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Analysing the population dynamics of the Parreysia cylindrica mussel in the Western Ghats of India (Annandale and Prashad, 1919)

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Abstract

The freshwater mussel Parreysia cylindrica Annandale and Prashad, 1919, which lives in the Malthi River, a tributary of the Tunga River, in Thirthahalli Taluk, was studied for its morphometric and length-weight correlations, condition index, age and growth, mortality, exploitation, and lifespan. L = 1.6869 + 0.4688 B for mussels and L = -2.9198 + 0.4687 W for breadth and length, respectively, were the linear equations that were found. As for the length-width relationship, the computed b values ranged from 0.4006 to 0.4776, and for the length-breadth link, they ranged from 0.4285 to 0.4991. The estimated equations for the relationship between length and total weight, wet weight, shell weight, and dry weight were as follows: W = 0.000046L3.279, W = 0.00005L3.461, and W = 0.000021L3.332, which is the order in which they were estimated. The monthly averages of the condition index varied between 5.07 and 11.97. The worst condition levels were seen in October and February, while the best were observed in March and May. The projected asymptotic length was 56.97 mm, but the maximum length recorded in the field was 50.2 mm. The growth coefficient was 0.53 y-1 and the theoretical time at zero length was -0.0376 y. There was a growth performance index of 3.236. There was a total mortality rate of 2.01, an exploitation rate of 0.505, and an overall mortality rate of 0.99 per 1,000 individuals. The estimated lifespan was 5 years

Introduction

Bivalve mollusks such as oysters, mussels, and clams are widely distributed in both marine and freshwater environments, and some of these species are commercially exploited. Many different types of inland aquatic settings are home to freshwater bivalves throughout the Indian subcontinent. In aquatic environments, they serve as bio-depositors and take part in energy transfer by burrowing and filter-feeding. Researchers have focused on the development and life duration of bivalve mollusks (Wilbur and Owen, 1964; Ansell et al., 1972; Cerrato, 1980; Thippeswamy and Joseph, 1991; Strahl et al., 2007; Moss et al., 2016) because they are thought of as instances of natural ageing. Indians do not commercially employ these inland aquatic resources for human nourishment, with the exception of few northeastern tribal communities (Ramakrishna and Dey, 2007). However, freshwater pearls are made from some of these species.

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Parreysia is a genus of bivalves belonging to the Unionidae family. The Indian subcontinent is home to twenty of these species (Preston, 1915; Ramakrishna and Dey, 2007). Located in the Krishna River basin of Maharashtra, the holotype of the seldom seen Parreysia cylindrica was discovered in the river Venna in the Upper Krishna watershed near Medha (Annandale and Prashad, 1919). Information on various aspects of freshwater bivalve biology such as condition index of Parreysia corrugata (Ramesha and Thippeswamy, 2009a; Malathi and Thippeswamy, 2011) and P. favidens (Thippeswamy et al., 2014), allometric relationships of Lamellidens corrianus (Desai and Borkar, 1989), L. marginalis (Agrawal, 1976; Suryawanshi and Kulkarni, 2014a; Pradhan et al., 2020; Sarma et al., 2022), P. corrugata (Ramesha and Thippeswamy, 2009a; Malathi and Thippeswamy, 2011; Suryawanshi and Kulkarni, 2014b) and P. favidens (Thippeswamy et al., 2014), age and growth of P. corrugata (Malathi and Thippeswamy, 2013) and L. marginalis (Nahar et al., 2019) and mortality of P. corrugata (Malathi and Thippeswamy,

The Indian subcontinental version is from 2013. However, there is a dearth of biological data on P. cylindrica, an indigenous species of the Western Ghats in India. A tributary of the Tunga in the sub-basin of the Tungabhadra in the Krishna river system, the Malthi is located in the Western Ghats of Karnataka and was used to study the population dynamics of P. cylindrica. For ecological reasons and to aid in the preservation and management of freshwater bivalve resources in the Western Ghats, a global hotspot of biological variety, this project will provide the primary biological data on P. cylindrica.

while looking at the evolution of modes (Devaraj, 1983). The recruitment and settling of mussels into the population were estimated using the sample's mean shell length and the number of immature mussels. The determination of mussel settling time was made possible by backward projecting the median growth lines for many broods. The growth variables for the von Bertalanffy growth function (VBGF) (von Bertalanffy, 1938), namely the asymptotic length (L∐) and growth coefficient (K), were determined using the FiSAT software (Gayanilo et al., 1996). Using the K-scan approach, we evaluated how well the K value could be predicted. Using the least squares method (Bagenal, 1955), we calculated the theoretical time at zero length (t0). Electronic Length Frequency Analysis (ELEFAN-1) was used to the length frequency data in the FiSAT (Pauly and David, 1981).

Materials and methods

One freshwater bivalve, P. cylindrica, was sampled monthly from March 2007 to June 2008 in the Shimoga District's Kalmane river (13o39'11"N; 75°10'52"E). After manually collecting mussels from the riverbed, morphometric measurements were performed in a controlled laboratory environment. The amount of samples was totally dictated by the availability of mussels at the time of sampling; a total of 547 samples were gathered. The collecting of samples was impeded by the monsoon rains that occurred from June to September 2007.

