Factors influencing Molluscan (Gastropod) populations in Thirumeni Lake, Tamil Nadu, India.

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Abstract

Diversity and abundance of freshwater molluscs (Gastropods) in Thirumeni lake, Thiruvarur District, Tamilnadu, India and their relationships with the water quality and soil parameters of the lake were studied. Six families and 13 species of molluscs (Gastropods) were recorded in Thirumeni lake during different months and seasons of the study period. Season-wise variations in the density, biomass and diversity of mollusks (Gastropods) have been observed in Thirumeni lake . Monsoon and post monsoon are usually the favourable periods for breeding of molluscs. Emergent or free floating plants are the favoured microhabitats for most of the gastropod species in Thirumeni lake, while the shore line i.e. the littoral zone of the lake are for the *Pila* spp. Levels of pH and bicarbonates in the lake water have been found to be the most important variables has they entered into the multiple regression equation to predict the density of gastropods in Thirumeni lake, while the variations in the biomass of gastropods could best be explained by variation in water pH and soil potassium levels .

Key words: biomass, density, diversity, Gastropods, Molluscs, soil parameters, water quaity

INTRODUCTION

The freshwater molluscs constituent an important part of the freshwater benthic ecosystem. Besides the flowing nature (lotic) of otherwise (lentic) of waters, there are other factors like aquatic vegetation, water chemistry, nature of substratum etc., could influence the distribution and occurrence of fresh water molluscs (Rao, 1997).

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The lake with muddy bottom with high organic matter deposition and acidic pH is favourable for molluscan growth (Sarkar, 1989). The level of calcium, total hardness and alkalinity also favours molluscan abundance in lakes as observed by

Dudani *et al.* (1998) in several lakes and ponds of Darbhanga district, North Bihar, India. Negative and significant correlations are established between biomass of molluscs and sodium, potassium, calcium, nitrite, ammonical nitrogen and phosphate of water (Kumar and Gupta, 2002). Negative and significant correlations are also established between molluscan biomass and total calcium, total magnesium, total sodium, total potassium, ammonical nitrogen and available phosphorus of soil (Kumar and Gupta, 2002). These correlations show that during the growth phase of molluscan population these nutrients are consumed while on decomposition these nutrients are again returned to the ecosystem. However, the molluscs get their nutrients through the primary producers. An increase in the biomass of molluscs with an increase in biomass of macrophytes has also been observedþ in lake ecosystem by (Singh and Roy 1991).

But the level of our understanding of fresh water molluscs is such that we have not been able to comprehend their value in the ecosystem and the anthropic significance of their studies (Rao, 1997). Many of the fresh water molluscs serve as food for humans; but their production rates and turnover values have not been determined. As vectors of trematode parasites they are instrumental in the transmission and spread of many diseases in livestock and humans, and so are important from the medical and veterinary point of view. About one hundred species of freshwater gastropods are reported to act as intermediate host for the digenetic trematode parasites. Most of these are reported from African countries. But in India only 14 species are implicated as intermediate hosts of which only 10 species are considered significant (Subbarao and Mitra, 1989). Eleven species of schistosomes, lung flukes and liver flukes and 33 species of amphistomes

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are reported to spend their lives in intermediate snail hosts (Mukherjee, 1989; Srivastava, 1989). Thus the occurrence of some of the freshwater gastropods in India has dangerous portents for human health. At the other end of the larval bivalves are parasites of fishes. þFrom the Zoogeographical point of view some of the molluscs rank as excellent material.

The freshwater molluscs also have excellent aquaculture potential (Subbarao and Dey, 1989). In recent years have been reports of the natural occurrence of freshwater pearls (Raut and Biswas, 1989; Subbarao and Dey, 1989). Certain species of fresh water molluscs can form good indicators of pollutions (Abdulappa and Lakshminarayana, 1970). Rao (1997) has stated that freshwater molluscs are going to be the future living resource of our country.

Not withstanding their role in aquatic ecosystem they are least explored ecologically and biologically (Rao, 1984)þ. Ecology of a great majority of the Indian freshwater molluscs is not known. Biological studies are limited only to few species of viviparids, thiarids, lymnaeids and pilids. (Annandale, 1921; Annandale and Sewell, 1921; Ramamoorthi 1950, 1955; Jacob, 1958; Prasad, 1925, 1928; Muley, 1987). The discontinuousþ and transient þnature of fresh water bodies leads to isolation of freshwater species into small local populations. According to Rao (1984) much remains to be worked out on the ecology of Indian fresh water molluscs, as very few studies were undertaken in the past to investigate the influence of various biotic and abiotic factors on the distribution of freshwater molluscs in India (Starmuthhlner, 1982; Janakiram and Radhakrishna, 1984). Further, Rao (1997) has stated that more studies are needed to establish the þimportance of various environmental factors that produce of collective effect on the nature and distribution freshwater molluscs.

Based on the considerations of the foregoing account on various abiotic and biotic aspects of lentic ecosystem, the objectives of the present research were designed to record the diversity and abundance of freshwater molluscs in Thirumeni lake, Thiruvarur District, Tamilnadu, India and their relationships with the water quality and soil parameters of the lake.

STUDY AREA

The Thirumeni Lake

Thirumeni lake is one of the major freshwater habitats and resources of old Thanjavur District, Tamil Nadu, Southern India. After trifurcation of the old Thanjavur District it now comes under the Thiruvarur District. The lake extends from 10° 33′ 28" to 10° 34′ 30.9" N and from 79° 26′ 17.7" to 79° 27′ 54.1" E .

Sampling Stations

For recording periodically the various physico-chemical and biological fluctuations in the lake, three stations were selected. The stations were located nearby the villages Thirumakkottai, Painganadu and Paravakkottai.

Station I : (10° 33′ 46.44" N; 79° 27′ 18.36" E) was at the southern part of the lake near Thirumakkottai.

Station II : (10° 34′ 17.4" N; 79° 27′ 5.4" E) was at the Northern side of the lake near Painganadu.

Station III : 10° 34′ 0.48" N; 79° 26′ 40.56" E) was at the western part of the lake near Paravakkottai.

The stations were selected based on variations in depth and microhabitat variations due to the prevalence of aquatic vegetation and/or open water. Painganadu region of the lake is characterized by the lower depth with abundance of littoral vegetation. Thirumakkottai region is the deepest part of the lake with more open waters. Paravakkottai region of the lake is characterized by the abundance of *Ipomoea* and intermittent *Acacia* plantations.

METHODS

Study Period

Data were collected from October 2000 to May 2001 and November 2001 to April 2002, during three seasons *viz.*, Monsoon (October, November and December) and Post Monsoon (January, February and March) and Summer (April and May) of two successive years (during the months in an year when water was available in the lake which varied depending on the variations on water inflow from the feeder canals and rains). Data were collected on calm, sunny days and days with high wind, heavy rain and dense fog were avoided.

Measuring Water Quality Variables

The following water quality factors were measured once in a week from the three stations. Sample collections and preservation were as per the specifications of APHA (1995).

Physical Factors

Surface water temperature was measured at 8.00 a.m. It was measured in centigrade (C) with a LCD-portable digital Multi-Thermo meter with external sensor probe in all the three stations 0.1m below the water level (Danell and Sjoberg, 1982) with 0.1°C accuracy. Turbidity was measured by using the Nephelometer and expressed as NTU. Total dissolved solids were measured using Standard TD Scan I pocket TDS tester (10-1990 ppm range).

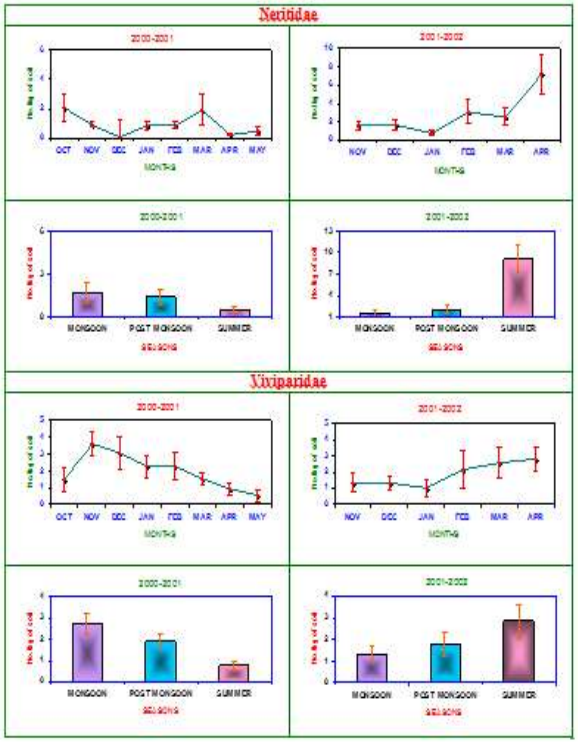

Fig. 1 : Month-wise and Season-wise variations (X±1SE) in the density (No./kg of soil) of Neritidae and Viviparidae in the Thirumeni lake during the study period.

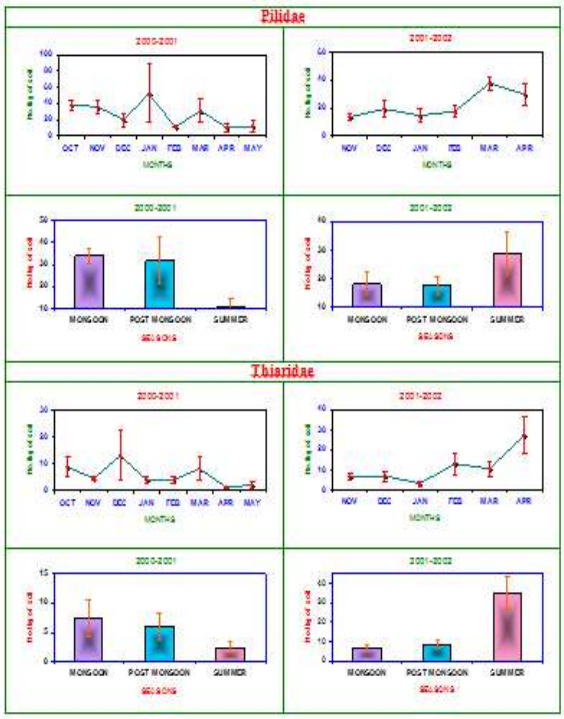

Fig. 2 : Month-wise and Season-wise variations (X±1SE) in the density (No./kg of soil) of Pilidae and Thiaridae in the Thirumeni lake during the study period.

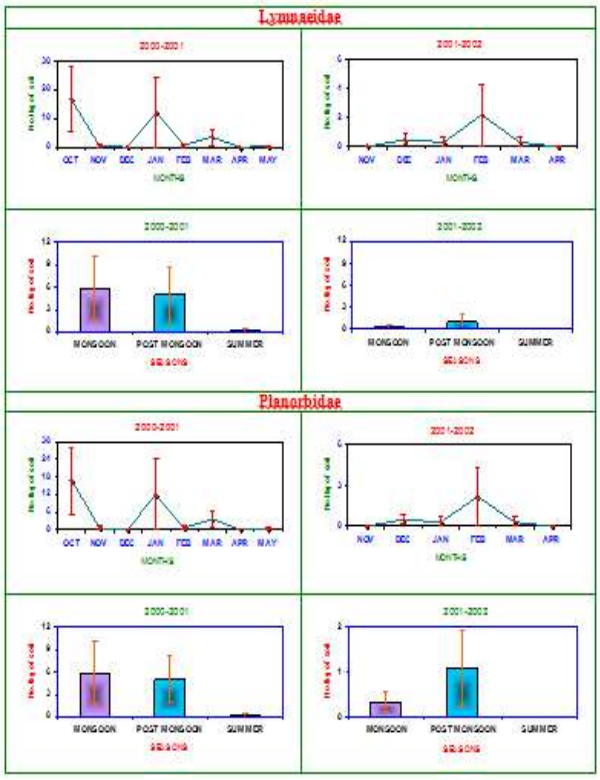

Fig. 3 : Month-wise and Season-wise variations (X±1SE) in the density (No./kg of soil) of Lymnaeidae and Planorbidae in the Thirumeni lake during the study period.

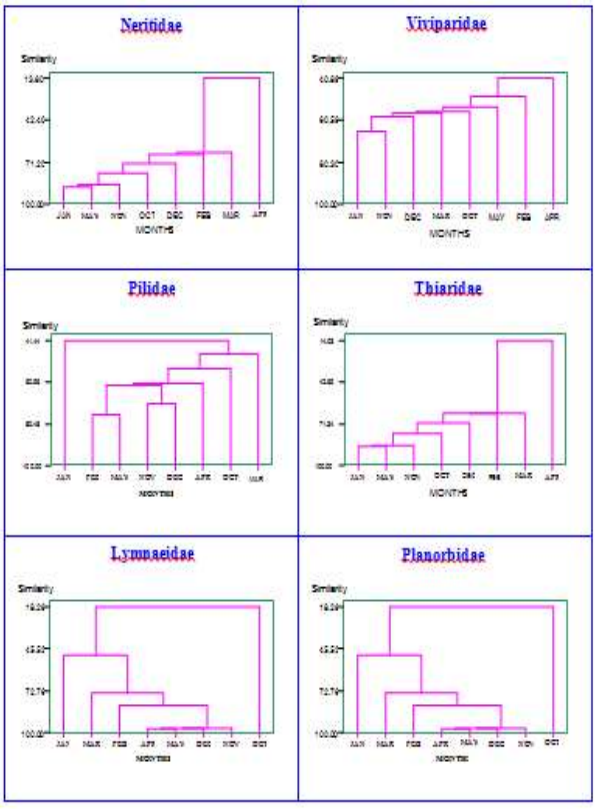

Fig. 4 : Similarity between months with regard to density of different families of gastropods in Thirumeni lake.

Table 1. Month-wise variations in the density (No./kg of soil) of gastropods in the lake during the first year of study (2000-2001). Values are X±1SD Values in parentheses are per cent composition by number of various families and species of gastropods in the lake during that particular month.

