Recent Research in Science and Technology 2013, 5(4): 20-26
ISSN: 2076-5061
Available Online: http://recent-science.com/

Population ecology of freshwater mussel *Parreysia corrugata (*Mullar 1774*)* from River Malthi, Tributary of river Tunga in the Western Ghats, India

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Abstract

The The freshwater mussel *Parreysia corrugata* (Muller, 1774) is common in rivers of India. The growth, mortality and recruitment of *P. corrugata* were studied from March 2007 to June 2008 from river Malthi, tributary of river Tunga, in the Western Ghats. A total of 1587 individuals ranging from 17 to 57 mm size were subjected to analysis. The recruitment pattern produced one cohort per year and the highest peak occurred during November-December. In the first year the growth of mussel was fast, about 50% of its maximum size, and in subsequent years the growth decreased. The sizes attained by *P. corrugata* were 22, 36, 46, 51, 55 and 57 mm at the end of 1st to 6th years respectively. The average growth rates of *P. corrugata* from first to sixth years were 2.00 1.08, 0.75, 0.5, 0.25 and 0.17 mm/month respectively. The life span of the mussel was about 6 years at the study area. The von Bertalanffy growth equation for length was $L_t = 60.76\ [1- e^{-0.47\ (t+0.0426)}]$. The growth performance index (Φ) was 3.896. The total mortality (Z) was 1.84/ year. The natural mortality (M) and fishing mortality (F) rates were 0.9 and 1.19/year respectively. The exploitation level (E) of *P. corrugata* was 0.57.

Keywords: Freshwater mussel, *Parreysia corrugata*, age and growth, mortality, Karnataka, Western Ghats.

INTRODUCTION

Freshwater mussels are very important components of aquatic ecosystems. They often dominate benthic biomass and production [1]. The freshwater mussels are burrowing and filter feeding organisms and are ideal for pollution surveillance. Until the middle of twentieth century freshwater mussels were exploited principally for natural pearls to produce nacre buttons and to feed poultry [2,3]. By filtration mussels reduce the seston concentration and by excretion release ammonia, a useful nutrient for phytoplankton, into the water. Thus at high population densities mussels play an important role in the conversion of energy and matter [4,5]. Studies on population biology of freshwater bivalves have been increasing [6,7,8,9,10]. There is a dearth of information on population ecology of freshwater mussel *Parreysia corrugata* from Indian region. The freshwater mussels are now extensively used in the production of freshwater pearls in India. Freshwater mussels were widely distributed in Indian water bodies [11]. The allometry and condition index of *P. corrugata* [12, 13] inhabiting in Indian rivers have been reported. The data on population ecology is crucial to manage a species of commercial importance. Therefore it was aimed to understand the age, growth, mortality and recruitment patterns of *Parreysia corrugata* inhabiting a tropical river in the Western Ghats of India.

MATERIALS AND METHODS

Received: Feb 12, 2013; Revised: March 14, 2013; Accepted: April 25, 2013.

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The samples of freshwater mussel *Parreysia corrugata* (Mullar 1774) were collected from the river Malthi at Kalmane (13°39'11" N; 75°10'52" E) near Thirthahalli, Shimoga district of Karnataka state in the Western Ghats at monthly intervals from March 2007 to June 2008. A total of 1547 individuals of *P. corrugata* were collected during the study period and subjected to length measurements. During June-September 2007 mussels could not be collected due to the flooding of river by southwest monsoon. Shell length (maximum anterio-posterior) was measured individually using vernier calipers and grouped into different size groups with class intervals of 3 mm. The percentage frequencies of different size groups were analyzed using FiSAT software [14]. The population parameters namely asymptotic length (L_∞) and growth coefficient (K) of the von Bertalanffy Growth Function (VBGF) were estimated by means of ELEFAN-1 [15]. The K-scan routine was conducted to assess a reliable estimate of the K value. The theoretical time when an animal has zero length (t_o) was calculated using the least square method [16]. Preliminary estimates of L_∞ and Z/K were obtained through the Powell-Wetherall Plot [17,18]. The von Bertalanffy growth curve for length was fitted [19,20]. The inverse growth equation [21] was used to find the length at various ages. The estimates of L_∞ and K were used to estimate the growth performance index (Φ') [22] using the equation, $\Phi' = 2 \log_{10} L_\infty + \log_{10} K$. Normal distribution of the recruitment pattern was determined by NORMSEP [23] with FiSAT programme. The total annual instantaneous mortality rate (Z) was estimated by length converted catch curve method [24]. Instantaneous natural mortality rate (M) was estimated using the habitat mean annual surface temperature of (°C) of river water. The fishing mortality (F) was estimated [24] using the equation, $F = Z\text{-}M$. The exploitation level (E) was obtained by the equation of [25], $E = F/Z$ where, $Z = F/F+M$.