Allometry and condition index

Following exact measurements to the nearest 0.05 mm using vernier callipers, the weights of the mussels were recorded. The length, breadth,

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and width of each mussel were defined as the maximum distances from the front to rear ends of the shell, the dorsal and ventral margins of the shell, and the outer surfaces of two shell valves, respectively. The whole soft body of opened mussels was extracted, blotted, and weighed independently. The individual shell weights of each mussel were recorded. Following two days of drying at 60ºC, the mussels' dry weights were individually quantified to within 0.001 g. The morphometric relationships between length and width and length and breadth in P. cylindrica were found using the formula Y = a + bX, where "a" is the intercept and "b" is an exponent (Pauly, 1983). Pauly (1983) devised a formula for length-weight relationships (LWRs) using the variables "a" and "b" to represent the intercept and exponent, respectively. Logarithmic data transformation using the least square linear regression statistic, Log10 W = Log10 a + bLog10 L, was used to establish relationships between length and total weight, wet weight, dry weight, and shell weight throughout the entire study period and for different months. After measuring the shell cavity capacity of each mussel, we calculated its index of condition using the following formula (Baird, 1958):

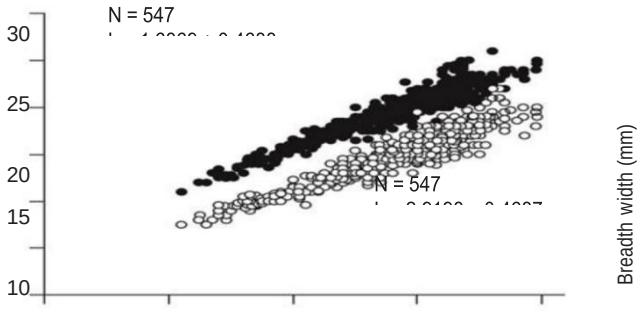
Growth and mortality

After collecting mussels of varying sizes, they were sorted into several classes according to Herbert Sturges's criteria (Sturges, 1926). This period's and each month's length distributions were determined using length frequency analysis. The results showed a modal pattern of growth and an average monthly growth rate. The growth performance index (GPI) or Phi-prime (Φ') value was computed using the estimated values of L∞ and K (Pauly and Munro, 1984). Pauly (1983) provided the expected life span. Using the length-converted catch curve approach, we were able to determine the overall mortality (Z). The formula proposed by Pauly in 1980 was used to determine natural mortality (M) and fishing mortality (F). F = Z-M was used to measure the mortality rate of fish. The statistic E = F/Z was used to measure the exploitation rate (E) (Gulland, 1965, 1983).

Results and discussion

Morphometric relationship

L = 1.6869 + 0.4688 B for the length and breadth and L = -2.9198 + W for the length and width, respectively, as shown in Figure 1. The data show that the dimensions of breadth and width are proportionate to the length. The form differences were explained by the fact that several people who were the same length had different widths and breadths. So, the shape-preserving properties of the shell were due to proportional fluctuation in its dimensions. Similar findings have been shown in higher taxa as well as in bivalve mollusks (Thippeswamy and Joseph, 1992; Hemachandra and Thippeswamy, 2008; Jolicoeur and Mosimann, 1960).



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Similar linear relationships have been observed in freshwater mussels from India, P. corrugata (Agrawal, 1980; Ramesha and Thippeswamy, 2009a; Malathi and Thippeswamy, 2011; Suryawanshi and Kulkarni, 2014b) and P. favidens (Thippeswamy et al., 2014). Whereas the values for the length-width connection varied between 0.4006 in January 2008 and 0.4776 in March 2007, the b values of the length-breadth relationship ranged between 0.4285 in June 2008 and 0.4991 in November 2007 (Fig. 2). While the length and width connection in the current research was larger than that of many freshwater bivalves reported from the Indian subcontinent, the b value of the length and breadth relationship was lower (Table 1). Such differences in dimensional connections could be caused by the way the environment in various habitats affects the size of the shell. Environmental factors vary more so in size than in morphology of mussels (Wilbur and Owen, 1964). Shape therefore usually offers more accurate information on morphometric relationships than

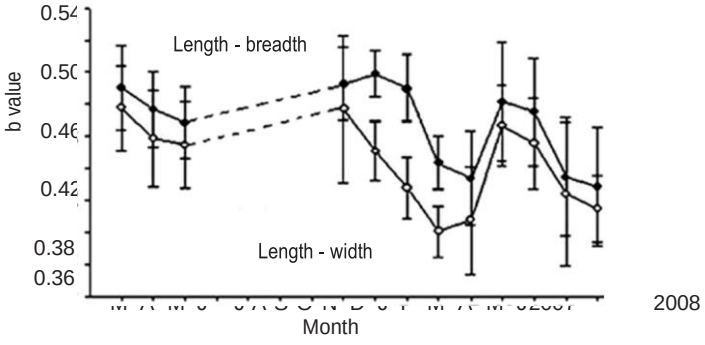

Fig. 2. Monthly variability in the b-values of length-breadth and length-width relationships of *P. cylindrica*

size. Probably, shape is restrained by the genetic compositions of species whereas size is managed by surrounding environmental variables (Malathi and Thippeswamy, 2011; Thippeswamy *et al*., 2019).

Species	L-B	L-W	L-TW	L-WW	L-DW	L-SW	Location	Habitat	Source
Lamellidens corrians	-	-	2.6775	2.8919	2.8946	2.552	Rajshali, Bangladesh.	Lake	Mondol *et al.* (2016)
L. marginalis	-	-	2.6084	-	-	-	Nanded District, Maharashtra		Suryawanshi and Kulkarni (2014b)
L. marginalis	0.475	0.3163	2.9066	2.7377	2.7849	2.918	Rajshahi District, Bangladesh.	Lake at Rajshahi University	Nahar *et al.* (2019)
L. marginalis	-	-	2.712	-	-	-	Bhubaneswar, Odisha	Farm, CIFA, ICAR	Pradhan *et al.* (2020)
L. marginalis	-	-	-	-	3.856	-	Patna	Low lying areas	Sarma *et al.* (2022)
L. marginalis	-	-	2.75	-	-	-	Ratargul Swamp, Bangladesh	Freshwater swamp	Hossain *et al.* (2022)
Parreysia corrugata	0.585	0.333	2.777	2.885	2.832	2.802	Hosmata, near Subhramanya, Karnataka	River Kempuhole	Rameha and Thippeswamy (2009a)
P. corrugata	0.603	0.432	2.666	2.669	2.937	-	Kalmane near Tirthahally, Shimoga District	Malthi river tributary of river Tunga	Malathi and Thippeswamy (2011)
P. corrugata	-	-	3.5489	-	-	-	Nanded District, Maharashtra	Naigaon Lake	Suryawanshi and Kulkarni (2014a)
P. corrugata	-	-	3.2631	-	-	-	Nanded District, Maharashtra		Suryawanshi and Kulkarni (2014b)
P. favidens	0.5985		3.2371	3.6763	2.9182	-	River Burhi Gandak, Bihar	River Burhi Gandak	Begum and Sinha (2000)
P. favidens	0.599	0.440	2.785	2.599	2.499	-	Chikamagalur, Karnataka	River Bhadra,	Thippeswamy *et al.* (2014)
P. cylindrica	0.4688	0.4687	3.0266	2.624	2.439	2.899	Kalmane, near Tirthahally, Karnataka	Malthi river, tributary of river Tunga	Present study