S. No.	Families and species of gastropods	MONTHS (2000-2001)							
		October	November	December	January	February	March	April	*May*
I	**Neritidae**	2.10±1.539 -2.54	0.90±0.300 -1.95	0.03±3.970 -7.82	0.83±0.450 -1	0.83±0.404 -4.16	1.95±2.602 -3.89	0.23±0.152 -1.86	*0.46±0.450 -2.88*
1	*Neritina (Dostia) violacea*	0.36±0.321 -0.43	0.90±0.300 -1.95	0.76±0.404 -1.97	0.56±0.288 -0.68	0.56±0.351 -2.84	0.38±0.213 -0.76	0.23±0.152 -1.86	*0.13±0.152 -0.81*
2	*Neritina (Vittina) variegata*	1.73±1.222 -2.11	0	12.26±3.585 -5.85	0.26±0.230 -0.32	0.26±0.230 -1.32	1.56±2.605 -3.12	0	*0.33±0.305 -2.07*
II	**Viviparidae**	1.46±1.285 -1.78	3.60±1.200 -7.82	3.06±1.616 -7.92	2.26±1.154 -2.75	2.26±1.404 -11.48	1.53±0.854 -3.06	0.93±0.611 -7.54	*0.53±0.611 -3.33*
3	*Bellamya dissimilis*	1.46±1.285 -1.78	3.60±1.200 -7.82	3.06±1.616 -7.92	2.26±1.154 -2.75	2.26±1.404 -11.48	1.53±0.854 -3.06	0.93±0.611 -7.54	*0.53±0.611 -3.33*
III	**Pilidae**	38.00±10.536 -46.34	35.66±13.796 -77.55	19.66±15.044 -50.91	52.33±60.929 -63.82	11.33±0.577 -57.56	31.50±31.986 -63.24	10.00±8.718 -81.16	*12.33±13.051 -77.59*
4	*Pila virens*	34.20±9.482 -41.71	32.10±12.417 -69.81	17.70±13.540 -45.84	47.10±54.836 -57.45	10.20±0.520 -51.82	28.35±28.787 -56.93	9.00±7.846 -73.05	*11.10±11.746 -69.85*
5	*Pila globosa*	3.80±1.053 -4.63	3.56±1.379 -7.74	1.96±1.504 -5.07	5.23±6.092 -6.37	1.13±0.057 -5.74	3.15±3.198 -6.31	1.00±0.871 -8.11	*1.23±1.305 -7.74*
IV	**Thiaridae**	8.76±1.500 -10.63	4.50±16.269 -9.77	12.90±16.26 -33.3	3.90±2.066 -4.68	3.90±1.916 -19.65	8.18±10.416 -16.33	1.16±0.764 -9.4	*2.00±1.952 -12.36*
6	*Thiara (Stenomelania) punctata*	0.86±0.611 -1.05	0	1.13±1.792 -2.92	0.13±0.115 -0.15	0.13±0.115 -0.66	0.78±1.302 -1.56	0	*0.16±0.152 -1*
7	*Thiara (Stenomelania) torulosa*	1.74±1.224 -2.11	0	2.27±3.584 -5.85	0.27±0.232 -0.31	0.27±0.232 -1.32	1.57±2.606 -3.12	0	*0.34±0.306 -2.07*
8	*Thiara (Tarebia) granifera*	0.86±0.611 -1.04	0	1.13±1.792 -2.92	0.13±0.115 -0.15	0.13±0.115 -0.66	0.78±1.302 -1.56	0	*0.16±0.152 -1*
9	*Thiara (Melanoides) tuberculata*	3.46±2.444 -4.22	0	4.53±7.170 -11.73	0.53±0.461 -0.64	0.53±0.461 -2.69	3.13±5.211 -6.27	0	*0.66±0.611 -4.15*
10	*Thiara (Mainwaringia) paludomoidea*	0.37±0.322 -0.43	0.91±0.301 -1.95	0.75±0.403 -1.96	0.57±0.289 -0.68	0.57±0.352 -2.84	0.39±0.214 -0.76	0.24±0.153 -1.86	*0.14±0.152 -0.81*
11	*Paludomus (Paludomus) tanschauricus*	1.47±1.286 -1.78	3.61±1.201 -7.82	3.06±1.6167 -7.92	2.26±1.155 -2.75	2.27±1.405 -11.48	1.53±0.855 -3.06	0.94±0.612 -7.54	*0.53±0.613 -3.33*
V	**Lymnaeidae**	15.00±17.578 -18.29	0.66±1.154 -1.43	0	10.66±18.475 -13.05	0.66±1.154 -3.5	3.16±6.33 -6.41	0	*0.33±0.577 -1.88*
12	*Lymnaea luteola*	15.00±17.578 -18.29	0.66±1.154 -1.43	0	10.66±18.475 -13.05	0.66±1.154 -3.5	3.16±6.33 -6.41	0	*0.33±0.577 -1.88*
VI	**Planorbidae**	16.66±19.655 -20.37	0.66±1.154 -1.43	0	12.00±20.784 -14.63	0.66±1.154 -3.5	3.50±7.148 -7.01	0	*0.33±0.577 -1.88*
13	*Indoplanorbis exustus*	16.66±19.655 -20.37	0.66±1.154 -1.43	0	12.00±20.784 -14.63	0.66±1.154 -3.5	3.50±7.148 -7.01	0	*0.33±0.577 -1.88*
	Family diversity (H')	0.4688	0.3311	0.4824	0.3728	0.4934	0.4371	0.2881	*0.329*
	Species diversity (H')	*0.6098*	*0.4618*	*0.8067*	*0.4903*	*0.6967*	*0.6468*	*0.4231*	*0.5329*

Chemical Factors

Fifteen chemical factors *viz*., pH., dissolved oxygen, total alkalinity, carbonate alkalinity, bicarbonate alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, iron, ammonia, nitrite, nitrate, sulphate and phosphate were assessed. The water samples were collected from the three stations in pre-cleaned separate water cans (1-2 L capacity) and were analyzed separately (Murphy *et al*., 1984). The water samples were collected and preserved for later analyses as per the procedures described in APHA (1995). The methods used to measure the water chemistry variables were as follows.

pH of the water samples were determined by portable pen type electronic pH meter. The pH meter was immersed in the water and pH values were read directly from the digital screen (Nagarajan and Thiyagesan, 1996). The dissolved oxygen content was estimated by the standard volumetric Winkler method. (Nagarajan and Thiyagesan, 1996). The alkalinity of water sample was estimated by Acid-Base titrimetric method (Trivedy et al., 1987). Hardness was measured by the

Table 2: Month-wise variations in the density (No./kg of soil) of gastropods in the lake during the second year of study (2001-2002). Values are X ± 1SD. Values in parentheses are per cent composition by number of various families and species of gastropods in the lake during that particular month.

S. No.	Families and species of gastropods	MONTHS (2001-2002)					
		November	December	January	February	March	April
I	**Neritidae**	1.53±0.709	1.66±1.437	0.75±0.647	3.10±3.200	2.50±1.552	*7.20±5.267*
		-6.67	-5.46	-3.66	-7.75	-4.63	*-10.74*
1	*Neritina (Dostia) violacea*	0.33±0.251	0.33±0.258	0.25±0.288	0.53±0.725	0.63±0.404	*1.18±1.081*
		-1.45	-1.09	-1.22	-1.33	-1.17	*-1.87*
2	*Neritina (Vittina) variegata*	1.20±0.871	1.33±1.336	0.50±0.701	2.56±2.975	1.86±1.724	*6.01±4.916*
		-5.22	-4.37	-2.44	-6.42	-3.46	*-9.52*
II	**Viviparidae**	1.33±1.006	1.33±1.032	1.00±1.152	2.13±2.902	2.53±1.616	*2.81±1.913*
		-5.8	-4.37	-4.88	-5.33	-4.69	*-4.2*
3	*Bellamya dissimilis*	1.33±1.006	1.33±1.032	1.00±1.152	2.13±2.902	2.53±1.616	*2.81±1.913*
		-5.8	-4.37	-4.88	-5.33	-4.69	*-4.2*
III	**Pilidae**	13.66±4.726	19.50±15.294	14.83±10.458	17.50±10.271	37.66±7.572	*29.83±20.054*
		-59.42	-63.93	-72.36	-43.75	-69.75	*-44.52*
4	*Pila virens*	12.30±4.253	17.55±13.764	13.35±9.412	15.75±9.244	33.90±6.815	*23.25±15.952*
		-53.48	-57.54	-65.12	-39.38	-62.78	*-36.8*
5	*Pila globosa*	1.36±0.472	1.95±1.529	1.48±1.045	1.75±1.027	3.76±0.757	*2.58±1.772*
		-5.94	-6.39	-7.24	-4.38	-6.98	*-4.09*
IV	**Thiaridae**	6.46±2.710	7.00±5.875	3.25±2.613	12.93±13.115	10.63±6.093	*27.16±22.136*
		-28.12	-22.95	-15.85	-32.33	-19.69	*-40.54*
6	*Thiara (Stenomelania) punctata*	0.60±0.435	0.66±0.668	0.25±0.350	1.28±1.487	0.93±0.862	*3.03±2.448*
		-2.61	-2.19	-1.22	-3.21	-1.73	*-4.8*
7	*Thiara (Stenomelania) torulosa*	1.21±0.872	1.33±1.337	0.51±0.701	2.57±2.976	1.87±1.725	*5.83±5.014*
		-5.22	-4.37	-2.44	-6.42	-3.46	*-9.23*
8	*Thiara (Tarebia) granifera*	0.60±0.435	0.66±0.668	0.25±0.350	1.28±1.487	0.93±0.862	*3.00±2.461*
		-2.61	-2.19	-1.22	-3.21	-1.73	*-4.75*
9	*Thiara (Melanoides) tuberculata*	2.40±1.743	2.66±2.673	1.00±1.402	5.13±5.951	3.73±3.448	*11.13±10..438*
		-10.43	-8.74	-4.88	-12.83	-6.91	*-17.62*
10	*Thiara (Mainwaringia) paludomoidea*	0.34±0.251	0.34±0.288	0.26±0.288	0.53±0.726	0.64±0.404	*1.36±1.504*
		-1.45	-1.09	-1.22	-1.33	-1.17	*-2.16*
11	*Paludomus (Paludomus) tanschauricus*	1.34±1.006	1.34±1.032	1.00±1.153	2.14±2.902	2.53±1.618	*2.81±1.928*
		-5.8	-4.37	-4.88	-5.33	-4.69	*-4.43*
V	**Lymnaeidae**	0	0.50±0.836	0.33±0.816	2.16±5.307	0.33±0.577	*0*
			-1.64	-1.63	-5.42	-0.62	
12	*Lymnaea luteola*	0	0.50±0.836	0.33±0.816	2.16±5.307	0.33±0.577	*0*
			-1.64	-1.63	-5.42	-0.62	
VI	**Planorbidae**	0	0.50±0.836	0.33±0.816	2.16±5.307	0.33±0.577	*0*
			-1.64	-1.63	-5.42	-0.62	
13	*Indoplanorbis exustus*	0	0.50±0.836	0.33±0.816	2.16±5.307	0.33±0.577	*0*
			-1.64	-1.63	-5.42	-0.62	
	Family diversity (H')	0.4393	0.4285	0.3741	0.5381	0.3858	*0.4773*
	Species diversity (H')	*0.7337*	*0.6894*	*0.5969*	*0.8365*	*0.6333*	*0.8592*

Table 3: Season-wise variations in the density (No./kg of soil) of gastropods in the lake during the study period. Values are X ± 1SD. Significant F values (P<0.05) are indicated by bold types.

S. No.	Families and species of gastropods	2000-2001			2001 -2002			*ANOVA*					
		Monsoon	Post Monsoon	Summer	Monsoon	Post Monsoon	Summer	Source	DF	SS	MS	F	*P*
I	**Neritidae**	2.01	1.39	0.35	1.62	2.04	7.2	Year (Y)	1	71.63	71.63	**11.87**	*0.001*
		±	±	±	±	±	±	Season (S)	2	38.64	19.32	**3.2**	*0.049*
		2.326	1.866	0.327	1.192	2.321	5.267	Y * S	2	106.51	53.25	**8.83**	*0.001*
								Error	51	307.76	6.03		
1	*Neritina (Dostia) violacea*	0.67	0.47	0.18	0.33	0.44	1.18	Year (Y)	1	0.54	0.54	2.3	*0.135*
		±	±	±	±	±	±	Season (S)	2	0.42	0.21	0.9	*0.412*
		0.383	0.259	0.147	0.239	0.518	1.081	Y * S	2	3.43	1.71	**7.25**	*0.002*
								Error	51	12.09	0.23		
2	*Neritina (Vittina) variegata*	1.33	0.91	0.16	1.28	1.6	6.01	Year (Y)	1	59.67	59.67	**11.12**	*0.002*
		±	±	±	±	±	±	Season (S)	2	31.08	15.54	2.9	*0.064*
		2.154	1.888	0.265	1.145	2.167	4.916	Y * S	2	71.91	35.95	**6.7**	*0.003*
								Error	51	273.8	5.36		
II	**Viviparidae**	2.71	1.9	0.73	1.33	1.76	2.81	Year (Y)	1	0.44	0.44	0.19	*0.66*
		±	±	±	±	±	±	Season (S)	2	0.56	0.28	0.12	*0.88*
		1.533	1.039	0.588	0.959	2.071	1.913	Y * S	2	21.59	10.79	**4.66**	*0.01*
								Error	51	118.18	2.31		
3	*Bellamya dissimilis*	2.71	1.9	0.73	1.33	1.76	2.81	Year (Y)	1	0.44	0.44	0.19	*0.66*
		±	±	±	±	±	±						
		1.533	1.039	0.588	0.959	2.071	1.913	Season (S)	2	0.56	0.28	0.12	*0.88*
								Y * S	2	21.59	10.79	**4.66**	*0.01*
								Error	51	118.18	2.31		
III	**Pilidae**	31.11	31.66	11.16	17.55	20.46	29.83	Year (Y)	1	52.5	52.5	0.12	*0.733*
		±	±	±	±	±	±	Season (S)	2	256.5	128.2	0.29	*0.752*
		14.377	37.005	10.008	12.66	12.872	20.054	Y * S	2	2260.5	1130.2	2.52	*0.09*
								Error	51	22829.2	447.6		
4	*Pila virens*	28	28.5	10.05	15.8	18.42	23.25	Year (Y)	1	116.9	116.9	0.33	*0.569*
		±	±	±	±	±	±	Season (S)	2	387.6	193.8	0.54	*0.583*
		12.937	33.304	9.007	11.394	11.585	15.952	Y * S	2	1389.4	694.7	1.95	*0.152*
								Error	51	18135.2	355.6		
5	*Pila globosa*	3.11	3.16	1.11	1.75	2.04	2.58	Year (Y)	1	1.44	1.44	0.33	*0.569*
		±	±	±	±	±	±	Season (S)	2	4.78	2.39	0.54	*0.583*
		1.437	3.7	1	1.266	1.287	1.772	Y * S	2	17.15	8.57	1.95	*0.152*
								Error	51	223.89	4.39		
IV	**Thiaridae**	8.72	6.04	1.58	6.82	8.6	27.16	Year (Y)	1	976	976	**9.48**	*0.003*
		±	±	±	±	±	±	Season (S)	2	448.9	224.5	2.18	*0.123*
		9.51	7.467	1.402	4.846	9.507	22.136	Y * S	2	1510.3	755.2	**7.34**	*0.002*
								Error	51	5249.8	102.9		
6	*Thiara (Stenomelania) punctata*	0.66	0.45	0.08	0.64	0.8	3.03	Year (Y)	1	15.15	15.15	**11.33**	*0.001*
		±	±	±	±	±	±	Season (S)	2	7.98	3.99	2.99	*0.059*
		0.077	0.944	0.132	0.572	1.083	2.448	Y * S	2	18.304	9.152	**6.84**	*0.002*
								Error	51	68.213	1.33		
7	*Thiara (Stenomelania) torulosa*	1.33	0.91	0.16	1.28	1.6	5.83	Year (Y)	1	56.35	56.35	**10.32**	*0.002*
		±	±	±	±	±	±	Season (S)	2	28.02	14.01	2.57	*0.087*
		2.154	1.888	0.265	1.145	2.167	5.012	Y * S	2	67.26	33.63	**6.16**	*0.004*
								Error	51	278.59	5.46		

S. No.	Families and species of gastropods	2000-2001			2001 -2002			ANOVA					
		Monsoon	Post Monsoon	Summer	Monsoon	Post Monsoon	Summer	Source	DF	SS	MS	F	P
8	*Thiara (Tarebia) granifera*	0.66	0.45	0.08	0.64	0.8	3	Year (Y)	1	14.84	14.84	**11.04**	*0.002*
		±	±	±	±	±	±	Season (S)	2	7.7	3.85	2.87	*0.066*
		1.077	0.944	0.132	0.572	1.083	2.461	Y * S	2	17.87	8.93	**6.65**	*0.003*
								Error	51	68.54	1.34		
9	*Thiara (Melanoides) tuberculata*	2.66	1.83	0.33	2.57	3.2	11.13	Year (Y)	1	206.75	206.75	**9.12**	*0.004*
		±	±	±	±	±	±	Season (S)	2	95.42	47.71	2.1	*0.132*
		4.308	3.777	0.531	2.29	4.334	10.438	Y * S	2	243.1	121.55	**5.36**	*0.008*
								Error	51	1156.61	22.68		
10	*Thiara (Mainwaringia) paludomoidea*	0.67	0.47	0.18	0.33	0.44	1.36	Year (Y)	1	0.91	0.91	2.66	*0.109*
		±	±	±	±	±	±	Season (S)	2	0.86	0.43	1.26	*0.293*
		0.383	0.259	0.147	0.239	0.518	1.502	Y * S	2	4.52	2.26	**6.58**	*0.003*
								Error	51	17.53	0.34		
11	*Paludomus (Paludomus) tanschauricus*	2.71	1.9	0.73	1.33	1.76	2.8	Year (Y)	1	0.42	0.42	0.18	*0.67*
		±	±	±	±	±	±	Season (S)	2	0.58	0.29	0.13	*0.882*
		1.533	1.039	0.588	0.959	2.071	1.926	Y * S	2	21.42	10.712	**4.61**	*0.014*
								Error	51	118.43	2.32		
V	**Lymnaeidae**	5.77	4.91	0.16	0.33	1.06		Year (Y)	1	126.87	126.87	2.3	*0.135*
		±	±	±	±	±		Season (S)	2	81.47	40.74	0.74	*0.483*
		12.794	11.032	0.408	0.707	3.348	0	Y * S	2	51.08	25.54	0.46	*0.632*
								Error	51	2810.24	55.1		
12	*Lymnaea luteola*	5.77	4.91	0.16	0.33	1.06		Year (Y)	1	126.87	126.87	2.3	*0.135*
		±	±	±	±	±		Season (S)	2	81.47	40.74	0.74	*0.483*
		12.794	11.032	0.408	0.707	3.348	0	Y * S	2	51.08	25.54	0.46	*0.632*
								Error	51	2810.24	55.1		
VI	**Planorbidae**	5.77	4.91	0.16	0.33	1.06		Year (Y)	1	126.87	126.87	2.3	*0.135*
		±	±	±	±	±		Season (S)	2	81.47	40.74	0.74	*0.483*
		12.794	11.032	0.408	0.707	3.348	0	Y * S	2	51.08	25.54	0.46	*0.63*
								Error	51	2810.24	55.1		
13	*Indoplanorbis exustus*	5.77	4.91	0.16	0.33	1.06		Year (Y)	1	126.87	126.87	2.3	*0.135*
		±	±	±	±	±		Season (S)	2	81.47	40.74	0.74	*0.483*
		12.794	11.032	0.408	0.707	3.348	0	Y * S	2	51.08	25.54	0.46	*0.63*
								Error	51	2810.24	55.1		
	Family diversity (H')	0.5864	0.5303	0.3394	0.4984	0.4922	0.4654						
	Species diversity (H')	*0.7829*	*0.7086*	*0.53*	*0.7577*	*0.7618*	*0.8266*						

complexometric titration using EDTA (Trivedy and Goel, 1986). Calcium was estimated by the complexometric titration using EDTA (Trivedy and Goel, 1986) Magnesium hardness was calculated as follows : Magnesium Hardness = Total Hardness - Calcium Hardness. Estimation of chloride was by following (Trivedy and Goel 1986). Iron was estimated by the Phenanthroline method (APHA, 1995). Ammonia was estimated by the Nesslerization method described by (Trivedy and Goel, 1986).The nitrite content was estimated by the colorimetric Griess – Ilosvay method described by Klein (1973). Determination of nitrate was based on the phenol disulfonic acid colorimetric method described by (Trivedy and Goel, 1986). Sulphate level was estimated by the barium chloride Turbidimetric method (Trivedy and Goel, 1986). The determination of phosphate was made by the colorimetric method of Trivedy et al. (1987).