RESULTS AND DISCUSSION

Length frequency analysis

The length frequency distribution of mussels at monthly intervals is presented in Fig. 1. During April 2007, February and April 2008 only one peak appeared at 41-44 and 44-47 size classes respectively. A total of two peaks were appeared during March 2007, January, March, May and June 2008 where as three peaks were noticed during May, October, November and December 2007. During March the primary peak and secondary peak were appeared at 41-44 and 47-50 class intervals respectively and were merged during April 2007 at 41-44 class interval resulting only one peak which was remained at same class interval during May 2007 as a secondary peak. The primary peak appeared at 35-38 size class during this month and the tertiary peak was at 50-53 class interval which was shifted to 56-59 size class during October 2007. The secondary peak appeared at 44-47 size class. However the primary peak was noticed at 20-23 size class intervals during October 2007 indicating the occurrence of young individuals in the population. This was further supported by the occurrence of young individuals in the population during November-December 2007 with the primary peak at 26-29 size class. The secondary and tertiary peaks were at 35-38 and 41-44 size classes respectively and shifted to 38-41 and 44-47 size class during December 2007. During January 2008 the primary peak was at 29-32 size class and the secondary peak was at 38-41 size class and merged at 44-47 size class during February as a primary peak. A total of two peaks were observed during March 2008 at 23-26 and 44-47 size class intervals, which were merged during April 2008 as a primary peak at 44-47 size class. During May 2008 again two peaks were appeared at 32-35 and 41-44 size classes and the secondary peak shifted to 47-50 size class during June 2008. The primary peak appeared at 20-23 size classes during June 2008 indicating the occurrence of young mussels in the population. During the study period, the entire mussel population showed only one peak at 44-47 mm size class (Fig. 1). The size of mussels varied from 17 (November 2007) to 57 mm (October 2007) during the study period. The majority of mussels were <50 mm. The average size of mussels was 41.63 mm.

