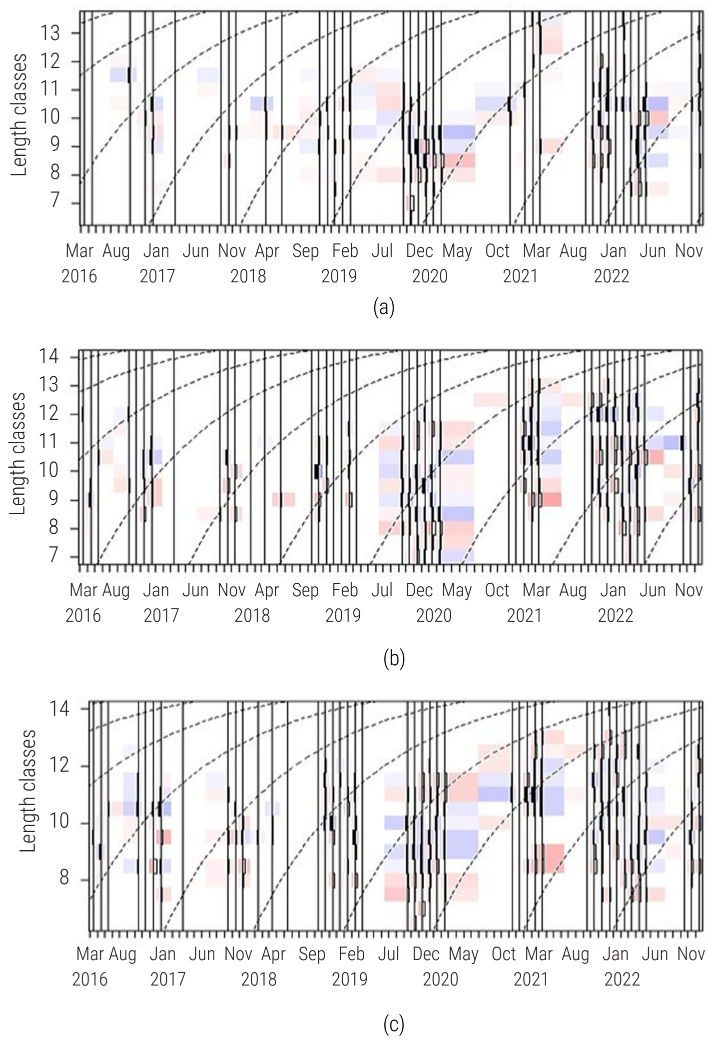

Fig. 5. Length-frequency histograms displaying growth curves (dashed lines) obtained through bootstrapped ELEFAN with GA analysis superimposed for (a) male; (b) female and (c) pooled specimens of *P. semilaevis*. Black bars signify positive peaks and white bars indicate negative peaks. This method aims to maximise the occurrence of positive peaks. Faint red and blue colours highlight positive and negative peaks, respectively