Molluscan Studies

Collection of Molluscs

In addition to the collection of molluscs from the bottom sediment by using dredge (Peterson grab). The grab was towed slowly for a distance of one foot

Table 4: Month-wise variations in the biomass (g/kg of soil) of gastropods in the lake during the first year of study (2000-2001). Values are X±1SD. Values in parentheses are per cent composition by biomass of various families and species of gastropods in the lake during that particular month.

S. No.	Families and species of gastropods	*MONTHS (2000-2001)*							
		October	November	December	January	February	March	April	*May*
I	**Neritidae**	0.34±0.273	1.36±1.211	0.83±0.872	0.77±0.161	0.55±0.617	0.66±0.274	0.48±0.120	*0.12±0.273*
		-0.96	-4.5	-6.28	-3.9	-4.89	-5.04	-6.46	*-3.74*
1	*Neritina (Dostia) violacea*	0.12±0.166	0.97±1.259	0.61±0.552	0.76±0.178	0.52±0.640	0.51±0.172	0.46±0.027	*0.10±0.124*
		-0.34	-4.5	-4.62	-3.84	-4.65	-3.88	-6.46	*-3.13*
2	*Neritina (Vittina) variegata*	0.22±0.163	0	0.22±0.346	0.01±0.023	0.02±0.023	0.15±0.262	0	*0.02±0.034*
		-0.62		-1.66	-0.07	-0.24	-1.16		*-0.61*
II	**Viviparidae**	0.71±0.973	5.68±7.349	3.57±3.222	4.45±1.039	3.05±3.735	2.99±1.004	2.70±0.162	*0.59±0.723*
		-1.99	-26.38	-26.94	-22.38	-27.13	-22.63	-37.97	*-18.23*
3	*Bellamya dissimilis*	0.71±0.973	5.68±7.349	3.57±3.222	4.45±1.039	3.05±3.735	2.99±1.004	2.70±0.162	*0.59±0.723*
		-1.99	-26.38	-26.94	-22.38	-27.13	-22.63	-37.97	*-18.23*
III	**Pilidae**	29.76±44.643	5.86±4.974	2.76±1.002	7.06±4.994	3.03±3.262	4.35±4.128	0.80±0.458	*1.56±2.454*
		-83.21	-27.16	-20.88	-35.49	-26.92	-32.84	-11.1	*-48*
4	*Pila virens*	27.38±41.071	5.39±4.576	2.54±0.922	6.50±4.595	2.79±3.001	4.00±3.798	0.73±0.422	*1.44±2.258*
		-76.56	-25.03	-19.21	-32.64	-24.77	-30.21	-10.26	*-44.15*
5	*Pila globosa*	2.38±3.571	0.46±0.397	0.22±0.080	0.56±0.399	0.24±0.261	0.34±0.330	0.06±0.036	*0.12±0.196*
		-6.66	-2.13	-1.67	-2.84	-2.15	-2.63	-0.84	*-3.84*
IV	**Thiaridae**	1.71±1.508	8.22±8.100	5.06±5.035	5.27±1.151	3.68±4.283	4.12±1.361	3.25±0.285	*0.77±0.823*
		-4.79	-30.88	-38.2	-26.48	-32.72	-31.14	-44.43	*-23.8*
6	*Thiara (Stenomelania) punctata*	0.14±0.106	0	0.14±0.225	0.008±0.015	0.01±0.015	0.09±0.170	0	*0.01±0.022*
		-0.4		-1.08	-0.04	-0.15	-0.75		*-0.4*
7	*Thiara (Stenomelania) torulosa*	0.23±0.171	0	0.23±0.364	0.01±0.024	0.02±0.024	0.16±0.275	0	*0.02±0.036*
		-0.65		-1.74	-0.07	-0.25	-1.22		*-0.64*
8	*Thiara (Tarebia) granifera*	0.28±0.212	0	0.28±0.451	0.01±0.030	0.03±0.030	0.19±0.340	0	*0.02±0.045*
		-0.8		-2.16	-0.09	-0.31	-1.5		*-0.8*
9	*Thiara (Melanoides) tuberculata*	0.23±0.164	0	0.23±0.346	0.01±0.024	0.03±0.023	0.15±0.264	0	*0.02±0.036*
		-0.62		-1.66	-0.07	-0.24	-1.16		*-0.61*
10	*Thiara (Mainwaringia) paludomoidea*	0.13±0.167	0.98±1.259	0.61±0.553	0.77±0.178	0.52±0.642	0.52±0.172	0.47±0.027	*0.11±0.125*
		-0.34	-4.5	-4.62	-3.84	-4.65	-3.88	-6.46	*-3.13*
11	*Paludomus (Paludomus) tanschauricus*	0.72±0.974	5.68±7.359	3.58±3.222	4.46±1.039	3.06±3.736	2.99±1.005	2.71±0.162	*0.59±0.724*
		-1.99	-26.38	-26.94	-22.38	-27.13	-22.63	-37.97	*-18.23*
V	**Lymnaeidae**	0.20±0.277	1.62±2.099	1.02±0.920	1.27±0.296	0.87±1.067	0.85±0.286	0	*0.17±0.206*
		-0.57	-7.52	-7.7	-6.39	-7.75	-6.47		*-5.21*
12	*Lymnaea luteola*	0.20±0.277	1.62±2.099	1.02±0.920	1.27±0.296	0.87±1.067	0.85±0.286	0	*0.17±0.206*
		-0.57	-7.52	-7.7	-6.39	-7.75	-6.47		*-5.21*
VI	**Planorbidae**	3.03±4.315	0.76±1.078	0	1.06±1.847	0.06±0.115	0.25±0.472	0	*0.03±0.057*
		-8.48	-3.52		-5.36	-0.59	-1.89		*-1.02*
13	*Indoplanorbis exustus*	*3.03±4.315*	*0.76±1.078*	*0*	*1.06±1.847*	*0.06±0.115*	*0.25±0.472*	*0*	*0.03±0.057*
		-8.48	*-3.52*		*-5.36*	*-0.59*	*-1.89*		*-1.02*

(Wetzel and Likens, 1979; Nagarajan and Thiyagesan, 1996).

The sample collected was sieved through a 0.5 mm sieve and the animals filtered were preserved in 5% formalin (Strin, 1981). Snails found adhering to the aquatic vegetation and floating objects were also collected as follows.

A scoop-net with 30cm x 30 cm frame of steel bars, wire netting, a scoop of

10 cm deep with a 8 cm wide blade soldered to the frame, and with a wooden handle was used for the collection of molluscs on aquatic vegetation. The hand net or scoop net was dragged over the aquatic

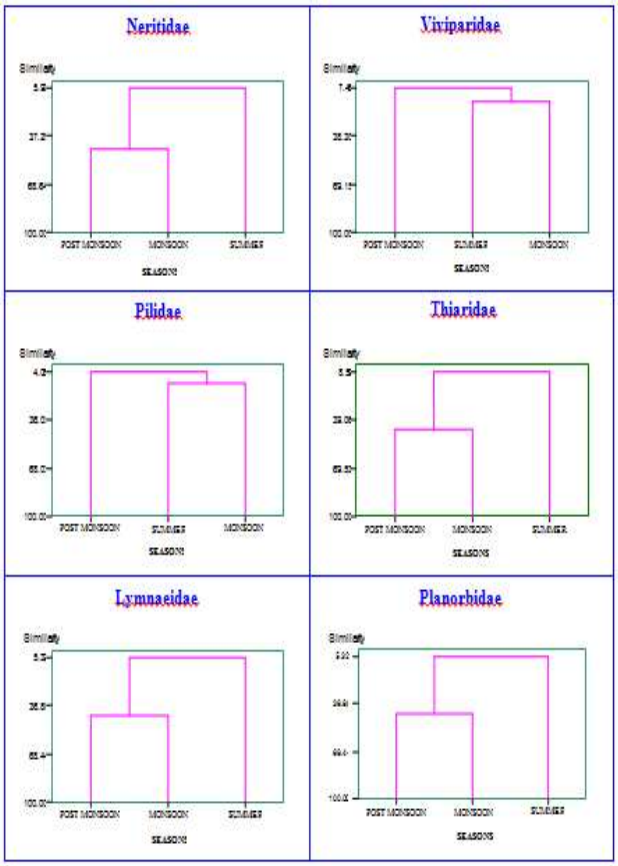

Fig. 5 : Similarity between seasons with regard to density of different families of gastropods in Thirumeni lake.

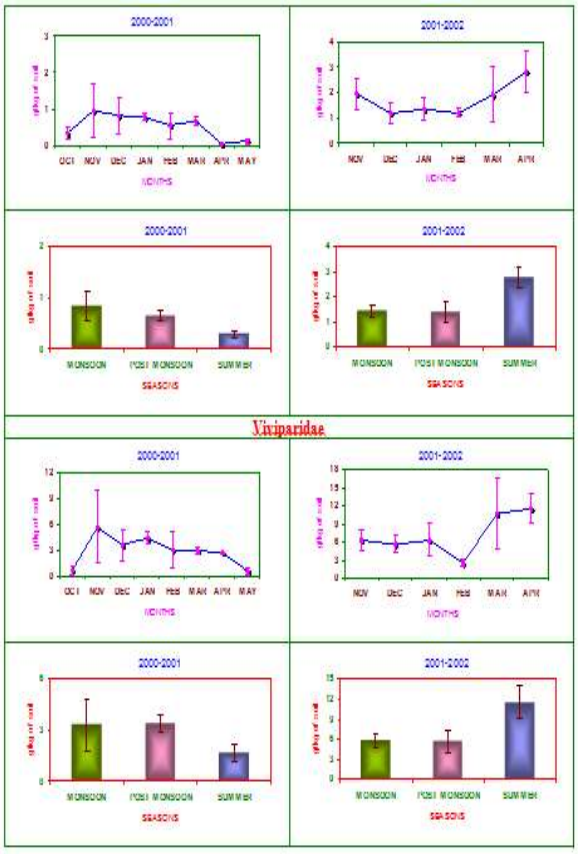

Fig. 6 : Month-wise and Season-wise variations (X±1SE) in the biomass (g/kg of soil) of Neritidae and Viviparidae in the Thirumeni lake during the study period.

vegetation, and when it is filled with aquatic weeds, the contents were poured out on a spread-out cloth piece. The molluscs were picked up with a pair of forceps from the weeds.

While, making the collections care was taken to use, boots and never with bare foot and the hands and arms were repeatedly cleaned with 70% ethanol, if bare hands were used to collect the molluscs.

Fixation and Preservation of Molluscs

Identification of molluscs was not entirely based on shell characters alone especially for the members of the family Lymnaeidae as it is difficult to identify them by shell characters alone. Morphological details like the structure of the radula, shape of the prostate gland etc., were also examined to arrive at an accurate identification of a species. For this purpose the soft parts of the animal were preserved along with the shell.

The aquatic molluscs collected were placed in an enamel tray with source water. Finely powdered menthol was sprinkled over the water surface and covered by a suitable lid. The specimens were left for 24 hours.

After narcotization, the snails were preserved in 70% ethyl alcohol.

Preparation of Dry Shells

After narcotization, the animal was extracted from the shell with a pair of curved forceps. Empty shells were boiled in water for about 30 minutes to an hour, so to remove any soft tissue sticking inside the shell. The shells were further cleaned with a smooth brush, and dried in air. In case of operculate shells, operculum was retained by pasting it to cotton wool plug inserted into the aperture of the shell.

Dry shells were packed in cotton wool in small glass vials or tubes or cardboard boxes depending upon the size of the shell. The packages were labelled with relevant details such as place of collection, date and time of collection.

Quantitative Studies

Estimation of Density and Biomass of Gastropods

The population density and biomass of snails of the lake was studied using the following method.

A dredge (Peterson grab) of standard size was passed over the required area (as described earlier in this section) and number of snails collected in each

Table 5 : Month-wise variations in the biomass (g/kg of soil) of gastropods in the lake during the second year of study (2001-2002). Values are X±1SD. Values in parentheses are per cent composition by biomass of various families and species of gastropods in the lake during that particular month.

S. No.	Families and species of gastropods	*MONTHS (2001-2002)*					
		November	**December**	**January**	**February**	**March**	***April***
I	**Neritidae**	1.96±0.820	1.19±0.651	1.35±1.358	1.20±1.228	1.92±1.657	*2.79±1.273*
		-7.13	-6.47	-6.14	-7.26	-5.88	*-8.18*
1	*Neritina (Dostia) violacea*	1.08±0.540	0.97±0.617	1.08±1.143	0.43±0.274	1.84±1.736	*1.97±1.044*
		-3.93	-5.25	-4.91	-2.64	-5.62	*-5.78*
2	*Neritina (Vittina) variegata*	0.88±0.714	0.22±0.183	0.27±0.381	0.76±1.009	0.08±0.117	*0.82±0.644*
		-3.2	-1.23	-1.23	-4.62	-0.26	*-2.4*
II	**Viviparidae**	6.30±3.150	5.65±3.600	6.30±6.670	2.55±1.599	10.73±10.128	*11.53±6.095*
		-22.94	-30.6	-28.67	-15.39	-32.78	*-33.85*
3	*Bellamya dissimilis*	6.30±3.150	5.65±3.600	6.30±6.670	2.55±1.599	10.73±10.128	*11.53±6.095*
		-22.94	-30.6	-28.67	-15.39	-32.78	*-33.85*
III	**Pilidae**	8.30±6.691	2.46±1.372	3.23±3.209	4.38±5.459	4.06±1.553	*2.98±2.003*
		-30.18	-13.34	-14.71	-26.41	-12.42	*-8.71*
4	*Pila virens*	7.63±6.156	2.26±1.262	2.97±2.952	4.03±5.023	3.74±1.429	*2.74±1.843*
		-27.78	-12.27	-13.54	-24.3	-11.42	*-8.04*
5	*Pila globosa*	0.66±0.535	0.19±0.109	0.25±0.256	0.35±0.436	0.32±0.124	*0.23±0.160*
		-2.4	-1.07	-1.18	-2.11	-0.99	*-0.67*
IV	**Thiaridae**	10.92±4.271	7.53±4.310	8.46± 8.609	6.06±5.583	12.92±11.545	*16.79±7.796*
		-39.66	-40.75	-38.5	-36.5	-39.45	*-48.73*
6	*Thiara (Stenomelania) punctata*	0.57±0.464	0.14±0.119	0.17±0.248	0.49±0.655	0.05±0.076	*0.53±0.419*
		-2.07	-0.8	-0.8	-3	-0.17	*-1.56*
7	*Thiara (Stenomelania) torulosa*	0.93±0.750	0.23±0.192	0.28±0.400	0.80±1.059	0.09±0.123	*0.86±0.677*
		-3.38	-1.29	-1.29	-4.85	-0.28	*-2.52*
8	*Thiara (Tarebia) granifera*	1.15±0.928	0.29±0.238	0.35±0.496	0.99±1.311	0.11±0.152	*1.06±0.838*
		-4.18	-1.59	-1.6	-6	-0.34	*-3.11*
9	*Thiara (Melanoides) tuberculata*	0.89±0.714	0.23±0.154	0.28±0.381	0.77±1.009	0.08±0.118	*0.82±0.646*
		-3.2	-1.23	-1.23	-4.62	-0.26	*-2.41*
10	*Thiara (Mainwaringia) paludomoidea*	1.09±0.540	0.98±0.617	1.08±1.146	0.44±0.274	1.85±1.737	*1.98±1.045*
		-3.93	-5.25	-4.91	-2.64	-5.62	*-5.78*
11	*Paludomus (Paludomus) tanschauricus*	6.31±3.152	5.66±3.600	6.31±6.671	2.56±1.599	10.74±10.179	*11.53±6.097*
		-22.9	-30.6	-28.67	-15.39	-32.78	*-33.85*
V	**Lymnaeidae**	0	1.61±1.028	1.80±1.905	0.73±0.456	3.06±2.893	*0*
			-8.74	-8.19	-4.4	-9.36	
12	*Lymnaea luteola*	0	1.61±1.028	1.80±1.905	0.73±0.456	3.06±2.893	*0*
			-8.74	-8.19	-4.4	-9.36	
VI	**Planorbidae**	0	0.01±0.040	0.83±2.041	1.66±4.082	0.03±0.057	*0*
			-0.09	-3.79	-10.04	-0.1	
13	*Indoplanorbis exustus*	*0*	*0.01±0.040*	*0.83±2.041*	*1.66±4.082*	*0.03±0.057*	*0*
			-0.09	*-3.79*	*-10.04*	*-0.1*	

operation was counted (Rao, 1984) and expressed as no./kg of soil or g/kg of soil.