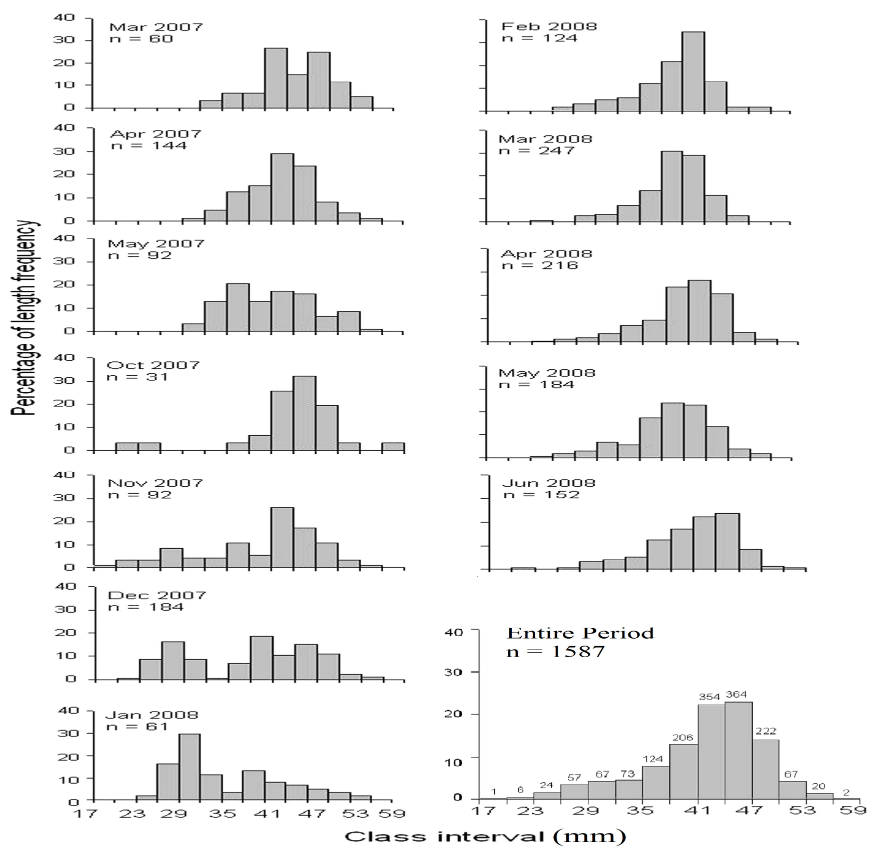

Fig 1. Length frequency distribution of *Parreysia corrugata*

Growth rate

Variability in the growth rate of freshwater bivalves of different species as well as those inhabiting different habitats is well documented and cessation of shell growth occurs in old and large mussels [26,27] because habitats do not always manifest conditions that are optimal for mussel growth. The great variability in growth rates of species from different sites reflected the fact that differences in food availability and water temperatures [1]. Growth rates also vary with stable environmental gradients [28]. Increases in growth rate during the summer were probably due to increased water temperature and phytoplankton food sources [29]. However, high temperatures can inhibit growth and increase mortality of the species [30]. Comfort [31] suggested that large differences in growth rates at different sites were common among all Unionids. The mean shell length was maximum (44.83 ± 4.69 mm) during March 2007 and minimum (35.28 ± 7.5 mm) was during January 2008. In the present study the estimated length at age indicated the rapid growth in the first year, with the mussels attaining almost 50% of its maximum size. Subsequently in the following years the rate of growth was decreased. The sizes attained by *P. corrugata* were 23.53, 37.49, 46.21, 51.67, 55.08 and 57.21 mm at the end of 1, 2, 3, 4, 5, and 6 years respectively. The average growth rates of *P. corrugata* from 1 to 6 years were 2.00 1.08, 0.75, 0.5, 0.25 and 0.17 mm/month respectively (Fig. 2). In addition to size and age, the rate of growth of mussel was affected by a variety of ecological and environmental factors.