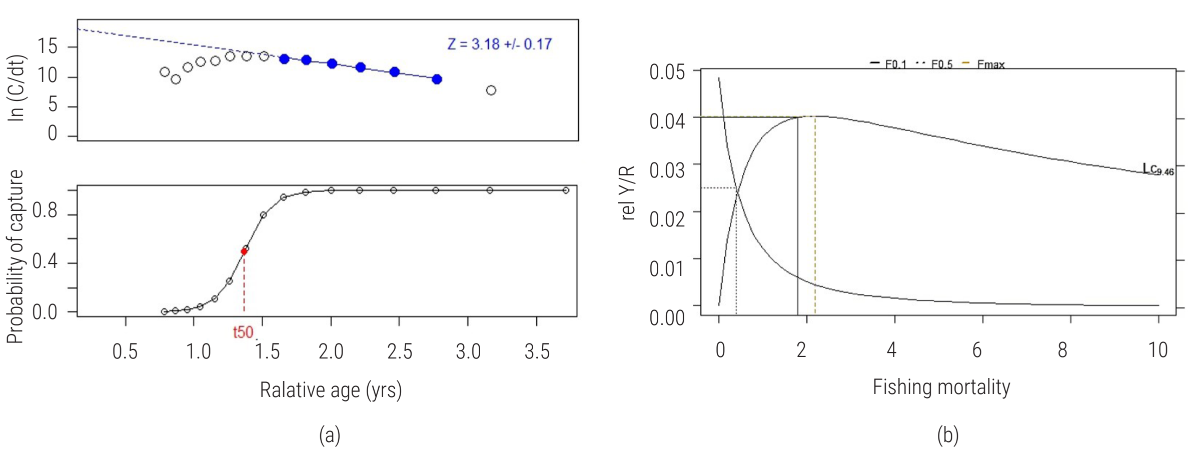

Fig. 6. Linearised length-converted catch curve of *P. semilaevis* (a), the selectivity function of the catch curve estimated a length at first capture (Lc_{50}) at 9.46 cm (b) and yield and biomass per recruit analysis with F0.1 = 1.8 yr^{-1}, Fmax = 2.2 yr^{-1}, F0.5 = 0.4 yr^{-1}

Table 1. Growth parameters, mortality and exploitation rates of *P. semilaevis* (pooled data) assessed by TropFishR

Parameters	Values
Growth parameters	
Asymptotic length (L_∞)	14.3 cm
Growth coefficient (K)	0.73 yr^{-1}
t_{anchor}	0.8
t_0	0.003
T_{max}	4.11 yr
Growth performance index (Φ')	2.21
Rn value	0.13
Mortality and exploitation	
Natural mortality (M)	1.12 yr^{-1}
Total mortality (Z)	3.18 yr^{-1}
Fishing mortality ($F_{current}$)	2.06 yr^{-1}
F_{max}	2.2 yr^{-1}
F0.1	1.8 yr^{-1}
F0.5	0.4 yr^{-1}
Current exploitation ($E_{current}$)	0.65
E_{max}	0.66
$E_{0.1}$	0.62
$E_{0.5}$	0.26

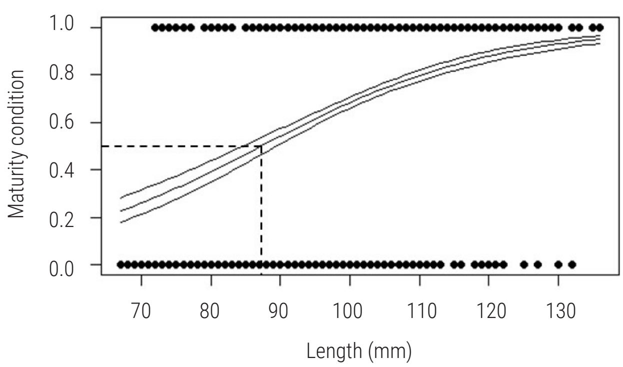

Fig. 7. Size at first maturity (TL_{50}) calculated for *P. semilaevis*

Discussion

The length frequency composition showed that males and females were nearly comparable in average size and both sexes exhibited a balanced proportion of juveniles and adults in the catch. This near-equal representation of younger and mature individuals suggests continuous recruitment to the fishery and an active contribution of both sexes to the population structure. Such a balanced size distribution indicates that exploitation is not disproportionately skewed towards a particular life stage, although sustained harvesting pressure could alter this equilibrium over time. From a management perspective, monitoring shifts in this distribution is critical, as changes may signal overexploitation of specific size classes or potential impacts on reproductive output.

The growth pattern for males and females in the current study indicates a negative allometric growth, implying that the increase in shrimp body length was faster than the shrimp body weight. ANCOVA for length and weight variables indicated a highly significant difference ($p<0.001$) between sexes in *P. semilaevis*, suggesting variations in length and weight between males and females. Such differences may have management implications, particularly in fisheries where sex-selective exploitation occurs (*e.g.,* targeting larger females or males of certain size groups). Hence, consideration of sex-based growth differences should be factored into management strategies to avoid disproportionate impacts on either sex. Table 2 displays a noteworthy variation in length-weight parameters across various *Plesionika* species in diverse water bodies worldwide. The variation in the length-weight relationship can be attributed to factors such as habitat, seasonal maturity stage, sex, health, and abundance of food items (Tesch, 1971; Sossoukpe *et al.,* 2016; de Carvalho-Souza *et al.,* 2023).