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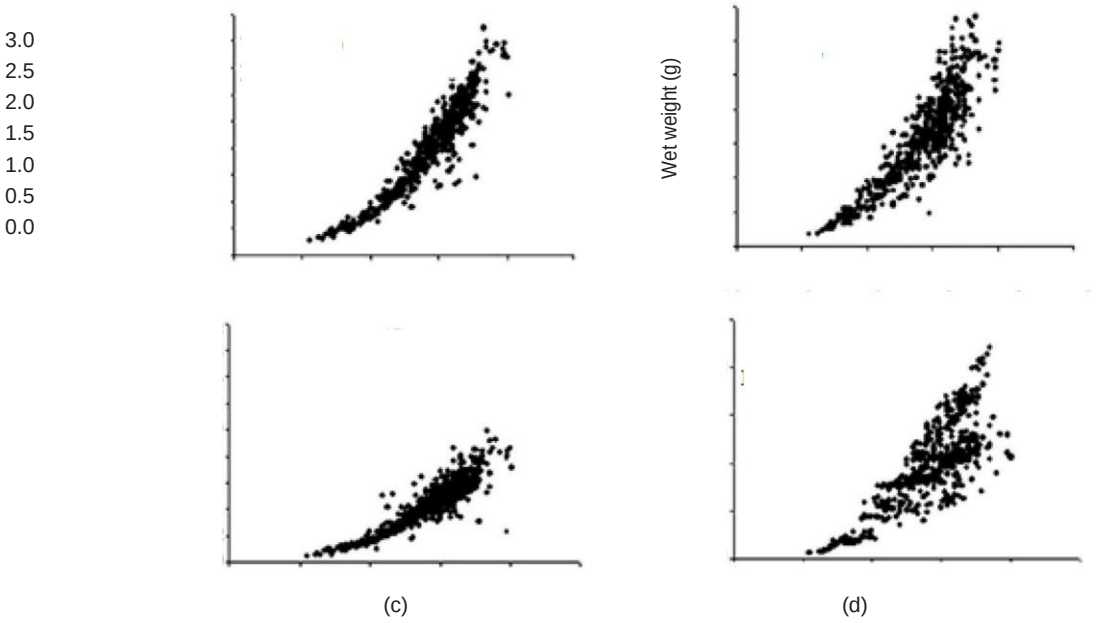

Fig. 3. Length-total weight (a), length-wet weight (b), length-shell weight (c) and length-dry weight (d) relationships of *P. cylindrica*

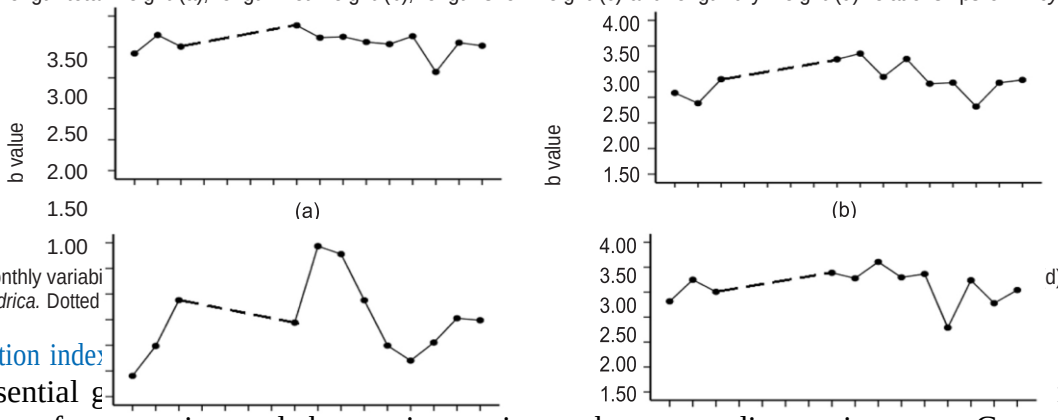

Fig. 4. Monthly variabi
P. cylindrica. Dotted
d) relationships of

Condition index

An essential g related to the wellness of an organism and changes in reaction to the surrounding environment. Generally speaking, the indicator of condition varies by species, among bivalve groupings like oysters, mussels, clams, and cockles, and within geographical areas, from habitat to habitat (Zeng and Yang, 201). Conditions index monthly mean values varied from 5.08 in January 2009 to 11.97 in May 2008 (Fig. 5). Three clear peaks occurred in March 2007, May 2007, and May 2008

Age and growth Length frequency

The length-frequency distribution of the sampled mussels (Fig. 7) indicated shell length range from 21 to 51 mm with one major peak at 41 mm and five minor peaks at 21, 27, 32, 45 and 47 mm. The mean shell length recorded during the study period was 38.6 mm. Entry of young mussels (<24 mm) into the population was in November-December (Fig. 8), indicating the breeding period of adult mussels and/or metamorphosis and settlement of larvae during September-October.

Recruitment

The modal growth curves showing the differential rate of growth and size ranges of *P. cylindrica* (Fig. 9) indicated the presence of mussels of <1 year class to 5-year class.