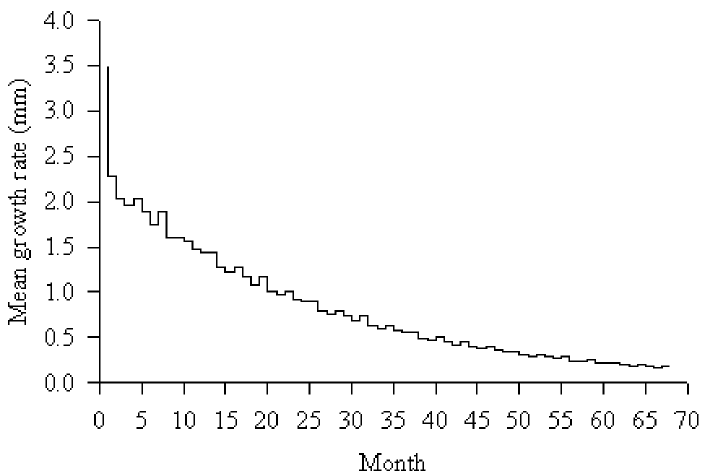

Fig 2. Mean growth rate of *Parreysia corrugata*

Growth parameters

The monthly length frequency distribution with growth curves superimposed using ELEFAN-I for *P. corrugata* is presented in Fig. 3. The growth parameters (L_∞, K, t_0) are helpful in comparison of growth rates between and within species inhabiting in different habitat. The growth parameters of different freshwater bivalves from geographical regions are presented in Table 1. The asymptotic length (L_∞) is the maximum theoretical length an organism can attain under given rate of growth and was 60.76 mm for *P. corrugata*. The L_{max} (maximum length reached by the mussel of a given stock) was 56.60 mm. The L_∞ of *P. corrugata* was more than the values reported for *Corbicula fluminea* [8] and less than the value reported for *Amblema plicata, Fusconaia ebena, Megalonaias nervosa* [9], *Elliptio complanata, Lampsilism siliquoidea, Pyganoden grandis* [7], *Pseudanodonta complanata, Unio pictorum* [6] and *Margaritefera margaritefera* [10].

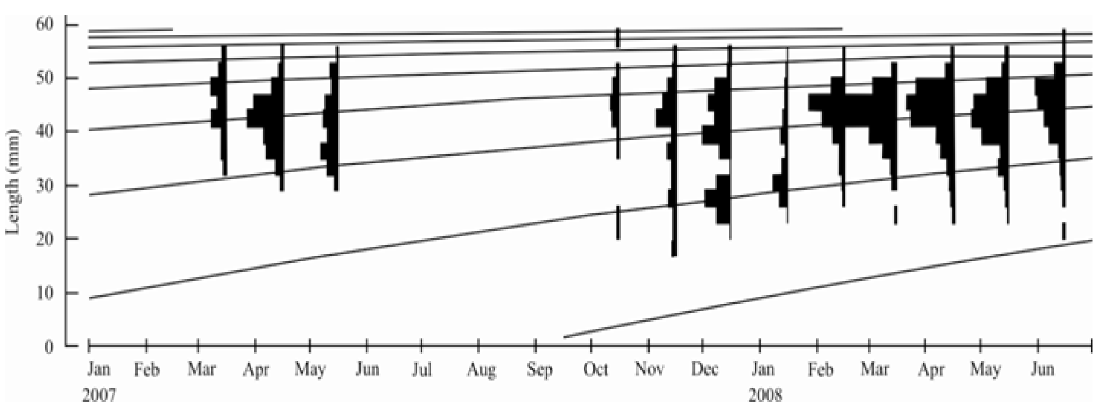

Fig 3. Length frequency distribution with growth curves of *Parreysia corrugata* superimposed using ELEFAN-I

The growth constant K, is the growth which determines the curvature of the growth curve that is, the rate at which the asymptotic length is approached [19]. The lower the value of the K, the slower is the asymptotic size approached. As the growth constant K is decreases, the asymptotic size L_∞ increases, leading to an increased maximum size L_{max}. Simultaneously the maximum age is increased. The growth coefficient (K) of *P. corrugata* was 0.47/ year. The K of *P. corrugata* was more than *Amblema plicata, Fusconaia ebena, Megalonaias nervosa, Unio pictorum* (9), *Elliptio complanata, Lampsilism siliquoidea, Pyganoden grandis* [7], *Pseudanodonta complanata, Unio pictorum* [6] and *Margaritefera margaritefera* [10] and less than *Corbicula fluminea* [8] (Table 1).