The condition factor K serves as a crucial indicator of shrimp wellbeing or fatness. Typically falling within the range of 0 to 2, with a mean value around 1 for fish, it reflects the nutritional status and overall health of the organism (Hanif, 2022). A low K, (females, 0.32±0.05 and males, 0.30±0.05) as observed in this study (Hanif, 2022), suggests a thin and elongated shrimp. K values are influenced by various factors such as size, sex, season, and gonad development, with females typically exhibiting higher values due to larger and heavier gonads (Froese, 2006). Factors like feeding rate and environmental conditions also contribute to variations in K (Heincke, 1908). In the case of *P. semilaevis*, a lower K might be attributed to factors such as feeding patterns, environmental influences, or the inherent lean nature of the species.

To effectively manage fisheries, it is advised to have a comprehensive knowledge of the life history parameters of species (Hilborn and Walters, 1992). In cases where age-structured data are lacking, length-composition data are commonly employed to assess the dynamics of species populations (Sparre and Venema, 1998). The only previous study on the growth parameters of *P. semilaevis* was conducted by Ohtomi (1997) in Kagoshima Bay, Japan.

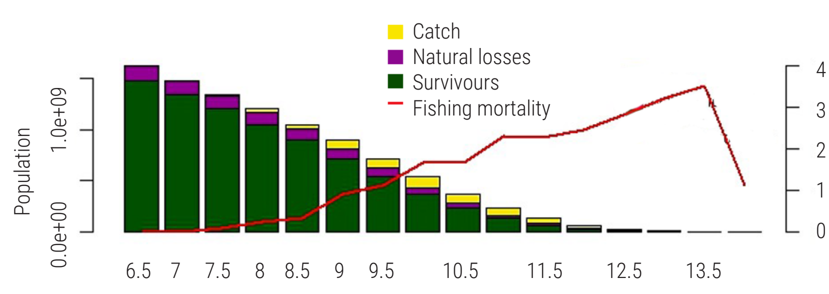

Fig. 8. Length structured virtual population analysis of *P. semilaevis*

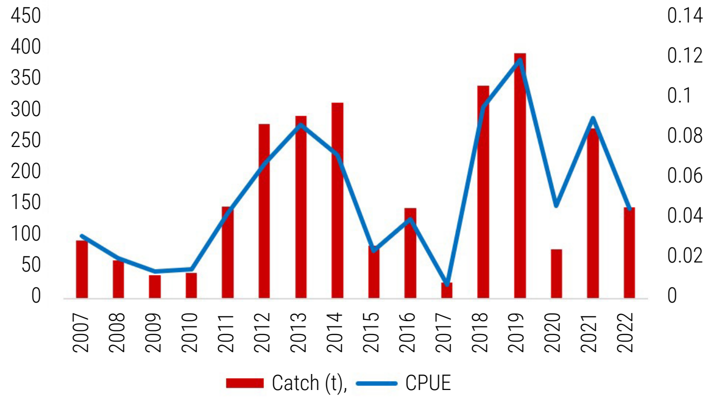

Fig. 9. *P. semilaevis* landings and CPUE along the south-west coast of India during 2007-2022

Table 2. Estimates of population parameters of *Plesionika* species in different water bodies of the world

Species	Location	a	b	L_∞	K yr^{-1}	Φ'	Reference
P. semilaevis	South-eastern Arabian Sea						Current study
Male		0.005	2.75	14 cm (TL)	0.74	2.16	
Female		0.0045	2.84	14.3 cm (TL)	0.73	2.17	
P. semilaevis	Kagoshima Bay, Japan						Ohtomi (1997)
Male		nd	nd	15.5 mm (CL)	0.103	nd	
Female		nd	nd	17.8 mm (CL)	0.091	nd	
P. heterocarpus	Mediterranean Sea						Company and Sarda (2000)
Male		0.0006	3.08	22.4 mm (CL)	1	0.62	
Female		0.0008	2.98	23 mm (CL)	0.9	0.62	
P. gigliolii	Mediterranean Sea						Company and Sarda(2000)
Male		0.001	2.92	21 mm (CL)	0.55	0.26	
Female		0.002	2.6	20.5 mm (CL)	0.75	0.44	
P. martia	Ionian Sea, Mediterranean						Maiorano *et al*. (2002)
Male		0.001	2.84	28 mm (CL)	0.5	2.59	
Female		0.001	2.85	30.5 mm (CL)	0.44	2.61	
P. martia	Aegean Sea, Mediterranean						Kocak *et al*. (2012)
Male		0.008	2.17	23.4 mm (CL)	0.49	2.44	
Female		0.007	2.25	26.3 mm (CL)	0.38	2.42	
P. acanthonotus	Mediterranean Sea						Company and Sarda (2000)
Male		0.0008	2.96	18.4 mm (CL)	0.5	0.13	
Female		0.002	2.55	19 mm (CL)	0.55	0.23	
P. quasigrandis	Kerala coast, Arabian Sea						Shanis (2014)
Male		0.0000	3.28	13.9 cm (TL)	0.68	2.72	
Female		0.0000	3.46	14.5 cm (TL)	0.52	2.66	
P. quasigrandis	Kerala coast, Arabian Sea						Chakraborty *et al*. (2014)
Male		0.003	3.11	12.4 cm (TL)	0.7	4.03	
Female		0.004	3.01	13.0 cm (TL)	0.8	4.13	
P. narval	Ustica, Tyrrhenian Sea						Arculeo and Lo (2011)
Male		nd	nd	17.8 mm (CL)	0.71	2.28	
Female		nd	nd	27.4 mm (CL)	0.65	2.62	
P. edwardsi	Madeira, Atlantic						González *et al*. (2016)
Male		0.005	2.36	33.1 mm (CL)	0.54	2.77	
Female		0.003	2.52	36.2 mm (CL)	0.59	2.88	