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Fig. 6. Monthly percentage frequency distribution of condition index in *P. cylindrica*

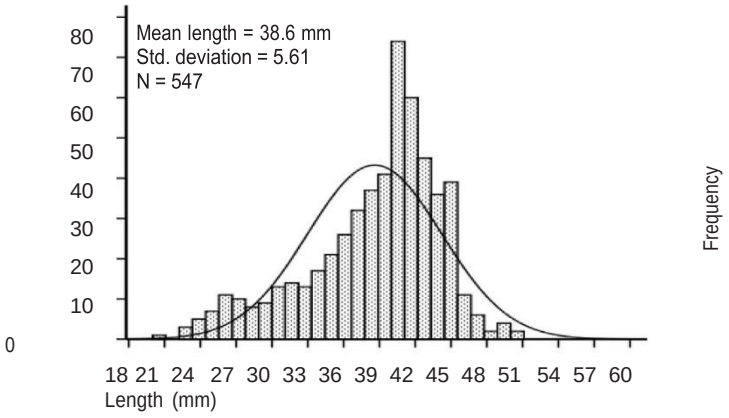


Fig. 7. Length frequency (%) distribution of *P. cylindrica*

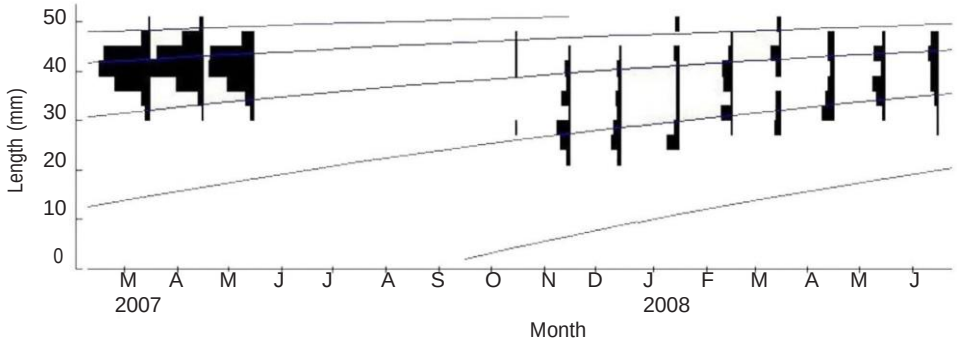
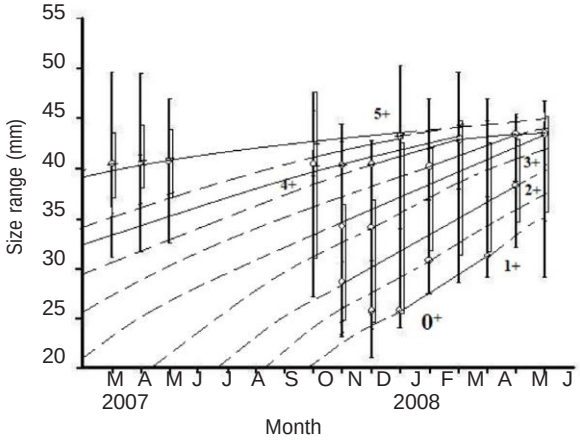


Fig. 8. Length frequency distribution with growth curves of *P. cylindrica* superimposed using ELEFAN-I



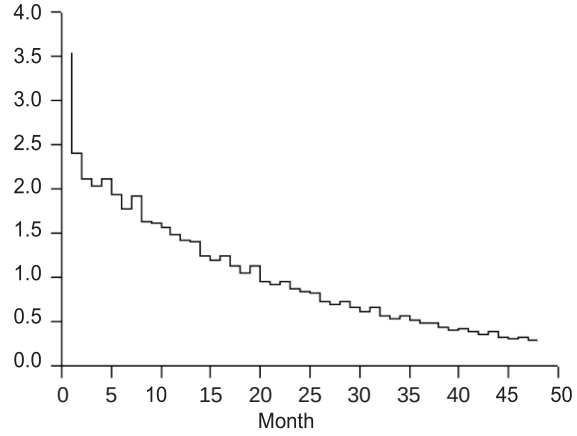


Fig. 10. Monthly mean growth rate of *P. cylindrica*

Young mussels after settlement showed faster rate of growth in the first few m showed similar growth pattern. The monthly mean growth rate of *P. cylindrica* during the present investigation (Fig. 10) indicated faster growth rate initially, which subsequently decreased. Newly settled young *P. cylindrica* attained 24, 38, 46 and 50 mm size at the end of 1st, 2nd, 3rd and 4th years, respectively. The mean growth rates of *P. cylindrica* were 2, 1.17, 0.66 and 0.33 mm month^{-1} during 1st, 2nd, 3rd and 4th years, respectively. Similar observations have been observed in other bivalves from the riverine environments of the Western Ghats (Ramesha and Thippeswamy, 2009a, 2000; Malathi and Thippeswamy, 2011; Thippeswamy *et al*., 2014).

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Growth parameters

The parameters of VBGF are useful in correlation of growth rates of similar species in different habitats and different speciesin the same habitat. The von Bertalanffy growth curve for
P. cylindrica is depicted in Fig. 11 and the calculated equation wasLt = 56.97 [1-e$^{-0.53(t+0.0376)}$). The recorded L_{max} was 50.2 mm. The L_{∞} of the VBGF of *P. cylindrica* was estimated to be 56.97 mm which is more
than that of the marine mussel *Modiolus auriculatus* from Byndoor intertidal region of Karnataka and less than that of *P. corrugata* and *Perna indica* and *P. viridis* from different marine environs of the Indian

Table 2. Population parameters of freshwater and marine mussels inhabiting the Indian subcontinent. K: Growth constant; L_{∞}: Asymptotic length; t_0: Age at zero length; GPI (Φ'): Growth performance index. GPI values in bold are calculated from the raw data reported by various authors