Microhabitat Preference of Gastropods

Microhabitat preference of snail species was studied by travelling in a boat criss-cross of the lake and counting the number of snails in different habitats by unit effort (Time spent in each microhabitat).

Data Analysis

Diversity Index

The species-diversity (H′) was calculated using the Shannon Weiner index (Shannon and Wiener, 1949).

$$H = -\sum_{i=1}^{s} pi \ln ip$$

Where pi = ni/N; ni = proportion of individual in each category; N=total number observed and s=number of categories).

Statistical Analyses

Basic statistics *viz*., arithmetic mean, standard deviation and standard error were calculated for all the replicate variables and are given as X ± 1 SD or X ± 1 SE. Statistical analyses were performed by using Window based statistical packages *viz*., Microsoft Excel, MINITAB (Ryan *et al*., 1992) and SPSS (Statistical Package for Social Science; Nie *et al*., 1975). Mainly parametric tests *viz*., Analysis of Variance (ANOVA), Cluster Analysis, and Multiple Regression equations were used to test hypothesis. Appropriate data transformations were made wherever needed. For hypothesis testing $P < 0.05$, $P < 0.01$ and $P < 0.001$ were considered and these levels of significance were indicated at appropriate places. Statistical inferences were made by following Sokal and Rohlf (1995) and Zar (2003).

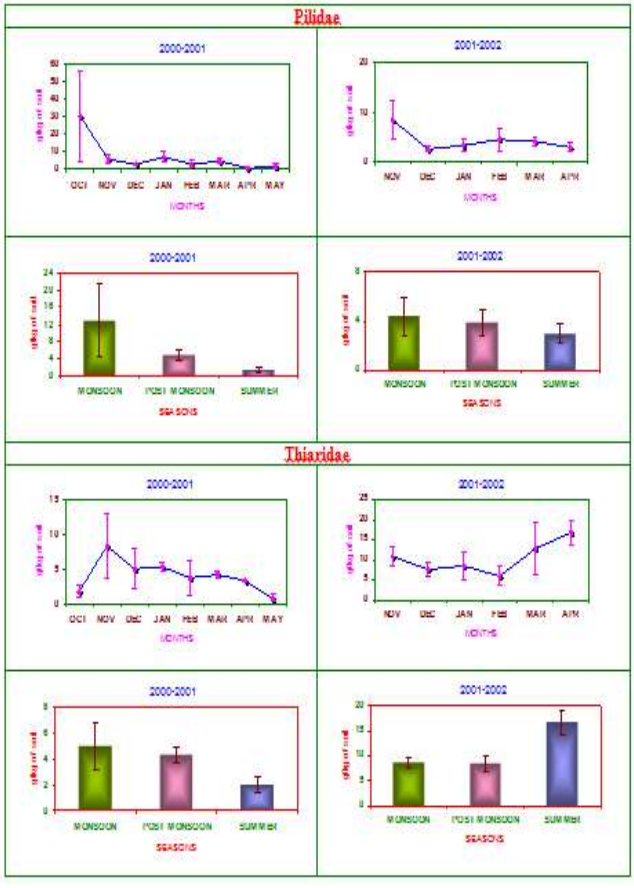

Fig. 7 : Month-wise and Season-wise variations (X±1SE) in the biomass (g/kg of soil) of Pilidae and Thiaridae in the Thirumeni lake during the study period.

RESULTS

Thirteen species of fresh water mollusks (Gastropods) belonging to 6 families were recorded in the lake during the study period.

1. *Neritina (Dostia) violacea*
2. *Neritina (Vittina) variegata*
3. *Bellamya dissimilis*
4. *Pila virens*
5. *Pila globosa*
6. *Thiara (Stenomelania) punctata*
7. *Thiara (Stenomelania) torulosa*
8. *Thiara (Tarebia) granifera*
9. *Thiara (Melanoides) tuberculata*
10. *Thiara (Mainwaringia) paludomoidea*
11. *Paludomus (Paludomus) tanschauricus*
12. *Lymnaea luteola*
13. *Indoplanorbis exustus*

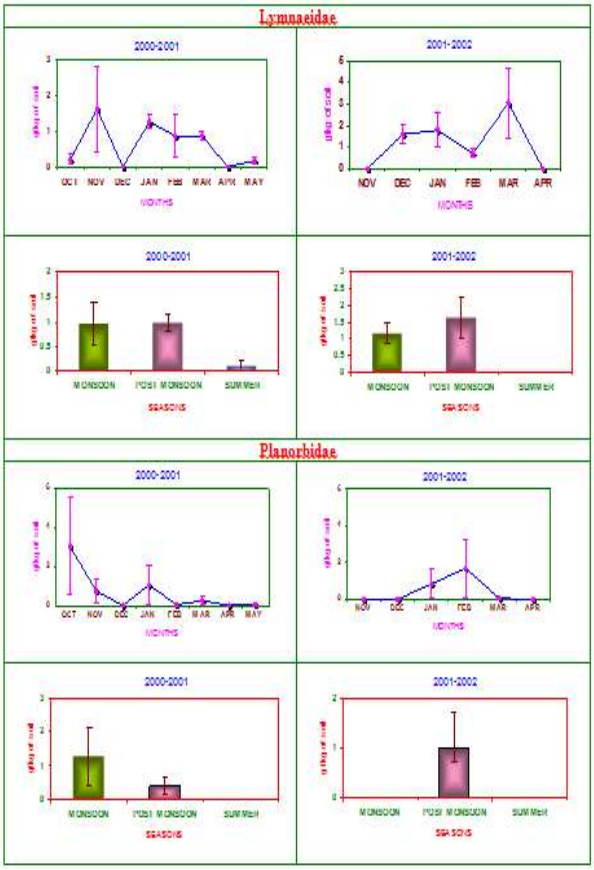

Fig. 8 : Month-wise and Season-wise variations (X±1SE) in the biomass (g/kg of soil) of Lymnaeidae and Planorbidae in the Thirumeni lake during the study period.

Table 6: Season-wise variations in the biomass (g/kg of soil) of gastropods in the lake during the study period. Values are X ± 1SD. Significant F values (P<0.05) are indicated by bold types.

S. No.	lies and species of gastrop	2000-2001			2001 -2002			*ANOVA*					
		Monsoon	Post Monsoo	Summer	Monsoon	Post Monsoo	Summer	Source	DF	SS	MS	F	*P*
I	**Neritidae**	0.84	0.66	0.3	1.45	1.4	2.79	Year (Y)	1	20.931	20.93	**24.4**	*0.001*
		±	±	±	±	±	±	Season (S)	2	2.213	1.106	1.29	*0.284*
		0.879	0.339	0.215	0.762	1.291	1.273	Y * S	2	7.78	3.89	**4.53**	*0.015*
								Error	51	43.794	0.858		
1	*Neritina (Dostia) violacea*	0.56	0.57	0.28	1	0.97	1.97	Year (Y)	1	9.063	9.063	**14.8**	*0.001*
		±	±	±	±	±	±	Season (S)	2	1.154	0.577	0.94	*0.397*
		0.785	0.325	0.213	0.56	1.101	1.044	Y * S	2	3.89	1.94	**3.17**	*0.05*
								Error	51	31.28	0.61		
2	*Neritina (Vittina) variegata*	0.27	0.08	0.02	0.44	0.43	0.82	Year (Y)	1	2.44	2.44	**9.71**	*0.003*
		±	±	±	±	±	±	Season (S)	2	0.24	0.12	0.49	*0.614*
		0.4	0.19	0.03	0.507	0.708	0.644	Y * S	2	0.73	0.36	1.46	*0.241*
								Error	51	12.86	0.25		
II	**Viviparidae**	3.32	3.37	1.65	5.87	5.68	11.53	Year (Y)	1	308.4	308.4	**14.8**	*0.001*
		±	±	±	±	±	±	Season (S)	2	39.27	19.64	0.94	*0.39*
		4.583	1.901	1.248	3.268	6.425	6.095	Y * S	2	132.49	66.24	**3.17**	*0.05*
								Error	51	1064.7	20.88		
3	*Bellamya dissimilis*	3.32	3.37	1.65	5.87	5.68	11.53	Year (Y)	1	308.4	308.4	**14.8**	*0.001*
		±	±	±	±	±	±	Season (S)	2	39.27	19.64	0.94	*0.39*
		4.583	1.901	1.248	3.268	6.425	6.095	Y * S	2	132.49	66.24	**3.17**	*0.05*
								Error	51	1064.7	20.88		
III	**Pilidae**	12.8	4.7	1.18	4.41	3.86	2.98	Year (Y)	1	78.2	78.2	0.67	*0.416*
		±	±	±	±	±	±	Season (S)	2	347.9	173.9	1.49	*0.234*
		25.854	4.07	1.634	4.569	3.868	2.003	Y * S	2	229.5	114.7	0.99	*0.38*
								Error	51	5939.4	116.5		
4	*Pila virens*	11.77	4.32	1.08	4.05	3.55	2.74	Year (Y)	1	66.19	66.19	0.67	*0.416*
		±	±	±	±	±	±	Season (S)	2	294.44	147.2	1.49	*0.234*
		23.785	3.745	1.503	4.204	3.559	1.843	Y * S	2	194.21	97.11	0.99	*0.38*
								Error	51	5027.1	98.57		
5	*Pila globosa*	1.02	0.37	0.09	0.35	0.3	0.23	Year (Y)	1	0.5	0.5	0.67	*0.416*
		±	±	±	±	±	±	Season (S)	2	2.22	1.11	1.49	*0.234*
		2.068	0.325	0.13	0.365	0.309	0.16	Y * S	2	1.46	0.73	0.99	*0.38*
								Error	51	38.01	0.74		
IV	**Thiaridae**	5	4.3	2.01	8.66	8.39	16.79	Year (Y)	1	719.85	719.9	22.2	*0.001*
		±	±	±	±	±	±	Season (S)	2	80.04	40.02	1.23	*0.3*
		5.592	2.19	1.463	4.364	7.961	7.796	Y * S	2	279.7	139.9	**4.3**	*0.019*
								Error	51	1657.1	32.49		
6	*Thiara (Stenomelania) puncta*	0.18	0.05	0.01	0.29	0.28	0.53	Year (Y)	1	1.03	1.03	**9.71**	*0.003*
		±	±	±	±	±	±	Season (S)	2	0.1	0.05	0.49	*0.614*
		0.26	0.123	0.02	0.329	0.46	0.419	Y * S	2	0.31	0.15	1.46	*0.24*
								Error	51	5.43	0.1		
7	*Thiara (Stenomelania) torulos*	0.29	0.09	0.02	0.46	0.45	0.86	Year (Y)	1	2.69	2.69	**9.71**	*0.003*
		±	±	±	±	±	±	Season (S)	2	0.27	0.13	0.49	*0.614*
		0.42	0.2	0.032	0.532	0.744	0.677	Y * S	2	0.81	0.4	1.46	*0.241*
								Error	51	14.18	0.27		

S. No.	Families and species of gastropods	2000-2001			2001 -2002			ANOVA					
		Monsoon	Post Monsoon	Summer	Monsoon	Post Monsoon	Summer	Source	DF	SS	MS	F	P
8	*Thiara (Tarebia) granifera*	0.36	0.11	0.02	0.58	0.56	1.06	Year (Y)	1	4.13	4.13	**9.71**	*0.003*
		±	±	±	±	±	±	Season (S)	2	0.41	0.2	0.49	*0.614*
		0.52	0.247	0.04	0.659	0.921	0.838	Y * S	2	1.24	0.62	1.46	*0.241*
								Error	51	21.73	0.42		
9	*Thiara (Melanoides) tuberculata*	0.27	0.08	0.02	0.44	0.43	0.82	Year (Y)	1	2.44	2.44	**9.71**	*0.003*
		±	±	±	±	±	±	Season (S)	2	0.24	0.12	0.49	*0.614*
		0.4	0.19	0.03	0.507	0.708	0.644	Y * S	2	0.73	0.36	1.46	*0.241*
								Error	51	12.86	0.25		
10	*Thiara (Mainwaringia) paludomoidea*	0.56	0.57	0.28	1	0.97	1.97	Year (Y)	1	9.06	9.06	**14.77**	*0.001*
		±	±	±	±	±	±	Season (S)	2	1.15	0.57	0.94	*0.397*
		0.785	0.325	0.213	0.56	1.101	1.044	Y * S	2	3.89	1.94	**3.17**	*0.05*
								Error	51	31.28	0.61		
11	*Paludomus (Paludomus) tanschauricus*	3.32	3.37	1.65	5.87	5.68	11.53	Year (Y)	1	308.4	308	**14.77**	*0.001*
		±	±	±	±	±	±	Season (S)	2	39.27	19.6	0.94	*0.39*
		4.583	1.901	1.248	3.268	6.465	6.095	Y * S	2	132.49	66.2	**3.17**	*0.05*
								Error	51	1064.7	20.9		
V	**Lymnaeidae**	0.94	0.96	0.47	1.67	1.62	0	Year (Y)	1	25.17	25.2	**14.77**	*0.001*
		±	±	±	±	±		Season (S)	2	3.2	1.6	0.94	*0.19*
		1.309	0.543	0.356	0.933	1.835		Y * S	2	10.81	5.4	**3.17**	*0.05*
								Error	51	86.91	1.7		
12	*Lymnaea luteola*	0.94	0.96	0.47	1.67	1.62	0	Year (Y)	1	25.17	25.2	**14.77**	*0.001*
		±	±	±	±	±		Season (S)	2	3.2	1.6	0.94	*0.19*
		1.309	0.543	0.356	0.933	1.835		Y * S	2	10.81	5.4	**3.17**	*0.05*
								Error	51	86.91	1.7		
VI	**Planorbidae**	1.26	0.4	0.01	0.01	1	0	Year (Y)	1	0.64	0.64	0.19	*0.66*
		±	±	±	±	±		Season (S)	2	4.31	2.15	0.63	*0.53*
		2.61	0.942	0.04	0.033	2.8		Y * S	2	9.27	4.63	1.36	*0.26*
								Error	51	174.09	3.41		
13	*Indoplanorbis exustus*	1.26	0.4	0.01	0.01	1	0	Year (Y)	1	0.64	0.64	0.19	*0.66*
		±	±	±	±	±		Season (S)	2	4.31	2.15	0.63	*0.53*
		2.61	0.942	0.04	0.033	2.8		Y * S	2	9.27	4.63	1.36	*0.26*
								Error	*51*	*174.09*	*3.41*		

Density of Molluscs

Variations in the densities of the six families and 13 species of molluscs recorded in Thirumeni lake during different months and seasons of the study period have been given in tables 1 - 3.