He calculated the L_∞ for males and females as 15.47 and 17.83 mm carapace length respectively and the *K* values were 0.103 for males and 0.091 for females. The estimated longevity of *P. semilaevis* was approximately 3 years (males 34 months and females 38 months). The maximum theoretical length, was L_∞ = 14 cm (TL) for males and 14.3 cm TL for females in the current study. The growth coefficient *K*, was 0.74 yr^{-1} for males and 0.73 yr^{-1} for females both higher than the the estimates for *P. semilaevis* in

Japanese waters reported by Ohtomi (1997) (Table 2). These values indicate that *P. semilaevis* in tropical waters is a fast-growing, shorter-lived species compared to conspecifics in temperate Japanese waters. Such differences align with the general ecological trend that tropical species exhibit higher metabolic rates and faster growth due to warmer temperatures, increased primary productivity, and shorter seasonal cycles, whereas temperate species typically grow more slowly but have longer lifespans. Similar patterns have been documented in other *Plesionika* species, reinforcing the role of environmental factors in shaping life-history traits (Table 2).

The growth performance index is regarded as a valuable tool for comparing growth curves among populations of the same species or different species within the same family (Park *et al.,* 2013). The growth performance index (Φ') was 2.16 for males and 2.17 for females. The growth performance index from the study was similar to the estimates reported Shanis (2014) for *P. quasigrandis* from the same region. *K*, L_∞ and Φ' values indicated differences in these parameters among various *Plesionika* species and geographic regions (Table 2). The potential factors contributing to variations in growth parameters like *K*, L_∞ and Φ' may include geographical locations, environmental conditions, stock, population size, feeding habits, diet composition and the data analysis method used (Tesch, 2003; Sequeira *et al.,* 2009; Sossoukpe *et al.,* 2016; Hirota *et al.,* 2022; Barua *et al.,* 2023; Sreelakshmy *et al.,* 2023).

In the study on populations, two categories of mortality are considered; natural mortality (M) and fishing mortality (F), adding up to total mortality (Z). In the present study, natural mortality was determined by the formula proposed by Then *et al.* (2015). For *P. semilaevis*, Z was estimated at 3.18 yr^{-1}, M as 1.12 yr^{-1} and F at 2.06 yr^{-1}. In this case, the F value was higher than the M value, indicating that fishing is the primary cause of the decline in *P. semilaevis* individuals in the south-eastern Arabian Sea. Although F exceeds F_{msy} (F0.1 = 1.8 yr^{-1}) it remains below the maximum fishing mortality rate (F_{max} = 2.2 yr^{-1}), suggesting that the shrimp species is not currently under excessive fishing pressure in the study area. Another key parameter is exploitation $E_{current}$, which is 0.65 for *P. semilaevis* which is close to E_{msy} (E0.1 = 0.62). This suggests that there exists an optimal level of exploitation for *P. semilaevis* in the south-eastern Arabian Sea ensuring the maintenance of its maximum sustainable yield. Additionally, the $E_{current}$ is less than the maximum exploitation rate (E_{max} = 0.66) indicating that the resource from the south-eastern Arabian Sea is not over-exploited. This finding highlights the need for precautionary management to ensure long-term sustainability. Regulatory measures such as optimising mesh size to allow smaller individuals to escape, and implementing stricter control of fishing effort during peak recruitment periods, would help maintain stock productivity. Continuous monitoring of exploitation trends is essential, as maintaining E below E_{msy} is critical to avoid overfishing and to ensure the resilience of the *P. semilaevis* fishery.