Species	L_{∞} (mm)	K (year $^{-1}$)	t_0 (year)	GPI (Φ')	Location	Source
Modiolus auriculatus	27.77	0.620	-0.267	2.679	Intertidal rocky shore at Byndoor, Karnataka	Tenjing *et al.* (2016)
Parreysia corrugata	56.7	0.62	0.0304	3.299	River Kempuhole Hosmata near Kadaba, Karnataka	Ramesha and Thippeswamy (2008)
P. corrugata	60.76	0.470	-0.042	3.239	Malthi river at Kalmane, near Tirthahally, Karnataka	Malathi and Thippeswamy (2013)
P. favidens	64.58	1.20	0.0073	3.699	River Seeta at Seetanadi near Hebri, Karnataka	Ramesha and Thippeswamy (2009b)
Perna indica	110.0	0.0954	-	3.062	Coastal waters of Calicut	Kuriakose (1973)
P. viridis	159.5	0.9294	-	4.369	Ennore Estuary, Madras	Shafee (1979)
P. viridis	41.927	0.1518	-0.038	2.426	Intertidal, at Someshwar near, Mangalore	Ramachandra (1980)
P. viridis	62.51	0.1278	-	2.698	Low littoral, at Malpe, Udupi	Ramachandra (1980)
P. viridis	184.6	0.2512	-1.73	3.932	Sub tidal, Kakinada Bay, Andhra Pradesh	Narasimham (1981)
P. viridis	110.0	0.1124	-	3.133	Raft culture, Goa	Chatterji *et al.* (1984)
P. viridis	52.825	0.2025	-0.2384	2.752	Intertidal, at Someshwar, near Mangalore	Thippeswamy (1990)
P. viridis	85.0	0.1014	-0.1153	2.865	Raft culture, Zuari Estuary, Goa	Rivonkar *et al.* (1993)
P. viridis	124.65	0.1075	0.5066	3.223	Moheshkhali , Bay of Bengal, Bangladesh	Kamal and Khan (1998)
P. viridis	194.3	0.56	-	2.325	Intertidal at Cox's Bazaar, Bangladesh	Amin *et al.* (2005)
P. viridis	136.5	1.30	-	2.380	Naf river coast, Bangladesh	Khan *et al.* (2010)
P. viridis	75.4	1.51	-	3.934	Intertidal, at Mukka, near Mangalore	Thejasvi (2016)
P. viridis	117.5	0.28	-	3.587	Sub tidal, at Amdalli, near Karwar	Thejasvi (2016)
P. viridis	136.9	0.420	-0.380	3.896	Intertidal, at St. Mary's Islands, Malpe near Udupi	Hemachandra *et al.* (2017)
P. viridis	162.75	0.87	-0.7025	4.363	Sub tidal bed of Ye Estuary, Myanmar	Nwe *et al.* (2020)
Parreysia cylindrica	56.97	0.53	-0.0376	3.236	Malthi River at Kalmane, near Tirthahally, Karnataka	Present study

Growth performance index or Phi-prime index

Growth performance index (GPI) or Phi-prime index is a length and time-based indicator in which K and L_{∞} of VBGF are used to ascertain the growth potential of species. Phi-prime is also used to differentiate the performance of growth of the same species orbetween the species of the same genus (Mathews and Samuel, 1990). The GPI values for inland and marine mussels from Indian subcontinent are presented in Table 2. The Phi-prime value of
P. cylindrica in the present study was 3.236, which is more than that of *M. auriculatus*, *P. indica* and *P. viridis* inhabiting certain marine environmentss of the Indian subcontinent (Table 2). Marine mussels are exposed to reduced feeding time during low tide and subjected to anthropogenic activities and also exposed to coastalmarine pollution during submersion which probably results in lowgrowth efficiency of intertidal mussels than river mussels. The Phi-prime value of *P. cylindrica* in the present study was less than that of *P. corrugata* from river Malthi, India (Malathi and Thippeswamy, 2013) and *P. viridis* from different coastal habitats of the Indian sub-continent (Table 2).

Reduced flow of water in the river throughout the study period, except during monsoon months, and anthropogenic activities at the study sites probably contributed to relatively low growth efficiencyof *P. cylindrica* in the Malthi River.

Mortality and exploitation

The total, natural and fishing mortalities of *P. cylindrica* were 2,0.99 and 1.01 y^{-1}, respectively (Fig. 12). Loss of freshwater mussel populations has been reported worldwide due to predation, parasites, environmental flow and eutrophication. Natural mortality is closely related to age and size since larger species of bivalves generally have less rate of predation pressure. High fishing (1.19 y^{-1})and low natural (0.90 y^{-1}) mortality rates have been reported for

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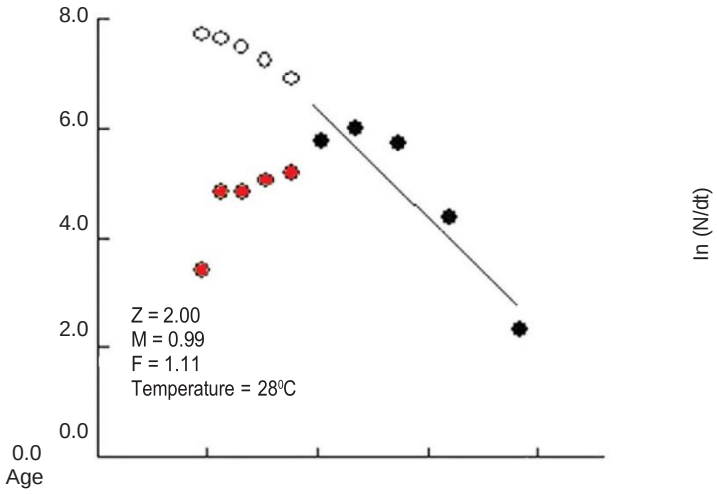

Fig. 12. Length–converted catch curve used to plot probability of capture of each length class of *P. cylindrica* from the river Malthi, the Western Ghats, India

P. corrugata inhabiting the same habitat (Malathi and Thippeswamy, 2013). Removal of mussels during local sand mining activities and exposure to detergents that enter into the river through domestic discharge and washing of clothes and vehicles, coupled with lack of motility, contribute to mortality rates in bivalve populations. Further, the mussel populations in the area are subjected to mortality during the summer season when water flow is almost reduced or restricted to small poundings in the river. Therefore, the stock of *P. cylindrica* in the present investigation is seen to be slightly above optimaly exploited (E=0.505). A slightly higher value of exploitation rate(E = 0.57) for *P. corrugata* was also noticed in this same study area by Malathi and Thippeswamy (2013). These sympatric species are not exploited for human consumption but are used as baits for angling, in the deep waters of river Tunga and river Malthi, in the downstream stretch where a natural barrier at Bhimanakatte Village obstructs the flow of river Tunga, just after the confluence of river Malthi with river Tunga.