Family – wise variations

Neritidae

Neritidae were more in October during the first year (2000 – 2001) and in April during the second year (2001 – 2002) of study (Fig. 1). Correspondingly their density was more during monsoon season in the first year and during summer in the second year (Fig. 1).

Viviparidae

Density of the viviparids was highest in November and lowest in May during the first year. Contrastingly, the density of viviparids was lowest in January and highest in April during the second year. Their density showed a declining trend across seasons from monsoon to summer in the first year and a increasing trend for the corresponding seasons in the second year (Fig. 1).

Pilidae

Density of Pilidae was highest in January during the first year (2000 – 2001) and in March during the second year (2001 –2002) of study. In the first year their density in the lake was highest during the

Table 7 : Season-wise variations (X±1SD) in the density (No./kg of soil) of gastropods at station I (Thirumakkottai) of the lake during the study period.

S.No.	Families and species of gastropods	2000-2001			*2001 -2002*		
		Monsoon	**Post Monsoon**	**Summer**	**Monsoon**	**Post Monsoon**	***Summer***
I	**Neritidae**	3.96±3.385	0.62±0.403	0.20±0.2082	2.00±1.682	2.68±2.132	*7.05±8.273*
1	*Neritina (Dostia) violacea*	0.90±0.300	0.42±0.125	0.20±0.282	0.40±0.173	0.80±0.784	*0.65±0.636*
2	*Neritina (Vittina) variegata*	3.06±3.208	0.20±0.400	0	1.60±1.743	1.88±1.900	*6.40±7.636*
II	**Viviparidae**	3.60±1.200	1.70±0.503	0.80±1.131	1.60±0.692	3.20±3.136	*2.60±2.545*
3	*Bellamya dissimilis*	3.60±1.200	1.70±0.503	0.80±1.131	1.60±0.692	3.20±3.136	*2.60±2.545*
III	**Pilidae**	37.00±14.422	46.25±52.867	11.00±12.728	28.66±12.662	21.40±15.821	*27.00±29.698*
4	*Pila virens*	33.30±12.980	41.62±47.580	9.90±11.455	25.80±11.396	19.26±14.239	*24.30±26.729*
5	*Pila globosa*	3.70±1.442	4.62±5.286	1.10±1.272	2.86±1.266	2.14±1.582	*2.70±2.969*
IV	**Thiaridae**	16.76±13.731	2.92±1.640	1.00±1.414	8.40±6.678	11.52±8.920	*28.85±33.729*
6	*Thiara (Stenomelania) punctata*	1.53±1.604	0.10±0.200	0	0.80±0.871	0.94±0.950	*3.20±3.818*
7	*Thiara (Stenomelania) torulosa*	3.07±3.209	0.21±0.402	0	1.61±1.744	1.89±1.900	*6.41±7.638*
8	*Thiara (Tarebia) granifera*	1.53±1.604	0.10±0.200	0	0.80±0.871	0.94±0.950	*3.20±3.818*
9	*Thiara (Melanoides) tuberculata*	6.13±6.416	0.40±0.800	0	3.20±3.487	3.76±3.801	*12.80±15.273*
10	*Thiara (Mainwaringia) paludomoidea*	0.91±0.302	0.43±0.125	0.21±0.283	0.41±0.175	0.80±0.786	*0.66±0.638*
11	*Paludomus (Paludomus) tanschauricus*	3.61±1.202	1.71±0.505	0.80±1.136	1.60±0.694	3.21±3.138	*2.61±2.548*
V	**Lymnaeidae**	3.66±4.775	5.25±8.539	0	0	0.40±0.894	*0*
12	*Lymnaea luteola*	3.66±4.775	5.25±8.539	0	0	0.40±0.894	*0*
VI	**Planorbidae**	3.70±4.825	5.35±8.639	0	0	0.41±0.896	*0*
13	*Indoplanorbis exustus*	3.70±4.825	5.35±8.639	0	0	0.41±0.896	*0*
	Family diversity (H')	0.5686	0.4018	0.2498	0.3681	0.5081	*0.4753*
	Species diversity (H')	*0.828*	*0.5366*	*0.3856*	*0.6211*	*0.8059*	*0.8319*

monsoon season and declined in the following seasons and was lowest during summer. Contrastingly, the trend was opposite in the second year as it was lowest during the monsoon season which gradually increased later and reached the highest value during summer (Fig. 2).

Thiaridae

Thiarids density was highest in December during the first year (2000 – 2001) and in April during the second year (2001 – 2002) of study. Similar to the earlier families described above, the season – wise variations in the density of thiarids was quite contrasting for the two years of study (Fig. 2).

Lymnaeidae

Lymnaeidae were recorded during October, January, February and March of first year (2000 – 2001) and December to March of second year (2001 – 2002) only (Fig. 3).

Planorbidae

Planorbids were recorded during October and January to March in the first year (2000 – 2001) and from December to March in the second year (2001 – 2002) only (Fig. 4.276). Their density was highest during the monsoon season in the first year and during post monsoon season in the second year (Fig. 3). Family wise diversity was highest in February in both the years of study (Tables 1 and 2).

Similarities between months

A cluster analysis showed that April was the month with distinct density values for Neritidae, Viviparidae and Thiaridae. The density value of Pilidae in January was dissimilar to the other months. With regard to lymnaeids and planorbids the density values were unique during the month of October (Fig. 4.).

Similarities between seasons

Cluster analysis showed that for Neritidae, Thiaridae, Lymnaeidae and Planorbidae their density were similar

during post monsoon and monsoon seasons with summer being distinct. For viviparids and pilids post monsoon seasons was quite distinct with summer and monsoon seasons being similar (Fig. 5).

Biomass of Molluscs

Variations in the biomass of the six families and 13 species of molluscs observed in Thirumeni lake during different months and seasons of the study period have been given in tables 4 - 6.

Family – wise Variations

Neritidae

The biomass of neritides was highest during November and then gradually decreased to the lowest value during May in the first year of study (2000 – 2001).

The biomass was almost similar between December and February and attained a peak during April in the second year. With regard to seasons, the first year there was a declining trend from monsoon to summer and an opposite trend in the second year (Fig. 6).

Viviparidae

The biomass of Viviparidae was highest during November and April for first and second year of study, respectively. The biomass declined to lowest value towards the end of the first year whereas the opposite trend was noticed during the second year. With regard to seasons, the biomass was maximum during monsoon in the first year and summer in second year (Fig. 6).

Pilidae

The biomass of Pilidae was maximum at the beginning of the study period for both years (October and November for year I and II, respectively) and minimum towards the end of the year in both years. The biomass was highest in monsoon and lowest in summer for both years (Fig. 7).

Thiaridae

The biomass of Thiaridae was highest in November during the first year and in April during the second year. Between January and May, the biomass declined in the first year but increased in the second year. The biomass declined gradually from monsoon, post monsoon and summer in first year. On the contrary the opposite trend was observed with regard to seasons in the second year (Fig. 7).

Lymnaeidae

The biomass of Lymnaeidae was maximum in November and then gradually declined throughout to nil value during December and April. On the other hand the biomass was nil during November fluctuated very little during December and January, then showed a sudden drop in February before showing peak in March during the second year. It once again dropped dawned to nil during April of second year.

The biomass was highest during monsoon and post monsoon for first and second year, respectively (Fig. 8).

Planorbidae

In the first year the biomass was highest at the beginning of the year i.e. October and lowest in March. The biomass was highest during February in the second year of study when the biomass was nil for first year. Among the seasons, the monsoon had highest biomass for first year and post monsoon had highest for second year (Fig. 8).

Similarities between months

A cluster analysis showed that April was the month with distinct biomass with regard to Neritidae, Viviparidae, Thiaridae and Lymnaeidae (Fig. 9). October stood entirely different with regard to the biomass of Pilidae and Planorbidae (Fig. 9).

Similarities between seasons

The biomass of Neritidae, Viviparidae, Thiaridae and Lymnaeidae were similar as revealed by a cluster analysis (Fig. 10). The biomass of Pilidae during the monsoon was quite dissimilar from the other seasons and the summer and monsoon seasons had similar biomass values for Planorbidae (Fig. 10).

Station – wise Variations

Season - wise variations in the density and biomass of molluscs during the study period in different stations of Thirumeni lake are given in tables 7-12.

Density of Molluscs

Thirumakkottai (Station I)

Seasons-wise variation in the density of gastropods at Thirumakkottai station during the study period has been given in table 7.

Family-wise Variations in Density

During the first year of study, the population of Neritidae, Viviparidae and Thiaridae had their peak in the monsoon season, while the Pilidae had the highest population density in the post monsoon season. On the other hand, the peak season was monsoon for Pilidae, post monsoon for Viviparidae and summer for Neritidae and Thiaridae, during the second year of the study period. Lymnaeids and planorbids were recorded in the monsoon and post monsoon seasons of first year and in the post monsoon season of second year only, in Thirumakkottai station. Pilids dominated the

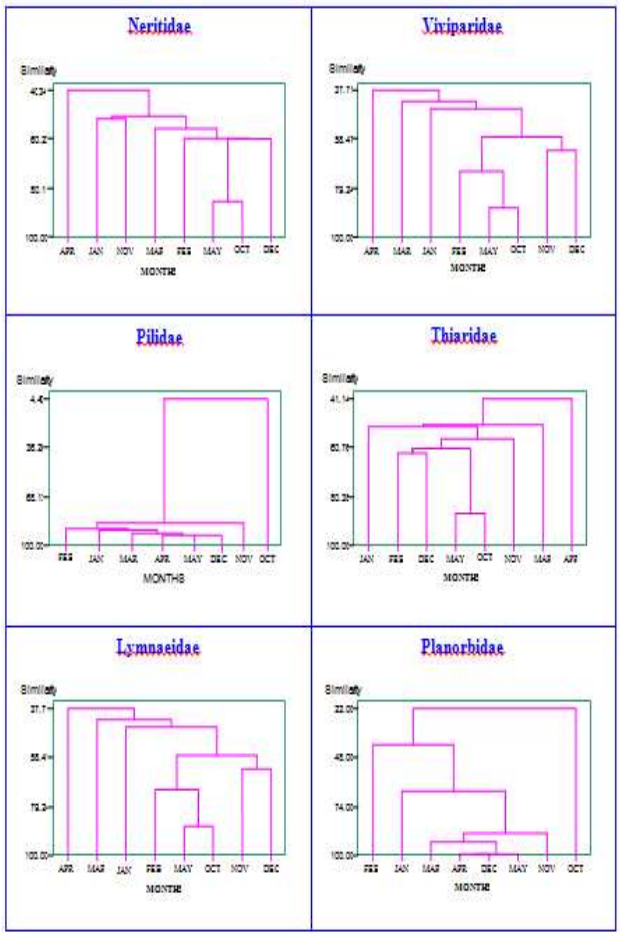

Fig. 9 : Similarity between months with regard to biomass of different families of gastropods in Thirumeni lake.

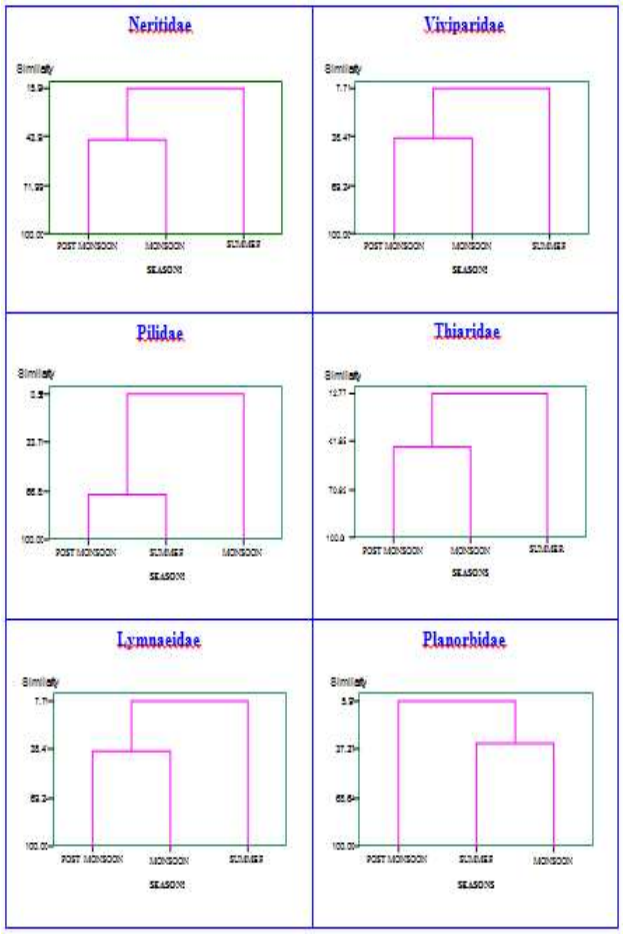

Fig. 10 : Similarity between seasons with regard to biomass of different families of gastropods in Thirumeni lake.

Thirumakkottai station in all the seasons of both years of study except in summer 2001 – 2002 when thiarids were slightly more (Fig. 11)

Painganadu (Station II)

Season-wise variation in the density of gastropods at the Painganadu station during the study period has been given in table 8.

Family–wise Variations in Density

Neritids, viviparids and thiarids attained their highest densities in the post monsoon season during the first year, whereas the pilids had their peak density in the monsoon season at that period of study (Fig. 12). In the second year neritids, viviparids, pilids and thiarids had their peak density in summer. The lymnaeids and planorbids were found during the monsoon season of first year and monsoon and post monsoon seasons of second year only. Pilidae was the predominant family in all the seasons of both years of study except summer 2001 – 2002 when Thiaridae became predominant (Fig. 12).

Paravakkottai – (Station III)

Season-wise variation in the density of gastropods at Paravakkottai station during study period has been given in table 9.

Family–wise Variations in Density

Post monsoon was the season of peak population density for Neritidae and Thiaridae in both the years of study in the Paravakkottai area of the lake. Viviparidae had their population peaks in the monsoon and summer season during the first and second year of study, respectively. Lymnaeidae and Planorbidae had their highest density in the monsoon season during the first year while they could be recorded only in the monsoon season during the second year. Population of Pilids outnumbered others in all the seasons of both years of study in this station (Fig. 13).

Similarity between stations

Family – wise Variations in Density

Thirumakkottai season was quite distinct with regard to the density of Viviparidae and Pilidae while

Table 8 : Season-wise variations (X±1SD) in the density (No./kg of soil) of gastropods at station II (Painganadu) of the lake during the study period.

S. No.	Families and species of gastropods	2000-2001			*2001 -2002*		
		Monsoon	Post Monsoon	Summer	Monsoon	Post Monsoon	*Summer*
I	**Neritidae**	0.90±0.435	1.22±0.699	0.55±0.495	0.66±0.208	0.66±0.973	*6.90±8.343*
1	*Neritina (Dostia) violacea*	0.63±0.602	0.72±0.287	0.25±0.070	0.26±0.152	0.18±0.109	*0.90±0.707*
2	*Neritina (Vittina) variegata*	0.26±0.230	0.50±0.503	0.30±0.424	0.40±0.200	0.48±0.965	*6.00±7.636*
II	**Viviparidae**	2.53±2.411	2.90±1.148	1.00±0.282	1.06±0.611	0.72±0.438	*3.60±2.828*
3	*Bellamya dissimilis*	2.53±2.411	2.90±1.148	1.00±0.282	1.06±0.611	0.72±0.438	*3.60±2.828*
III	**Pilidae**	36.00±9.165	20.75±12.527	16.50±14.849	12.66±10.017	17.60±11.036	*16.00±17.728*
4	*Pila virens*	32.40±8.249	18.67±11.274	14.85±13.364	11.40±9.015	15.84±9.933	*14.40±11.455*
5	*Pila globosa*	3.60±0.916	2.07±1.252	1.65±1.484	1.26±1.001	1.76±1.103	*1.60±1.272*
IV	**Thiaridae**	4.23±2.325	5.62±3.030	2.45±2.051	2.93±0.907	2.82±3.910	*28.50±34.083*
6	*Thiara (Stenomelania) punctata*	0.13±0.115	0.25±0.251	0.15±0.212	0.20±0.100	0.24±0.482	*3.00±3.818*
7	*Thiara (Stenomelania) torulosa*	0.27±0.231	0.51±0.504	0.31±0.425	0.41±0.201	0.49±0.966	*6.01±7.736*
8	*Thiara (Tarebia) granifera*	0.13±0.115	0.25±0.251	0.15±0.212	0.20.100	0.24±0.482	*3.00±3.818*
9	*Thiara (Melanoides) tuberculata*	0.53±0.461	1.00±1.006	0.60±0.848	0.80±0.400	0.96±1.930	*12.00±15.273*
10	*Thiara (Mainwaringia) paludomoidea*	0.64±0.612	0.73±0.289	0.26±0.072	0.26±0.155	0.19±0.109	*0.91±0.708*
11	*Paludomus (Paludomus) tanschauricus*	2.54±2.412	2.91±1.149	1.01±0.284	1.07±0.612	0.73±0.439	*3.61±2.829*
V	**Lymnaeidae**	0.66±1.154	0	0	0.33±0.577	2.81±5.719	*0*
12	*Lymnaea luteola*	0.66±1.154	0	0	0.33±0.577	2.81±5.719	*0*
VI	**Planorbidae**	0.67±1.156	0	0	0.32±0.578	2.80±5.718	*0*
13	*Indoplanorbis exustus*	0.67±1.156	0	0	0.32±0.578	2.80±5.718	*0*
	Family diversity (H')	0.3321	0.4022	0.2922	0.4245	0.508	*0.4945*
	Species diversity (H')	*0.5006*	*0.6224*	*0.494*	*0.6456*	*0.6765*	*0.9025*

Painganadu station was for the density of Planorbidae and Paravakkottai for Neritidae, Thiaridae and Lymnaeidae (Fig. 14).