From an ecosystem-based management perspective, high exploitation of one species can influence the dynamics of others by altering trophic interactions and shifting fishing pressure. Conversely, maintaining sustainable exploitation levels across species is critical for preserving the ecological balance and economic viability of the fishery. Therefore, precautionary measures such as mesh size optimisation, seasonal effort regulation and catch monitoring should be integrated within a broader multi-species framework.

The length at first capture (L_{C50}) was 9.46 cm while the age at first capture (t_{50}) was 1.37 years. Shanis (2014) reported an L_{C50} of 8.63 cm for *P. quasigrandis* from the same locality, while Chakraborty *et al.* (2014) observed a L_{C50} values of 8.48 cm for males and 9.34 cm for females. Variations in the mesh size of fishing gears used may contribute to these differences in the length at first capture. It is conceivable that fishing gears with larger mesh sizes are more likely to capture larger shrimps, whereas those with smaller mesh sizes may capture smaller ones. A similar value of the optimum length of exploitation and L_{C50} suggests that the shrimps are being harvested at a safe size and that a sufficient number of juvenile shrimps are allowed to mature from the stock. The size at first maturity (TL_{50}) calculated for the females was 8.73 cm, which is smaller than the L_{C50} value, thereby allowing females to spawn before being captured.

Results from the Virtual Population Analysis (VPA) indicate that individuals with mid lengths of 9.5 cm and above are significantly more susceptible to fishing pressure, likely due to the higher economic value of larger individuals. In contrast, smaller-sized individuals exhibit higher natural mortality rates compared to fishing mortality. The relatively high number of survivors in the population suggests that recruitment overfishing is unlikely for this stock in the south-eastern Arabian Sea. This may be attributed to the species not being harvested before reaching the size at first maturity .

In recent years, monitoring the status of fishery resources, including the collection of biological data, has become increasingly important due to the growing demand for these resources (Cilbiz and Uysal, 2023; Hashemi *et al.,* 2024). Biomass and CPUE estimates are commonly used to estimate stock indices, which are essential for the effective management of fishery resources. The variation in landings of *P. semilaevis* species from 2007 to 2022 may be attributed to several factors, including changes in species abundance, technological advancements, differences in fishing effort across gear types, shifts in fishing grounds, or market-driven demand leading to targeted harvesting. CPUE trends followed a similar fluctuating pattern, with peaks in 2013, 2019, and 2021, suggesting periods of relatively higher stock availability or reduced fishing effort. The sharp decline in CPUE during 2017 coincided with the lowest catch, indicating possible reductions in stock abundance or changes in fishing intensity. Conversely, the high CPUE in 2019 reflects improved catch rates despite variable effort, possibly linked to favourable recruitment and stock conditions. The more recent decline after 2021 suggests that increased fishing pressure or biological stressors may have reduced availability.

This study aimed to assess the stock status of *P. semilaevis* from the south-eastern Arabian Sea based on growth and population parameters. The length-weight parameters revealed a negative allometric growth pattern for both sexes, indicating that body length increases at a faster rate than body weight. The shrimp was found to be a fast-growing species and appears to be in a sustainable condition as the current fishing mortality rate is below F_{max}. The size at first maturity (TL_{50} = 8.73) is smaller than the length at first capture (L_{C50} = 9.46 cm) suggesting that females have the opportunity to spawn before being harvested and juveniles have time to grow. However, the exploitation rate ($E_{current}$ = 0.65) is very close to E_{msy} (0.62), suggesting that the fishery is operating at the threshold of sustainability. T_o prevent over-exploitation, precautionary measures are recommended, including continuous monitoring of fishing effort, strict enforcement of mesh size regulations to allow for recruitment and the implementation of effort controls during peak spawning seasons. Adopting these measures within a multi-species management framework will help ensure the long-term sustainability of *P. semilaevis* and associated deep-sea shrimp resources in the region.

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