Lifespan

More than 150 years are the lifetime of many bivalve molluscs, especially in the temperate zone (Abele et al., 2008). Thus, throughout the past several decades, there has been a rise in study on the biogerontological features of bivalve molluscs (Ziuganov et al., 2000; Abele et al., 2009) (Ridgway et al., 2011). With Donax species, the maximum life span (MLSP) has been recorded to range from 1-2 years (Thippeswamy and Joseph, 1991) to hundreds of years (Ziuganov et al., 2000). Comparing tropical unionid species to temperate species, P. cylindrica is smaller and less common. P. cylindrica in this research had a lifetime of 5.6604 years, which is less than that of P. corrugata (6.383 years) from the same environment (Malathi & Thippeswamy, 2013). Baseline information on population features including shell shape, LWRs, condition index, population structure, age and growth, mortality, and longevity of P. cylindrica from a tropical riverine system is provided by this work. The data will be valuable information for creating and putting into practice appropriate strategies for the conservation and sustainable management of this unique species to the Western Ghats of India. Reducing the indirect human pressures on this less known species,

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which might become a possible source of harvest for consumption in fresh or value-added forms, can help to preserve the stock of P. cylindrica at its holotype locality.

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References

Published in 2009 by Philipp, E., Brey, T., and Abele, D. Molluscan lifespans and bivalve models of ageing. Experimental Gerontology, 44, 307-315. 2008; Abele, D.; Philipp, E. E. R.; Strahl, J. DOI 10.1016/j.exger.2009.02.012. Arctica islandica, more commonly known as the ocean quahog, ages invisibly. Journal of Radiation Research, 42, 474–480. 10.1177/10715760802108849 is the DOI. "P. Agrawal" from 1976. Notes on the correlation between the linear development of the shell and the length of the body of the freshwater mussel Lamellidens marginalis (Lamarck). Science in Agriculture, 7(1), 19–20.

In 1980, Henderson made some observations on the gonad fluctuation in Indonaia caerulea (Lea) (Mollusca: Unionidae). Proceedings of the Zoological Survey of India, 3(1): 87-92. Arshad, A., Zafar, M., Barua, M., and Amin, N. S. M. (2005). The population dynamics and level of exploitation of green-lipped mussels

Conducting a survey of Perna viridis from the offshore island of Cox's Basar in Bangladesh using FiSAT technology. Journal of Tropical Agriculture, Vol. 28, No. 2, pp. 103–109. Nathaniel Annandale and B. Prashad. 1919. Several freshwater mollusks from the Bombay Presidency? 16: 139–152; Record of the Indian Music.

Ansell, A. D., Trevallion, A., Narayanan, B., and Sivadas, P. 1971. The life of two sandy beaches in southwestern India. Populations of the Donax spiculum and Donax incarnatus have been studied. View the article at this link: Mar. Biol., 17(4), 318-322. 10.1007/BF00366743. In 1955, Bagenal was writing. The rate of growth of the lengthy rough dab Hipomastoides platessoides, Fabr. A. J. Publication: Mar. Biol. Assoc. U. K., Volume 34, Issue 3, Pages 297-311. DOI: 10.1017/S0025315400027673. R. H. Rees 1958. Condition assessment of mussels and oysters. Article number: 23 in the Marine Science ICES Journal, pages 249–257. The current working paper has the DOI 10.1093/icesjms/23.2.249.

In 1996, Begum and Munshi collaborated. Reproduction in the freshwater bivalve Parreysia favidens (Benson) of the Kosi River. Biological Survey of India, 1995, 95(3), 287-297.

Sinha, A. K., and Begum, S. (2000). Burhi Gandak's freshwater drainage system: length-weight relationship of Parreysia favidens (North Bihar, India). India. Journal of Zoological Survey, 98(3), 61-66. doi: 10.26515/ rzsi/v98/i3/2000/159660.

It was 1977. Kim, Carlander. A guide on the biology of freshwater fisheries. A total of 700 pages. Publication: Ames, USA: Iowa State University Press.

1980 Cerrato, R. M. A study of the demographics of the bivalve population. Includes sections 417–465, published by Plenum Press in London, UK. In their role as editors, Rhoads and Lutz The evolution of aquatic species' skeletons: Biological traces of shifting ecosystems.

This is from 1984 by Chatterji, Ingole, Ansari,

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and Parulekar. The green mussel, Perna viridis L., is cultivated in an aquaculture system that circulates saltwater. The allometric connection of Lambellidens corrianus was investigated in 1984 by Desai and Borkar (DOI: 10.1016/0044-8486(84)90215-1). Indian fish. 36, 180–182. (Devaraj, M.) in 1983. The development of fish populations throughout time. on the dot. published by the ICAR-Central Institute of Fisheries Education in Mumbai, India, volume 3, issue 10, CIFE Bulletin.
D. Pauly, P. Sparre, and F. C. Gayanilo. 1996. 288 pages, The FAO-ICLARM stock assessment tools (FiSAT) users guide is published by the Food and Agriculture Organisation of the United Nations in Rome, Italy, and is part of the FAO Computerised Bioinformation Series.
In 1965, Johan Gulland.... Assessment of mortality rate. Pages 231-241 in Cauhing, P. H. (ed.), Key papers on immigrant populations, IRL Press, Oxford, UK.
In 1983, Johan Gulland wrote. An outline of the most basic methods for assessing fish populations.
It has 223 pages and was published by Wiley in New York, USA.
The population dynamics of Perna viridis (L.) Asian green mussels off the coast of Malpe, India, were studied in 2017 by Hemachandra, Tenjing, and Thippeswamy. Pakistani Geographical Science Journal, 46(2), 1659-1663.
year 2008. Thippeswamy and Hemachandra did it. The allometry and condition index of the green mussel Perna viridis (L.) from St. Mary's Islands near Udupi, India, around Malpe: 39(16), 1747-1758, Aquac. Res. 10.1111/j.1365-2109.2008.02051.x.
The reproductive and morphometric features of the freshwater mussel Lamellidens marginalis, as well as its associated hydrology in the Ratargul freshwater Swamp Forest of Bangladesh, were studied by Hossain, Mohammed, Saha, Sarker, and Hussain, M. Volume 49, Issue 2, Pages 161–170, Journal of Aquatic Research, Egypt. DOI: 10.1016/j.ejar.2022.11.004. [Internet].