Biomass of Molluscs

Thirumakkottai (Station I)

Season-wise variation in the biomass of gastropods at Thirumakkottai station during the study period has been given table 10.

Family – wise Variations in Biomass

Neritids attained their peak biomass in the monsoon season of first year and during summer in the second year (Fig. 15).

Biomass of viviparids, pilids and thiarids attained peak in the post monsoon season during the first year. During the second year monsoon was the season of peak biomass for pilids and summer for neritids, viviparids and thiarids. The lymnaeids were found in station I during the monsoon and post monsoon seasons of first year and post monsoon season of second year only. The planorbids were regarded in station I during the monsoon and post monsoon seasons of first year only (Table 10).

The biomass of pilids was more than the other families in the monsoon and post monsoon seasons of first year. Later in all the other seasons of the study period biomass of thiarids was higher than the other families (Fig. 15).

Painganadu (Station II)

Season-wise variation in the biomass of the gastropods at Painganadu station during the study period has been given in table 11.

Family – wise Variations in Biomass

The peaks in the biomass of Neritidae, Viviparidae and Thiaridae were observed in the monsoon season while for the Pilidae in the post monsoon season, during the first year of the study period. During the second year, Viviparidae had their peak biomass in the monsoon season, while post monsoon was the season of peak population density for Pilidae and summer for Neritidae and Thiaridae. Lymnaeids and Planorbids could be recorded in the monsoon season

Table 9 : Season-wise variations (X±1SD) in the density (No./kg of soil) of gastropods at station III Paravakkottai) of the lake during the study period.

S. No.	Families and species of gastropods	2000-2001			*2001 -2002*		
		Monsoon	Post Monsoon	Summer	Monsoon	Post Monsoon	*Summer*
I	**Neritidae**	1.16±1.159	2.32±3.184	0.30±0.282	2.20±0.854	2.78±3.130	*7.65±0.212*
1	*Neritina (Dostia) violacea*	0.50±0.100	0.27±0.095	0.10±0.000	0.33±0.404	0.34±0.230	*2.00±1.697*
2	*Neritina (Vittina) variegata*	0.66±1.154	2.05±3.168	0.20±0.282	1.86±0.577	2.44±3.057	*5.65±1.909*
II	**Viviparidae**	2.00±0.400	1.10±0.383	0.40±0.000	1.33±1.616	1.36±0.920	*2.240±1.357*
3	*Bellamya dissimilis*	2.00±0.400	1.10±0.383	0.40±0.000	1.33±1.616	1.36±0.920	*2.240±1.357*
III	**Pilidae**	20.33±16.503	28.00±40.108	6.00±2.828	11.33±10.066	22.40±13.849	*46.50±3.536*
4	*Pila virens*	18.30±14.852	25.20±36.097	5.40±2.546	10.20±9.060	20.16±12.464	*31.05±12.092*
5	*Pila globosa*	2.03±1.650	2.80±4.010	0.60±0.282	1.13±1.006	2.24±1.384	*3.45±1.343*
IV	**Thiaridae**	5.16±4.646	9.57±12.757	1.30±1.131	9.13±3.753	11.46±12.602	*24.15±11.102*
6	*Thiara (Stenomelania) punctata*	0.33±0.577	1.02±1.584	0.10±0.141	0.93±0.288	1.22±1.528	*2.90±0.848*
7	*Thiara (Stenomelania) torulosa*	0.67±1.156	2.06±3.169	0.21±0.284	1.86±0.579	2.45±3.057	*5.11±2.658*
8	*Thiara (Tarebia) granifera*	0.32±0.578	1.03±1.585	0.11±0.142	0.94±0.289	1.22±1.529	*2.81±0.989*
9	*Thiara (Melanoides) tuberculata*	1.33±2.309	4.10±6.336	0.40±0.565	3.73±1.154	4.88±6.114	*8.60±7.636*
10	*Thiara (Mainwaringia) paludomoidea*	0.51±0.101	0.28±0.096	0.11±0.001	0.34±0.404	0.35±0.230	*2.55±2.478*
11	*Paludomus (Paludomus) tanschauricus*	2.01±0.402	1.11±0.385	0.41±0.001	1.33±1.618	1.36±0.922	*2.21±1.415*
V	**Lymnaeidae**	13.00±22.516	9.50±17.691	0.51±0.708	0.66±1.154	0	*0*
12	*Lymnaea luteola*	13.00±22.516	9.50±17.691	0.51±0.708	0.66±1.154	0	*0*
VI	**Planorbidae**	13.02±22.518	9.51±17.692	0.50±0.707	0.67±1.155	0	*0*
13	*Indoplanorbis exustus*	13.02±22.518	9.51±17.692	0.50±0.707	0.67±1.155	0	*0*
	Family diversity (H')	0.6413	0.6216	0.4876	0.558	0.4271	*0.5253*
	Species diversity (H')	*0.764*	*0.7986*	*0.6916*	*0.8788*	*0.7221*	*0.8168*

of first year and monsoon and post monsoon seasons of second year only. Biomass of Thiaridae was more than others in all the seasons of both years of study (Fig. 16).

Paravakkottai (Station III)

Season-wise variation in the biomass of gastropods at Paravakkottai stations during the study period has been given in table 12.

Family – wise Variations in Biomass

Gastropods belonging to Pilidae and Planorbidae had their peak biomass in the monsoon season while the peak biomass for the other families was in the post monsoon season, during the first year of study. During the second year the same trend was noticed for Pilidae whereas Neritidae, Viviparidae and Thiaridae peaked in biomass in summer during that period of study. The lymnaeids and planorbids were recorded in the monsoon season only during the second year with regard to Paravakkottai station. Biomass of pilidae was higher than other families in all the seasons of first year. In the second year biomass of thiarids was more than others (Fig. 17).

Similarities between stations

Family wise Variations in Biomass

With regard to biomass, all the three stations were similar for Neritidae (Fig.4.326). The Painganadu station was having distinct biomass values with regard to Viviparidae, Thiaridae and Lymnaeidae while the Paravakkottai station was unique in its biomass of Pilidae and Planorbidae (Fig. 18).

Microhabitat Use

Frequency and per cent of occurrence of different families and species of molluscs in different microhabitats at the three stations of the lake during the study period have been given in tables 13-18.

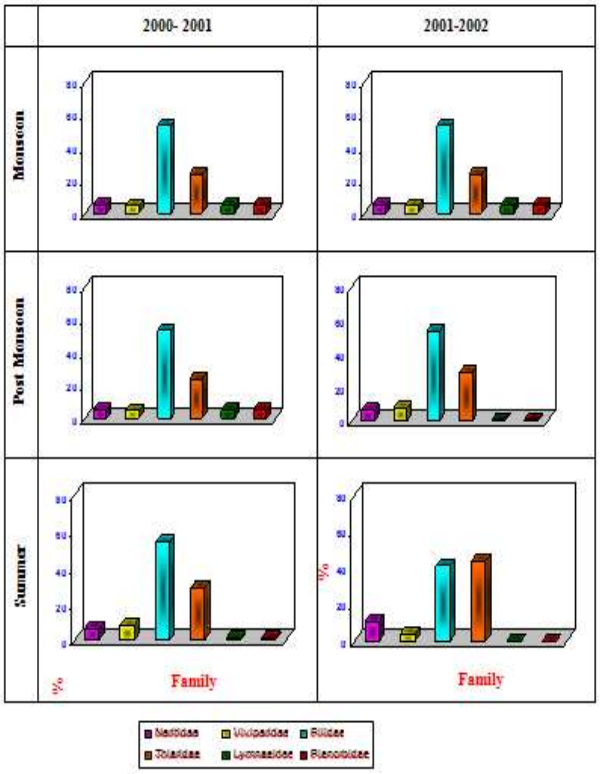

Fig. 11 : Family-wise percent composition of gastropod density in Thirumakkottai area (Station I) during different seasons of study period.

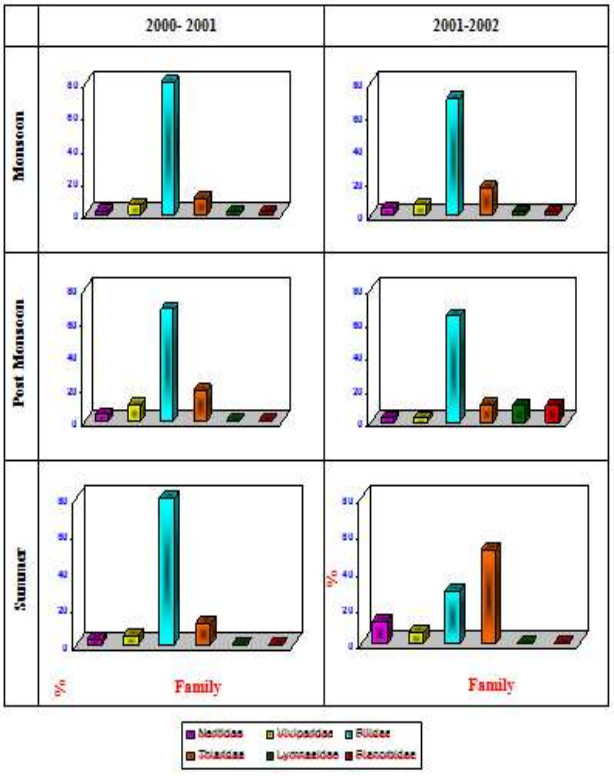

Fig. 12 : Family-wise percent composition of gastropod density in Painganadu area (Station II) during different seasons of study period.

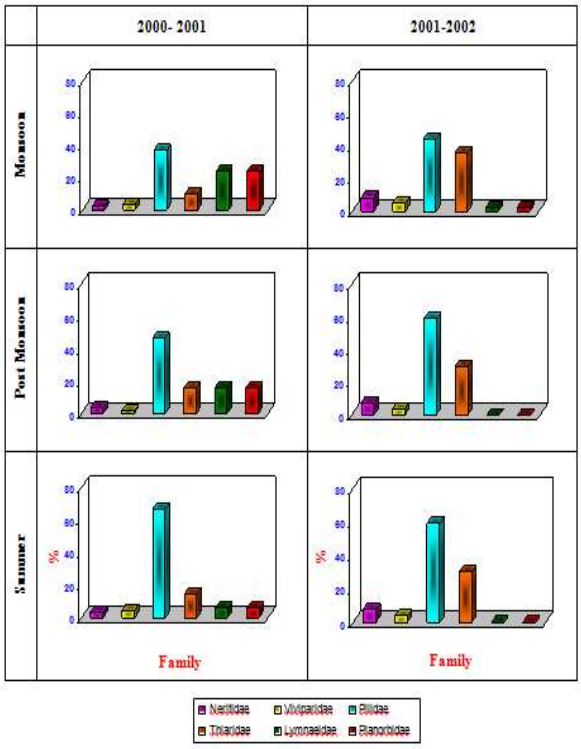

Fig. 13 : Family-wise percent composition of gastropod density in Paravakkottai area (Station III) during different seasons of study period.

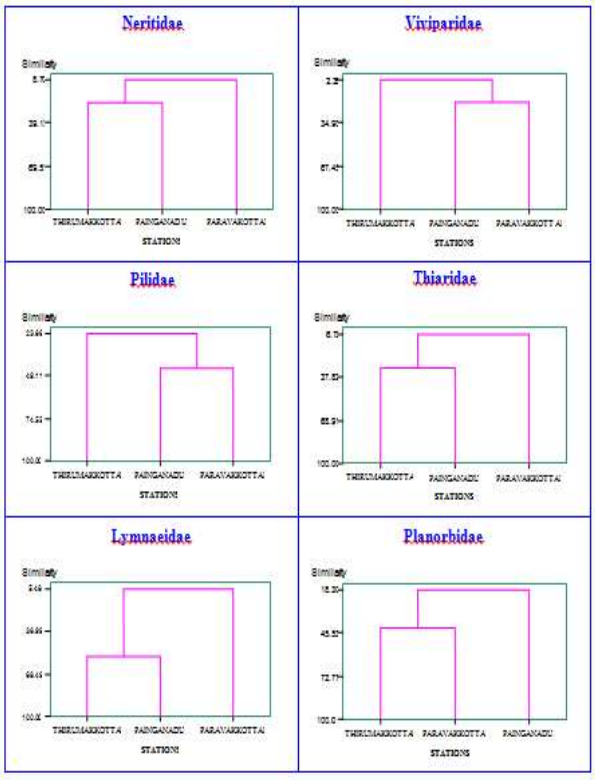

Fig. 14 : Similarity between stations of Thirumeni lake with regard to the density of different families of gastropods in them.

Table 10 : Season-wise variations (X±1SD) in the biomass (g/kg of soil) of gastropods at station I (Thirumakkottai) of the lake during the study period.

S.No.	Families and species of gastropods	2000-2001			*2001 -2002*		
		Monsoon	Post Monsoon	Summer	Monsoon	Post Monsoon	Summer
I	**Neritidae**	0.70±0.845	0.63±0.426	0.39±0.212	1.47±1.152	1.74±1.545	*2.83±1.088*
1	*Neritina (Dostia) violacea*	0.19±0.247	0.44±0.258	0.36±0.169	0.70±0.330	1.05±0.938	*2.37±0.636*
2	*Neritina (Vittina) variegata*	0.51±0.604	0.19±0.327	0.03±0.042	0.27±0.840	0.69±0.957	*0.46±0.452*
II	**Viviparidae**	1.13±1.445	2.59±1.506	2.10±0.990	4.08±1.928	6.16±5.476	*13.82±3.712*
3	*Bellamya dissimilis*	1.13±1.445	2.59±1.506	2.10±0.990	4.08±1.928	6.16±5.476	*13.82±3.712*
III	**Pilidae**	5.33±5.014	5.77±3.314	0.25±0.212	6.53±8.204	4.06±3.477	*4.75±0.919*
4	*Pila virens*	4.90±4.613	5.31±5.049	0.23±0.195	6.01±7.548	3.73±3.199	*4.37±0.846*
5	*Pila globosa*	0.42±0.401	0.46±0.265	0.02±0.017	0.52±0.656	0.32±0.278	*0.38±0.073*
IV	**Thiaridae**	3.37±4.070	3.79±2.246	2.58±1.329	7.87±5.516	9.98±8.482	*18.03±6.159*
6	*Thiara (Stenomelania) punctata*	0.33±0.393	0.12±0.212	0	0.50±0.546	0.44±0.622	*0.29±0.294*
7	*Thiara (Stenomelania) torulosa*	0.53±0.635	0.19±0.343	0	0.81±0.882	0.72±1.005	*0.48±0.475*
8	*Thiara (Tarebia) granifera*	0.66±0.786	0.24±0.425	0	1.00±1.092	0.89±1.245	*0.59±0.588*
9	*Thiara (Melanoides) tuberculata*	0.52±0.605	0.19±0.328	0	0.78±0.841	0.69±0.959	*0.47±0.454*
10	*Thiara (Mainwaringia) paludomoidea*	0.19±0.248	0.45±0.258	0.37±0.169	0.71±0.331	1.06±0.938	*2.38±0.6364*
11	*Paludomus (Paludomus) tanschauricus*	1.14±1.445	2.59±1.508	2.11±0.990	4.09±1.928	6.16±5.478	*13.83±3.714*
V	**Lymnaeidae**	0.32±0.412	0.74±0.430	0	0	1.76±1.564	*0*
12	*Lymnaea luteola*	0.32±0.412	0.74±0.430	0	0	1.76±1.564	*0*
VI	**Planorbidae**	0.96±1.001	0.37±0.556	0	0	0	*0*
13	*Indoplanorbis exustus*	*0.96±1.001*	*0.37±0.556*	*0*	*0*	*0*	*0*

Table 11 : Season-wise variations (X±1SD) in the biomass (g/kg of soil) of gastropods at station II (Painganadu) of the lake during the study period.