The asymptotic age at zero length (t_0) of *P. corrugata* was -0.0426 which is less than the values reported for *Margaretifera margaretifera* from rivers A, B, E(2), H, I and J of Scotland [10], *Fusconaia ebena* from Black river and White river of USA, *Amblema plicata* from White river, USA and *Megalonaias nervosa* from Cache river, USA [9], and more than the values reported for *Amblema plicata* from Quachita river, USA and *Megalonaias nervosa* from St. Francis river, USA [9] and *Margaretifera margaretifera* from rivers C, D, F, G, E(4) of Scotland [10] (Table 1). The differences in the environmental conditions and ecosystems characteristics in the different areas might explain the variations in the values of growth parameters. The von Bertalanffy growth equation for *P. corrugata* was L_t = 60.76 [1- $e^{-0.47\ (t\ +0.0426)}$]. The computed von Bertalanffy growth curve for length is presented in Fig. 4.

Table 1. Population parameters of freshwater bivalve species reported from different parts of the world. *GPI values calculated from raw data represented by the authors. # River is code-lettered because of the threat of illegal pearl fishing (the author)

Species and source	$L\infty$ (mm)	K ($year^{-1}$)	t_0 (month)	GPI (Φ')*	Habitat
Amblema plicata [9]	87.02	0.130	-0.34	2.993	Quachita river, Arkansas, USA
	137.96	0.090	0.83	3.233	White river, Arkansas
Corbicula fluminea [8]	32.00	0.650		2.823	Parana River Delta, Argentina
Elliptio complanata [7]	74.00	0.176		2.983	Yawgoo Pond, USA
	62.50	0.027		2.023	Worden Pond
Fusconaia ebena [9]	102.09	0.140	0.41	3.164	Black river, Arkansas, USA
	115.91	0.130	2.09	3.242	White river, Arkansas USA
Lampsilism siliquoidea [7]	130.30	0.055		2.970	Wabana Lake, USA
Margaritefera margaritefera [10]	107.00	0.074	0.064	2.928	#A , Scotland, UK
	77.00	0.075	4.33	2.648	#B
	158.00	0.031	-3.48	2.889	#C
	97.00	0.045	-1.03	2.627	#D
	110.00	0.063	1.65	2.882	#E (2)
	109.00	0.023	-1.68	2.437	#E (4)
	126.00	0.042	-2.11	2.803	#F
	107.00	0.048	-3.93	2.740	#G
	122.00	0.071	1.96	3.024	#H
	105.00	0.081	0.46	2.951	#I
	107.00	0.063	0.64	2.858	#J
Megalonaias nervosa [9]	131.06	0.060	0.16	3.013	Cache river, Arkansas, USA
	217.79	0.040	-14.33	3.278	St. Francis river, Arkansas, USA
Parreysia corrugata [PS]	60.76	0.470	-0.0426	3.239	Malthi river, tributary of river Tunga, India
Pseudanodonta complanata [6]	97.80	0.130		3.094	Wicken Lode, Cambridge, UK
Pyganoden grandis [7]	112.00	0.032		2.604	Wabana Lake, USA
Unio pictorum [6]	115.30	0.121		3.206	Wicken Lode, Cambridge, UK