Y. S. A. Khan and D. Kamal 1998. Perna viridis (Linn. 1758), a green mussel, is found in the Bay of Bengal in Bangladesh's Moheshkhali Channel. Journal of Marine Science in Pakistan, Volume 7, Issue 1, Pages 45–55.

Khan, A. A. M., Assim, Z. B., and Ismali, A. (2010). The green-lipped mussel population is dynamic off the coast of the Naf River in Bangladesh. Article citation: Chiang Mar Journal of Science, 37(2), 344-354. Included in Kuriakose, P. S. 1973. Coastal Mytilidae research in India. Kerala University, India, PhD thesis.
Thippeswamy and Malathi (2011). Fish morphology, length-weight, and condition of Parreysia corrugata (Mullar 1774) (Bivalvia: Unionidae) from the Malthi River in the Western Ghats of India. The article is published in Biol. Sci. International and spans pages 43 to 52.

In 2013, Thippeswamy and Malathi published some research. River Malthi, a tributary of the Tunga in India, and its population of freshwater mussels, Parreysia corrugata (Mullar 1774), as well as its ecological context in the Western Ghats. Volume 5, Issue 4, Pages 20–26, Journal of Modern Science and Technology.
In 1990, Mathews and Samuel published a paper. Using the growth performance index (Ŧ'), a species may be chosen for aquaculture in Kuwait, as shown in this example. A study conducted in a freshwater lake in Northwest Bangladesh examined the length-weight connections, condition index, and sex ratio of

Lambellidens corrianus (Lea, 1834) according to Aquabyte, 3(2), 1-4. 2016; Mondol, M. R.; Nasrin, F.; and Nahar, D. A. Fishing in Croatia, volume 74, pages 172-178. Doi.org, online at 10.1515/cjf-2016-0025.

This sentence is a citation for a 2016 publication by Moss, Ivany, Judd, Cummings, Bearden, Kim, Artuc, and Driscoll. Marine bivalvian life expectancy, growth rate, and body mass as a function of latitude: implications for paleozoic architecture. The publication reference is 283: 20161364, and the DOI is 10.1098/rspb.2016.1364.

The authors of the 1978 work are Lohgaonker and Nagabhushanam. Mating season for the mussel Lamellidens carrianus occurs once a year. Water Biology and Engineering, 61, 9–14. Growth trend of the freshwater bivalve mollusk Lamellidens marginalis (Lamarck, 1819) in Northwest Bangladesh (2019; Islam, M. R.; Jasmine, S.; Mondol, M. M. R.; Nahar, D. A.) https://doi.org/10.1007/BF00019019. The article is published in volume 27, issue 132, of the Journal of Bioscience. Accessed at 10.3329 /jbs.v27i 0.44677.

It was published in 1981 by A. Narasimham. Indian Journal of Fish, 28: 240-248, discusses the growth and dimensions relationships of the Kakinada Bay green mussel, Perna viridis. Presented in 2020 by W. W. Nwe, N. N. Oo, Z. M. Aye, and M. N. Myint. Features of the Perna viridis (Linnaeus, 1758) population in the Ye estuary in the Mon coastal area of Myanmar. Volume 10, Issue 12, Pages 309-314, International Journal of Scientific Research Publications. The article discusses the seasonal changes in the gonadal function of the adult freshwater mussel Parreysia favidens var. marcens (Benson) in 1970. The citation is: DOI 10.29322/IJSRP.10.12.2020.p10830. Journal of the Indian Academy of Sciences, Section B, 65(1), 26–33.

Edgar Allan Poe. 1980. Concerning the interplay between the average ambient temperature, growth traits, and mortality rates of 175 fish populations. March Science Journal, 39(2), 175-192. The link to the article is DOI 10.1093/icesjms/39.2.175.

The work of David Pauly from 1983. Simple approaches for tropical fish stock assessment. Technical Paper No. 235; FAO Fisheries. Page 1–52 of the United Nations Food and Agriculture Organisation publication, Rome, Italy.

From 1981, Pauly D. and David N. An ELEFAN-I BASIC programme for the objective extraction of growth characteristics from length-frequency data. Journal of Marine Research, 28, 205-211. Pauly D., Munro J. L. 1984. More on the analogy between invertebrate and fish development. Fishbyte, 2, 1–21. Pradhan, S.; Mohanty, U. L.; Sundaray, J. K.; Kumar, T.; Saurabh, S.; Padhi, N.; Kumarn, R. Relationships of length, breadth, and height between the weights of farmed freshwater pearl mussels Lamellidens marginalis (Lamarck, 1819). Fish. Indian Journal, 67(1), 157–160. 1021077/ijf.2019.67.1.78687-18.

B. Preston. 1915. The Mollusca, or Freshwater Gastropoda and Pelecypoda, of British India, includes Ceylon and Burma. Taylor & Francis, 244 pages, London, UK.

In 1980, Ramachandra. investigations on the biology of Perna viridis (Linnaeus) green mussels. University of Agricultural Sciences, Bangalore, India, M. F. Sc. thesis, 102 pages. A companion guide to freshwater mollusks in India, Dey and Ramakrishna, 2007. A 399-page publication from India's Zoological Survey, Kolkata.