S. No.	Families and species of gastropods	2000-2001			2001 -2002		
		Monsoon	Post Monsoon	Summer	Monsoon	Post Monsoon	Summer
I	**Neritidae**	1.58±0.931	0.83±0.367	0.21±0.305	1.84±0.163	1.98±1.305	2.57±2.357
1	*Neritina (Dostia) violacea*	1.29±1.053	0.81±0.400	0.21±0.305	1.58±0.124	1.42±1.628	1.44±2.032
2	*Neritina (Vittina) variegata*	0.29±0.311	0.02±0.040	0	0.26±0.087	0.55±0.737	1.13±0.325
II	**Viviparidae**	7.52±6.147	4.74±2.336	1.26±1.782	9.21±0.729	8.33±9.497	8.41±11.855
3	*Bellamya dissimilis*	7.52±6.147	4.74±2.336	1.26±1.782	9.21±0.729	8.33±9.497	8.41±11.855
III	**Pilidae**	4.26±1.620	4.70±5.358	0.75±0.778	3.46±0.513	5.84±5.212	2.50±2.687
4	*Pila virens*	3.92±1.490	4.32±4.930	0.69±0.716	3.18±0.472	5.37±4.795	2.30±2.472
5	*Pila globosa*	0.34±0.129	0.37±0.428	0.06±0.062	0.27±0.041	0.46±0.417	0.20±0.215
IV	**Thiaridae**	9.98±6.642	5.63±2.604	1.47±2.087	11.83±0.974	11.98±9.579	14.38±15.188
6	*Thiara (Stenomelania) punctata*	0.19±0.202	0.01±0.026	0	0.16±0.056	0.36±0.479	0.73±0.211
7	*Thiara (Stenomelania) torulosa*	0.30±0.326	0.02±0.042	0	0.27±0.091	0.58±0.774	1.18±0.341
8	*Thiara (Tarebia) granifera*	0.38±0.404	0.02±0.052	0	0.33±0.113	0.72±0.958	1.46±0.472
9	*Thiara (Melanoides) tuberculata*	0.29±0.312	0.03±0.040	0	0.27±0.087	0.55±0.739	1.14±0.325
10	*Thiara (Mainwaringia) paludomoidea*	1.29±1.055	0.82±0.400	0.22±0.305	1.58±0.126	1.43±1.628	1.45±2.032
11	*Paludomus (Paludomus) tanschauricus*	7.53±6.148	4.75±2.336	1.26±1.785	9.22±0.729	8.34±9.497	8.42±11.885
V	**Lymnaeidae**	2.15±1.756	0	0	2.63±0.208	2.38±2.713	0
12	*Lymnaea luteola*	2.15±1.756	0	0	2.63±0.208	2.38±2.713	0
VI	**Planorbidae**	0.06±0.115	0	0	2.63±0.208	3.02±4.455	0
13	*Indoplanorbis exustus*	0.06±0.115	0	0	2.63±0.208	3.02±4.455	0

Table 12 : Season-wise variations (X±1SD) in the biomass (g/kg of soil) of gastropods at station III (Paravakkottai) of the lake during the study period.

S. No.	Families and species of gastropods	2000-2001			2001 -2002		
		Monsoon	Post Monsoon	Summer	Monsoon	Post Monsoon	Summer
I	**Neritidae**	0.25±0.368	0.53±0.206	0.30±0.250	1.04±0.704	0.48±0.359	2.99±1.091
1	*Neritina (Dostia) violacea*	0.22±0.357	0.48±0.228	0.27±0.292	0.74±0.624	0.44±0.306	2.12±0.054
2	*Neritina (Vittina) variegata*	0.02±0.023	0.05±0.050	0.03±0.042	0.30±0.273	0.04±0.048	0.87±1.145
II	**Viviparidae**	1.30±2.084	2.80±1.332	1.59±1.708	4.31±3.643	2.57±1.786	12.37±0.317
3	*Bellamya dissimilis*	1.30±2.084	2.80±1.332	1.59±1.708	4.31±3.643	2.57±1.786	12.37±0.317
III	**Pilidae**	28.80±45.486	3.62±4.239	2.55±2.616	3.23±2.401	1.68±1.493	1.70±1.414
4	*Pila virens*	26.49±41.847	3.33±3.900	2.34±2.407	2.97±2.209	1.54±1.374	1.56±1.301
5	*Pila globosa*	2.30±3.638	0.29±0.339	0.20±0.209	0.25±0.192	0.13±0.119	0.13±0.113
IV	**Thiaridae**	1.63±2.485	3.48±1.464	1.98±1.831	6.28±4.503	3.21±2.290	17.97±4.211
6	*Thiara (Stenomelania) punctata*	0.01±0.015	0.03±0.032	0.01±0.027	0.19±0.177	0.03±0.062	0.56±0.744
7	*Thiara (Stenomelania) torulosa*	0.02±0.024	0.05±0.052	0.03±0.044	0.32±0.286	0.05±0.101	0.91±1.202
8	*Thiara (Tarebia) granifera*	0.03±0.030	0.06±0.065	0.03±0.055	0.39±0.0354	0.06±0.125	1.13±1.489
9	*Thiara (Melanoides) tuberculata*	0.03±0.024	0.06±0.050	0.04±0.042	0.30±0.275	0.05±0.096	0.87±1.148
10	*Thiara (Mainwaringia) paludomoidea*	0.23±0.358	0.48±0.229	0.28±0.292	0.75±0.624	0.44±0.308	2.13±0.054
11	*Paludomus (Paludomus) tanschauricus*	1.31±2.086	2.80±1.334	1.59±1.709	4.32±3.644	2.58±1.786	12.38±0.318
V	**Lymnaeidae**	0.37±0.595	0.80±0.380	0.45±0.487	1.23±1.040	0	0
12	*Lymnaea luteola*	0.37±0.595	0.80±0.380	0.45±0.487	1.23±1.040	0	0
VI	**Planorbidae**	2.76±4.534	0.85±1.569	0.05±0.070	0.03±0.057	0	0
13	*Indoplanorbis exustus*	2.76±4.534	0.85±1.569	0.05±0.070	0.03±0.057	0	0

Table 13 : Frequency occurrence (X±1SD) of different families and species of gastropods and their diversity (H′) in different microhabitats of Station I (Thirumakkottai) during the study period.

S. No.	Families and species of gastropods	*MICROHABITATS*				
		Shore line of the lake	Centre of the Lake	Emergent plants of the lake	Floating vegetation of the lake	Sub-merged vegetation of the lake
I	**Neritidae**	10.03±6.615	4.16±7.217	15.56±26.356	0.73±0.709	0.96±1.422
1	*Neritina (Dostia) violacea*	0.30±0.436	0.03±0.058	15.36±26.529	0.26±0.289	0.16±0.153
2	*Neritina (Vittina) variegata*	9.73±6.379	4.13±7.159	0.20±0.200	0.46±0.808	0.80±1.386
II	**Viviparidae**	1.05±1.526	0.11±0.202	53.78±92.853	0.93±1.010	0.58±0.535
3	*Bellamya dissimilis*	1.05±1.526	0.11±0.202	53.78±92.853	0.93±1.010	0.58±0.535
III	**Pilidae**	142.33±114.045	0.66±1.185	54.00±83.355	56.00±51.069	38.33±63.815
4	*Pila virens*	128.10±102.641	0.60±1.039	48.60±75.019	50.40±45.962	34.50±57.43
5	*Pila globosa*	14.23±11.405	0.06±0.115	5.40±8.335	5.60±5.107	3.83±6.381
IV	**Thiaridae**	40.28±26.585	16.68±28.896	69.95±118.690	3.06±2.818	3.95±5.712
6	*Thiara (Stenomelania) punctata*	4.86±3.191	2.06±3.581	0.11±0.101	0.23±0.405	0.41±0.694
7	*Thiara (Stenomelania) torulosa*	9.74±6.379	4.14±7.159	0.20±0.202	0.46±0.809	0.81±1.386
8	*Thiara (Tarebia) granifera*	4.86±3.190	2.06±3.580	0.10±0.100	0.23±0.404	0.40±0.693
9	*Thiara (Melanoides) tuberculata*	19.46±12.758	8.26±14.318	0.40±0.400	0.93±1.617	1.60±2.771
10	*Thiara (Mainwaringia) paludomoidea*	0.31±0.436	0.04±0.058	15.37±26.529	0.28±0.289	0.16±0.155
11	*Paludomus (Paludomus) tanschauricus*	1.06±1.527	0.11±0.204	53.79±92.854	0.94±1.011	0.59±0.535
V	**Lymnaeidae**	0.31±0.437	0.04±0.059	15.37±26.528	0.27±0.288	0.17±0.154
12	*Lymnaea luteola*	0.31±0.437	0.04±0.059	15.37±26.528	0.27±0.288	0.17±0.154
VI	**Planorbidae**	4.00±6.928	0	68.66±73.385	0	0
13	*Indoplanorbis exustus*	4.00±6.928	0	68.66±73.385	0	0
	Family diversity(H′)	0.3599	0.2881	0.7173	0.1605	0.2166
	Species diversity (H′)	0.5825	0.7171	0.8122	0.3288	0.4052

Table 14. Per cent occurrence (X±1SD) of different families and species of gastropods in various microhabitats of station I (Thirumakkottai) during the study period.

S. No.	Families and species of gastropods	*MICROHABITATS*				
		Shore line of the lake	Centre of the Lake	Emergent plants of the lake	Floating vegetation of the lake	Sub-merged vegetation of the lake
I	**Neritidae**	31.90±15.631	13.23±17.054	49.49±62.279	2.32±1.675	*3.05±3.360*
1	*Neritina (Dostia) violacea*	1.86±40.039	0.19±0.211	95.35±96.592	1.61±1.052	*0.99±0.557*
2	*Neritina (Vittina) variegata*	63.51±1.587	26.96±44.935	1.31±1.255	3.00±5.072	*5.22±8.699*
II	**Viviparidae**	1.86±3.638	0.19±0.210	95.27±96.595	1.65±1.051	*1.03±0.557*
3	*Bellamya dissimilis*	1.86±3.638	0.19±0.210	95.27±96.595	1.65±1.051	*1.03±0.557*
III	**Pilidae**	48.86±36.386	0.22±0.378	18.54±26.591	19.22±16.292	*13.16±20.358*
4	*Pila virens*	48.86±36.388	0.23±0.368	18.54±26.594	19.22±16.293	*13.16±20.359*
5	*Pila globosa*	48.87±14.551	0.21±0.367	18.54±26.593	19.23±16.294	*13.15±20.359*
IV	**Thiaridae**	30.07±40.040	12.45±15.816	52.23±64.964	2.29±1.542	*2.95±3.126*
6	*Thiara (Stenomelania) punctata*	63.52±40.031	26.93±44.935	1.31±1.255	3.01±5.071	*5.23±8.698*
7	*Thiara (Stenomelania) torulosa*	63.45±40.040	26.97±44.926	1.30±1.268	3.00±5.077	*5.28±8.698*
8	*Thiara (Tarebia) granifera*	63.53±40.040	26.93±44.935	1.31±1.255	3.01±5.071	*5.23±8.698*
9	*Thiara (Melanoides) tuberculata*	63.49±40.039	26.94±44.935	1.30±1.255	3.03±5.075	*5.22±8.696*
10	*Thiara (Mainwaringia) paludomoidea*	1.92±1.587	0.25±0.211	95.11±96.585	1.73±1.052	*0.99±0.564*
11	*Paludomus (Paludomus) tanschauricus*	1.88±1.588	0.20±0.212	95.22±96.591	1.66±1.052	*1.04±0.557*
V	**Lymnaeidae**	1.86±1.587	0.19±0.211	95.35±96.592	1.61±1.052	*0.99±0.557*
12	*Lymnaea luteola*	1.86±1.587	0.19±0.211	95.35±96.592	1.61±1.052	*0.99±0.557*
VI	**Planorbidae**	5.50±8.626	0	94.50±91.374	0	*0*
13	*Indoplanorbis exustus*	*5.50±8.626*	*0*	*94.50±91.374*	*0*	*0*

Family – wise Microhabitat Preference

Neritidae

The Neritidae were more in the emergent plants in all the three stations of Thirumeni lake.

Viviparidae

Viviparids preferred emergent plants in Thirumakkottai, floating vegetation in Painganadu and centre of the lake in the Paravakkottai area.

Pilidae

Pilids preferred the shore line in all the three stations of the lake.

Thiaridae

The microhabitat preference for thiarids was the emergent vegetation in all the stations of the lake.

Lymnaeidae

The preferred microhabitat for lymnaeids was emergent vegetation in the Thirumakkottai area, the floating vegetation in the Painganadu and the centre of the lake in Paravakkottai area of the lake.

Planorbidae

The planorbids were more in the emergent vegetation in the Thirumakkottai and in the floating vegetation in the Painganadu area, while they were found only in the emergent vegetation in the Paravakkottai area of the lake.

Influence of Water Quality and Soil Parameters on the Density of Gastropods

Levels of pH and bicarbonate in the lake water were the most important variables that entered into the multiple regression equations to predict density of gastropods in Thirumeni lake (Table 19) and they explained 26.5% of the total variation in the gastropods density variations in the Thirumeni lake ($F=6.38$; $P<0.001$)

Influence of Water Quality and Soil Parameters on the Biomass of Gastropods

The variation in the biomass of gastropods in Thirumeni lake could best be explained by variations in water pH and soil potassium levels, which entered the multiple regression predictor equation to explain

Table 15 : Frequency occurrence (X±1SD) of different families and species of gastropods and their diversity (H') in various microhabitats of station II (Painganadu) during the study period.

S. No.	Families and species of gastropods	*MICROHABITATS*				
		Shore line of the lake	Centre of the Lake	Emergent plants of the lake	Floating vegetation of the lake	Sub-merged vegetation of the lake
I	**Neritidae**	1.97±2.110	0.33±0.288	10.00±8.354	6.50±8.860	*8.70±13.046*
1	*Neritina (Dostia) violacea*	0.70±0.960	0.13±0.152	0.66±0.404	0.76±0.862	*0.10±0.173*
2	*Neritina (Vittina) variegata*	1.27±1.210	0.20±0.200	9.33±8.090	5.73±8.911	*8.60±12.873*
II	**Viviparidae**	2.45±3.380	0.46±0.534	2.33±1.415	2.68±3.018	*0.35±0.606*
3	*Bellamya dissimilis*	2.45±3.380	0.46±0.534	2.33±1.415	2.68±3.018	*0.35±0.606*
III	**Pilidae**	186.33±241.520	7.66±6.658	118.66±168.102	43.00±63.459	*6.33±3.055*
4	*Pila virens*	167.70±217.370	6.90±5.992	106.80±151.292	38.70±57.113	*5.70±2.750*
5	*Pila globosa*	18.63±24.150	0.76±0.665	11.86±16.810	4.30±6.346	*0.63±0.306*
IV	**Thiaridae**	8.23±8.910	1.00±1.000	46.66±40.452	28.66±44.557	*43.00±64.366*
6	*Thiara (Stenomelania) punctata*	0.63±0.600	0.10±0.100	4.66±4.045	2.86±4.456	*4.30±6.437*
7	*Thiara (Stenomelania) torulosa*	1.28±1.212	0.21±0.201	9.34±8.091	5.74±8.911	*8.61±12.873*
8	*Thiara (Tarebia) granifera*	0.64±0.601	0.10±0.100	4.66±4.045	2.86±4.456	*4.30±6.437*
9	*Thiara (Melanoides) tuberculata*	2.53±2.410	0.20±0.282	18.66±16.151	11.46±17.823	*17.20±25.746*
10	*Thiara (Mainwaringia) paludomoidea*	0.71±0.961	0.14±0.152	0.67±0.404	0.76±0.865	*0.11±0.173*
11	*Paludomus (Paludomus) tanschauricus*	2.46±3.381	0.47±0.534	2.34±1.415	2.68±3.019	*0.35±0.608*
V	**Lymnaeidae**	0.72±0.961	0.15±0.152	0.67±0.404	0.78±0.863	*0.11±0.175*
12	*Lymnaea luteola*	0.72±0.961	0.15±0.152	0.67±0.404	0.78±0.863	*0.11±0.175*
VI	**Planorbidae**	8.67±9.020	0	0	46.66±80.829	*0*
13	*Indoplanorbis exustus*	8.67±9.020	0	0	46.66±80.829	*0*
	Family diversity (H')	0.2064	0.3206	0.3739	0.5783	*0.3438*
	Species diversity (H')	*0.3629*	*0.5401*	*0.6143*	*0.7705*	*0.7812*

18.0% of the total variations in gastropods biomass of the lake (Table 20).