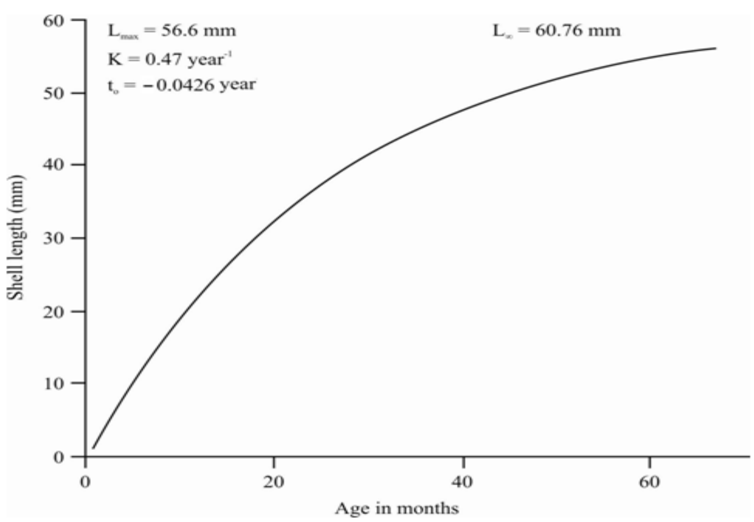

Fig 4. The von Bertalanffy growth curve of *Parreysia corrugata*

Growth performance index

Growth performance index (GPI) or phi prime (Φ') is a length-based index of growth performance which combines K and L_∞ and was used to give an expression of the growth potential of the species. This value is important for comparing growth performance of the same species or between the species of the same genus. The Phi-prime values for freshwater bivalves from various geographical regions are presented in Table 1. The GPI of *P. corrugata* was less than that of values reported for *Unio pictorum* from St. Francis river and *Unio pictorum* from White river [9] and more than *Amblema plicata* from Quachita river, *Unio pictorum* from White river, *Fusconaia ebena* from Black river, *Megalonaias nervosa* from Cache river, USA [9], *Corbicula fluminea* from Parana river delta, Argentina [8], *Elliptio complanata* from Yawgoo Pond and Worden Pond USA *Lampsilism siliquoidea* and *Pyganoden grandis* from Wabana lake, USA, [7], *Margaritefera margaritefera* from Scotland, UK [10], *Psedanodonta complanata* and *Unio pictorum* from Wicken Lode, Cambridge, UK [6].

Life span

The von Bertalanffy growth curves for freshwater bivalves are not equally long lived in all populations. It is responsible to believe that the estimate of mussel longevity varies among ecosystems. As the temperature decreases in temperate regions, the metabolic rate also declines and hence the decreased rate of growth. Therefore the asymptote is approached slowly and has a long life. *Parreysia corrugata* are small and short-lived Unionid species compared to other species. The life span (time taken to attained L_{max}) of *P. corrugata* was 68 months (about 6 years). *Margaritifera margaritifera* is one of the longest-lived invertebrates known and the life span was >100 years [32]. Maximum size and life span increase as the growth constant declines. The life span of the *P. corrugata* was less (6 years) than that of *Unio pictorum* (22 years) and *Pseudanodonta complanata* (15 years) from Wicken Lode, Cambridge, UK [6] and *Unio pictorum* (15 years) and *U. tumidus* (11 years) from Thames river, UK [1] and more than *Limnoperna fortune* (2 years) from Uji river, Kyoto [33]. Hastie et al., [10] reported that *Margaretifera margaritifera* reaches sexual maturity when they are 12 to 15 years old and length of about 65 mm in Scottish rivers. However, Cosgrove *et al., [34]* considered those populations containing individuals smaller than 65 mm shell lengths are also sexually functional and survive for many years. Further, Miguel et al., [35] reported that in the Iberian Peninsula, *Margaretifera margaritifera* reaches sexual maturity at about 6 years of age, which implies that *M. margaritifera* of 55–60 mm size would be adults. The growth constant and maximum life span also responds to the productivity of the habitat. There is a negative correlation between growth constant and eutrophication and the maximum life span was reduced as the concentration of nitrate increases [27].

Mortality

Length converted catch curve of *P. corrugata* is presented in Fig. 5. The total mortality (*Z*), *n*atural mortality (*M*) and fishing mortality (*F*) were 1.84, 0.9 and 1.19/year respectively. The most frequent causes of mortality of freshwater mussels were eutrophication [32], predation by crayfish [36] and by fish, limited to the small mussels [2] and parasites [36]. However for the large sized individuals of the Unionidae, compared with those of the other benthic freshwater species, there was no significant competition with other species and the predation pressure was generally limited. Extent of mortality will depend primarily on temperature, population size structure and spring tissue condition [30]. In certain habitats with a rapid decrease of the water level, a part of the population died because the mussels were not able to migrate towards the water to avoid drying up [2,37]. In the present study the natural mortality was less (0.90/year) compared to fishing mortality (0.94/year). The exploitation level (*E*) is the fraction of deaths due to fishing and for *P. corrugata* was 0.57. The higher value of *E* (>0.50) indicates the pressure on the species. According to Gulland [25] the yield was optimized when *F* = *M*. In the present study the exploitation rate was 0.57 thus indicating the exploitation of mussel is slightly higher.