Asian Fisheries Society, Indian Branch, Mangalore, India, 2008, Book of Abstracts, 8th Indian Fisheries Forum, 22-26 November 2008, Kolkata, India, p. 38. The authors of the 2008

work are Thippeswamy and Ramesha. Parreysia corrugata (Mullar), a Unionid mussel, population ecology in the Kempuhole River, a tributary of the Nethravathi River in the Western Ghats of India.

The allometry and condition index of the freshwater bivalve Parreysia corrugata (Muller) in the Indian river Kempuhole was published in 2009a by Thippeswamy and Ramesha. The article can be found in volume 22, pages 203-213. Ramesha, M. M., and Thippeswamy, S. (2009) published an article in Asian Fish Science with the DOI 10.33997/j.afs.2009.22.1.019. In this study, we examine the Parreysia favidens (Benson) freshwater mussel population dynamics in the Western Ghats of India. Book of Abstracts, page 32, from the 2009 national conference on sustainable development and environmental science, held at the University of Mysore in Mysore, India, on November 27th and 28th. This is a 2011 publication by Richardson, Austad, and Ridgway. Size of the maximal shell, pace of growth, and age of maturity are all factors that determine how long bivalve mollusks live. The cited article is from the Journal of Gerontology (66A, 183–190). doi: 10.1093/gerona/glq172 https://doi.org. 1993; Rivonkar, C. U.; Sreepada, R. A.; Parulekar, A. H. Growth characteristics of the cultivated green mussel, Perna viridis L. in the Goa-based Zuari Estuary. Asian Journal of Marine Science, 22: 72-74. 2022; Sarma, K.; Kumar, A.; Ahirwal, S. K.; Narayan, D. Freshwater mussel, Lamellidens marginalis: biological traits, culture potential, and dietary value (Lamarck, 1819). Indian Journal of Fishing, 69(3), 51–58, 10.21077/ijf.2022.69.3.119345–07.

Mary Shafee. 1979. Environmental energy requirements of the green mussel (Perna viridis Linnaeus) at the Ennore Estuary, Madras. In Oceanol. Acta, volume 2, pages 69–74. “Henry Sturges” from 1926. Choosing a class interval. Journal of the American Statist, 21(1), 65–66.

In 2014a, Kulkarni and Suryawanshi published their work. Examining the link between length and weight of two species found in the Nanded district of Maharashtra, India: Lamellidens marginalis (Lamarck) and Parreysia corrugate (Muller). Publication: Indian Journal of Legal Science, Volume 3, Issue 2, Pages 77–80. Dated: 2014b. Parreysia corrugata (Muller) in the Nanded area: length-height-weight relationships (A. N. Kulkarni and A. V. Suryawanshi, 2013). Paper published in the Indian Journal of Application Pure Biol., volume 29, issue 1, pages 133–137. Johann Strahl, Thomas Brey, Karl Broeg, Ernst Philipp, and Dieter Abele 2007. The physiological ageing of Icelandic inhabitants was studied in the context of Arctica islandica, the ocean quahog. Life in the oceans, volume 1, issue 1, pages 77–83, doi:10.3354/ab00008. 2016; Tenjing, S. Y.; Thippeswamy, S.; Narasimhaiah, N. Modiolus eared horse mussel: development, mortality, and longevity: an exploratory investigation. The ever-changing Parreysia cylindrica population asurucus (Krauss, 1848) is a species native to India. Chapters 323–332 of the Indian Journal of Geo-Marine Science, volume 45, issue 2. in 2016 According to Thejasvi, A. Research of the ecology of the green mussel Perna viridis in the subtidal Karwar and intertidal Mukka areas of Kerala, India. Doctoral dissertation, Mangalore University, Karnataka, India. Published in 1990 by Thippeswamy. Social ecology of the green mussel's island microhabitat (Perna viridis L.). Doctoral thesis, Bangalore, India: University of Agricultural Sciences.

In 1988, Joseph and Thippeswamy published a

paper. The Donax incarnates wedge clam's condition changes with the seasons (Gmelin). Papers presented at the First Indian Fisheries Forum, held in Mangalore, India, from December 4th to the 8th, 1987, by the Asian Fisheries Society's Indian Branch Pages 247–249 in Joseph, M. M. (Ed.). This was published in 1991 by Joseph and Thippeswamy. Population control measures for the Panambur beach, Mangalore wedge clam, Donax incarnatus (Gmelin). Pages 147–151 of the Indian Journal of Marine Science, volume 20, published in 2017. Thippeswamy, S., and Joseph, M. M. 1992. Geometry of the Mangalore wedge clam (Donax incarnatus Gmelin), found on Panambur beach. Twenty-one: 161–163. "Indian Journal of Marine Science"

Malathi S., Joseph M. M., Shubharekha B., and Thippeswamy S. Donax incarnatus (Gmelin) shells discovered in Panambur sandy beach in Mangalore, along with their dimensions and shapes. The citation is from the Indian Journal of Marine Geoscience, volume 48, issue 4, pages 275-283.
It was written in 2014 by Malathi, Thippeswamy, and Anupama. The freshwater bivalve Parreysia favidens in the Bhadra River in India: a condition index and allometry study (Benson, 1862). Indira Gandhi Fish. Indian Journal, 61(4), 47-53..
August von Bertalanffy in 1938. Development Laws Inquiries, II: A Quantitative Analysis of Biological Development, 10, 81-213. Human Biology by George Owen and K. M. Wilbur, 1964. Scaling up. This is in the book "Physiology of Mollusca" by K. M. Wilbur and C. M. Yonge. Pages 211-242 of Academic Press's publication from New York, USA.
In 2021, Yang and Zeng reviewed the calculation and implementation of the bivalve condition index for the Northern Quahogs (Mercenaria mercenaria), a species of mollusk. Aquac. Res. Org/10.1111/are.14866, volume 51, issue 1, pages 23–36.
By 2000, Ziuganov, Beletsky, Popkovitch, Kaliuzhin, Johnson, Longa, Fernandez, Amaro, Miguel, E. S., and Neves had already made their mark. An animal model for studying the mechanisms of longevity: the life span variability of freshwater pearl shells. 102–105. AMBIO, 29: 10.1579/0044-7447-29.2.102.