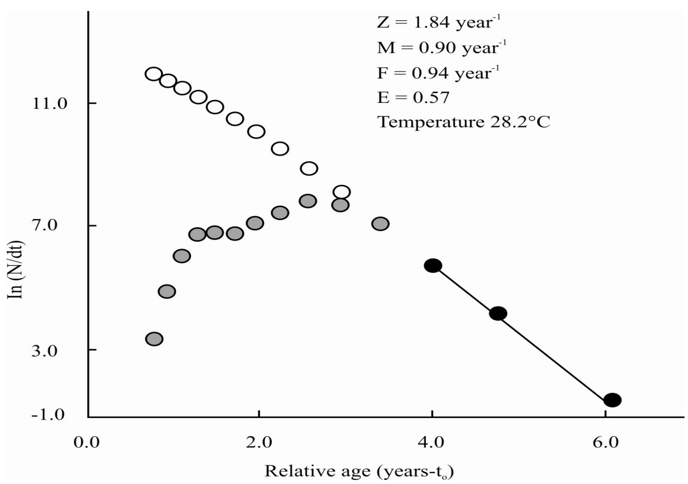

Fig 5. Length converted catch curve of *Parreysia corrugata.* Solid dots indicate the points used in estimation. Open dots indicates the point either not fully recruited or nearing L_∞.

Recruitment pattern

Studies on the densitiy and population structure of *M. margaritifera* have been carried out at tributaries in the Iberian Peninsula [38,39,40]. In all these studies, many of populations were functional since the population include individuals of <55–60 mm. The individuals of <30 mm were also recorded in the population [38,39] which indicated the recruitment of young mussel. The recruitment pattern of *P. corrugata* is presented in Fig. 6 and the data suggested that annual recruitment consisted of only one peak. Only one cohort was produced per year and the highest peak occurred during November-December. The major recruitment peak detected in this study corresponded to the major spawning season. Based on the length-frequency data, the highest recruitment was in November to December in *P. corrugata.* Cosgrove *et al*. [34] considered that recruitment has taken place when specimens <20 mm are present in a population. Hastie and Cosgrove [41] later increased this cut-off point to 30 mm, in view of the difficulties involved in finding such small specimens. They have further reported that in Scottish rivers, a population of *M. margaritifera* was viable when at least 25% of the individuals are younger. Bauer [42] found populations with 30% of individuals younger in the Iberian Peninsula thus indicating the recruitment. In the Iberian Peninsula the M. margaritifera reaches sexual maturity earlier and is shorter-lived [38,39].

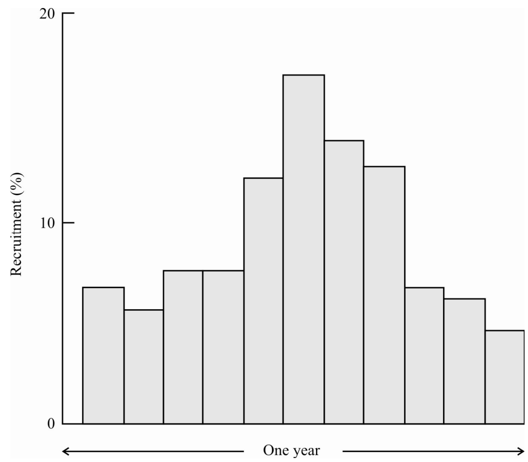

Fig 6. Recruitment pattern of *Parreysia corrugata*

ACKNOWLEDGEMENTS

The first author is thankful to the UGC, Government of India, New Delhi, for Research Fellowship in Science for Meritorious Students (RFSMS) and Mangalore University for providing facilities.

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