DISCUSSION

Diversity and Ecology of Molluscs in Thirumeni Lake

The Molluscan Species Diversity

The successful colonization and diversification of thirteen species of molluscs in Thirumeni lake indicates most favourable conditions with regard to molluscs, even though the pilids and viviparids can tolerate variations, the thiarids in general are known to be ubiquitous and occur widely almost everywhere in fluvial and lacustrine habitats and the plonorbids are also hardy and can survive in varying conditions.

In the present study, the occurrence of two species of neritids *viz., Neritina (Dostia) violacea* and *Neritina (vittina) variegata* in Thirumeni lake is interesting because the natural habitats for neritids are usually regarded to be estuarine area. However, Rao (1984) describes them as occurring in fresh waters also. According to Govindan and Natarajan (1972) the marine intertidal gastropod molluscs of the family Neritidae, an annectant group with a mosaic organization and great adaptability, has very successfully invaded fresh water through the estuaries in the tropics. Ondo and Nakamoto (1964) have also found the neritid *Clithon retropictus* to be distributed as far as 15km up from the mouth of the river Sendai in Japan, where water usually is fresh.

Seasonal Variations in Molluscan Density, Biomass and Diversity

In the present study season-wise variations in the density, biomass and diversity of molluscs have been observed in Thirumeni lake (vide Tables 1 - 6). Monsoon and post monsoon are usually the favourable periods for breeding of molluscs. Both the density and biomass estimates of gastropods in Thirumeni lake during 2000-2001 show increasingly high value during monsoon and post monsoon with summer of that year showing almost nil values. This is understandable as the snails are known to aestivate during dry periods. Since the Thirumeni lake gets totally dried during the pre monsoon period, one would expect the snail population to become increasingly difficult to record in summer because of onset of aestivation and consequently a lower density, biomass and diversity during summer. Khan *et al.* (1999) have observed the abundance of benthic

Table 16 : Per cent occurrence (X±1SD) of different families and species of gastropods in various microhabitats of station II (Painganadu) during the study period.

S. No.	Families and species of gastropods	*MICROHABITATS*				
		Shore line of the lake	Centre of the Lake	Emergent plants of the lake	Floating vegetation of the lake	Sub-merged vegetation of the lake
I	**Neritidae**	7.16±6.461	1.20±0.882	36.36±25.580	23.64±27.130	31.64±39.947
1	*Neritina (Dostia) violacea*	29.79±37.632	5.53±5.958	28.09±15.837	32.34±33.791	4.26±6.781
2	*Neritina (Vittina) variegata*	5.05±3.388	0.80±0.639	37.13±25.860	22.80±28.484	34.22±41.149
II	**Viviparidae**	29.63±37.753	5.56±5.965	28.17±15.805	32.41±33.709	4.23±6.769
3	*Bellamya dissimilis*	29.63±37.753	5.56±5.965	28.17±15.805	32.41±33.709	4.23±6.769
III	**Pilidae**	51.48±50.025	2.12±1.379	32.78±34.819	11.88±13.144	1.75±0.633
4	*Pila virens*	51.47±50.026	2.12±1.379	32.78±34.818	11.88±13.144	1.75±0.633
5	*Pila globosa*	51.49±50.024	2.10±1.376	32.78±34.820	11.89±13.145	1.74±0.634
IV	**Thiaridae**	6.45±5.594	0.78±0.628	36.58±25.396	22.47±27.973	33.71±40.409
6	*Thiara (Stenomelania) punctata*	5.02±3.837	0.80±0.640	37.13±25.866	22.79±28.495	34.26±41.163
7	*Thiara (Stenomelania) torulosa*	5.08±3.873	0.83±0.642	37.09±25.860	22.79±28.481	34.19±41.144
8	*Thiara (Tarebia) granifera*	5.10±3.843	0.80±0.639	37.10±25.865	22.77±28.493	34.24±41.160
9	*Thiara (Melanoides) tuberculata*	5.06±3.861	0.40±0.452	37.28±25.878	22.90±28.557	34.37±41.252
10	*Thiara (Mainwaringia) paludomoidea*	29.71±37.631	5.86±5.949	37.03±15.812	31.80±33.855	4.60±6.771
11	*Paludomus (Paludomus) tanschauricus*	29.64±37.747	5.66±5.962	28.19±15.798	32.29±33.705	4.22±6.788
V	**Lymnaeidae**	29.79±37.632	5.53±5.958	28.09±15.837	32.34±33.791	4.26±6.782
12	*Lymnaea luteola*	29.79±37.632	5.53±5.958	28.09±15.837	32.34±33.791	4.26±6.782
VI	**Planorbidae**	15.67±10.039	0	0	84.33±89.961	0
13	*Indoplanorbis exustus*	15.67±10.039	0	0	84.33±89.961	0

Table 17 : Frequency of occurrence (X±1SD) of different families and species of gastropods and their diversity (H′) in various microhabitats of station III (Paravakkottai) during the study period.

S. No.	Families and species of gastropods	*MICROHABITATS*				
		Shore line of the lake	Centre of the Lake	Emergent plants of the lake	Floating vegetation of the lake	Sub-merged vegetation of the lake
I	**Neritidae**	40.30±45.420	3.90±3.799	67.90±72.020	2.16±2.540	0.46±0.152
1	*Neritina (Dostia) violacea*	1.03±0.860	1.10±1.819	0.83±0.930	0.10±0.000	0.06±0.057
2	*Neritina (Vittina) variegata*	39.27±45.080	2.80±2.227	67.07±72.040	2.06±2.540	0.40±0.200
II	**Viviparidae**	3.62±3.020	3.85±6.368	2.92±3.250	0.35±0.000	0.23±0.202
3	*Bellamya dissimilis*	3.62±3.020	3.85±6.368	2.92±3.250	0.35±0.000	0.23±0.202
III	**Pilidae**	546.00±356.020	42.66±66.260	370.67±364.12	89.33±79.59	7.33±4.041
4	*Pila virens*	491.40±320.420	38.40±59.634	333.60±327.71	80.40±65.331	6.60±3.637
5	*Pila globosa*	54.60±35.600	4.26±6.626	37.07±36.410	8.93±7.259	0.73±0.404
IV	**Thiaridae**	201.63±249.480	21.10±24.288	466.52±416.48	16.48±12.146	3.00±2.372
6	*Thiara (Stenomelania) punctata*	19.64±22.541	1.41±1.116	33.54±36.022	1.02±1.28	0.21±0.102
7	*Thiara (Stenomelania) torulosa*	39.28±45.082	2.81±2.227	67.08±72.041	2.06±2.541	0.41±0.200
8	*Thiara (Tarebia) granifera*	19.63±22.540	1.40±1.114	33.53±36.020	1.03±1.270	0.20±0.100
9	*Thiara (Melanoides) tuberculata*	78.53±90.160	5.60±4.454	134.13±144.08	4.13±5.081	0.80±0.400
10	*Thiara (Mainwaringia) paludomoidea*	1.04±0.861	1.11±1.819	0.84±0.931	0.11±0.001	0.07±0.057
11	*Paludomus (Paludomus) tanschauricus*	3.63±3.021	3.86±6.368	2.93±3.251	0.36±0.001	0.24±0.202
V	**Lymnaeidae**	1.05±0.861	1.11±1.820	0.84±0.932	0.12±0.001	0.07±0.059
12	*Lymnaea luteola*	1.05±0.861	1.10±1.820	0.84±0.932	0.12±0.001	0.07±0.059
VI	**Planorbidae**	0	0	358.67±477.00	0	0
13	*Indoplanorbis exustus*	0	0	358.67±477.00	0	0
	Family diversity (H′)	0.3429	0.455	0.5473	0.2384	0.3789
	Species diversity (H′)	*0.5564*	*0.7179*	*0.7459*	*0.3644*	*0.5895*

Table 18 : Per cent occurrence (X±1SD) of different families and species of gastropods in various microhabitats of station III (Paravakkottai) during the study period.

S. No.	Families and species of gastropods	*MICROHABITATS*				
		Shore line of the lake	Centre of the Lake	Emergent plants of the lake	Floating vegetation of the lake	Sub-merged vegetation of the lake
I	**Neritidae**	35.13±36.649	3.40±3.065	59.19±58.113	1.88±2.050	*0.40±0.123*
1	*Neritina (Dostia) violacea*	33.01±23.459	35.26±49.618	26.60±25.368	3.21±0.000	*1.92±1.555*
2	*Neritina (Vittina) variegata*	35.19±36.924	2.51±1.824	60.10±59.007	1.85±2.080	*0.36±0.164*
II	**Viviparidae**	33.00±23.520	35.10±49.595	26.12±25.312	3.19±0.000	*2.10±1.573*
3	*Bellamya dissimilis*	33.00±23.520	35.10±49.595	26.12±25.312	3.19±0.000	*2.10±1.573*
III	**Pilidae**	51.71±40.920	4.04±7.616	35.10±41.852	8.46±9.148	*0.69±0.464*
4	*Pila virens*	51.71±41.252	4.04±7.678	35.10±42.191	8.46±8.411	*0.69±0.468*
5	*Pila globosa*	51.71±41.252	4.03±7.678	35.10±42.191	8.46±8.411	*0.69±0.468*
IV	**Thiaridae**	28.45±35.399	2.98±3.446	65.83±59.095	2.33±1.723	*0.42±0.337*
6	*Thiara (Stenomelania) punctata*	35.19±36.924	2.51±1.825	60.10±59.007	1.85±2.080	*0.36±0.164*
7	*Thiara (Stenomelania) torulosa*	35.19±36.925	2.52±1.824	60.09±59.006	1.85±2.081	*0.37±0.164*
8	*Thiara (Tarebia) granifera*	35.19±36.924	2.51±1.825	60.10±59.007	1.85±2.080	*0.36±0.164*
9	*Thiara (Melanoides) tuberculata*	35.19±23.924	2.51±1.824	60.10±59.007	1.85±2.081	*0.36±0.164*
10	*Thiara (Mainwaringia) paludomoidea*	32.81±23.467	35.02±49.578	26.50±25.375	3.47±0.027	*2.21±1.554*
11	*Paludomus (Paludomus) tanschauricus*	32.94±23.523	35.03±49.583	26.59±25.313	3.27±0.008	*2.18±1.573*
V	**Lymnaeidae**	33.01±23.459	35.26±49.618	26.60±25.368	3.21±0.000	*1.92±1.555*
12	*Lymnaea luteola*	33.01±23.459	35.26±49.618	26.60±25.368	3.21±0.000	*1.92±1.555*
VI	**Planorbidae**	0	0	100.00±100.00	0	*0*
13	*Indoplanorbis exustus*	*0*	*0*	*100.00±100.00*	*0*	*0*

Table 19 : Multiple regression equation to predict the influence of water quality and soil parameters on the density of gastropods in Thirumeni lake.

Variables Model F Model P and R2	Predictor	Coefficient	Standard Deviation	t	P
Molluscan density (No./kg of Soil) F=6.38 P<0.001 R2 = 26.5%	Constant	653	230.3	2.84	0.01
	pH	147	54.02	-2.7	0.01
	pH^2	9.04	3.153	2.87	0.01
	Bicarbonate	-0.15	0.05571	-2.7	0.01

Table 20 : Multiple regression equation to predict the influence of water quality and soil parameters on the biomass of gastropods in Thirumeni lake.

Variables Model F Model P and R2	Predictor	Coefficient	Standard Deviation	t	P
Molluscan biomass (g/kg of soil) F=2.85 P<0.033 R2 = 18.0%	Constant	-95.5	35.68	-2.68	0.01
	pH	7.43	3.048	2.44	0.018
	Potassium Potassium^2	1.94	0.9353	2.07	0.043
	Potassium^3	-0.0201	0.00945	-2.12	0.039
		0.000062	0.00002942	2.11	0.039

macrofauna to be maximum either in post monsoon or in winter and attributed this to more availability of organic matter during winter season. According to Olive and Dambach (1973) the rains, surface runoff and drainage during monsoon add a lot of organic matter and nutrients and thereby, encouraging the multiplication of benthos. Mandal and Moitra (1975) have also reported the benthos to peak in winter.

On the contrary density and biomass estimation of gastropods show uniformly and rather flourishingly very high values during summer of 2001-2002. This sudden spurt observed during the summer of 2001-2002 is intriguing. One possible reason for this could be unusual heavy rains in the post monsoon season of that year (vide Fig.2.15), which has caused a heavy inflow of flood water into the lake and as such must have favoured a luxuriant growth of vegetation and molluscs which are associated and depending on them. Further this high rainfall could have improved the water quality and edaphic factors as well. So, a combination of both climatic and biotic factors must have acted synergistically to enhance the molluscan density and biomass.

Heywood and Edwards (1962) and Ondo and Nakamoto (1964) have also found that the density of molluscs is influenced by season. Invertebrate

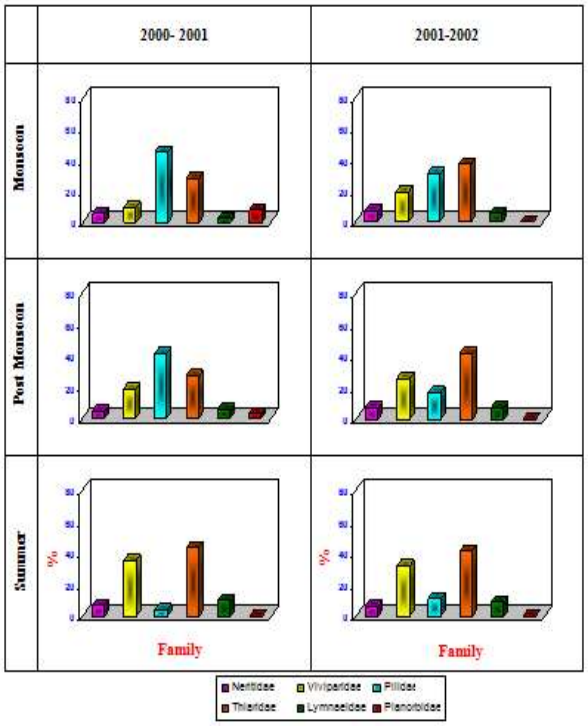

Fig. 15 : Family-wise percent composition of gastropod biomass in Thirumakkottai area (Station I) during different seasons of study period.

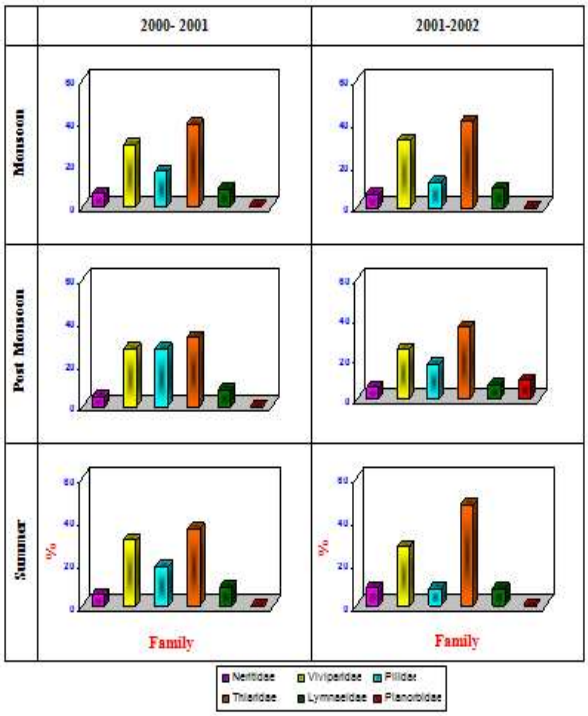

Fig. 16. Family-wise percent composition of gastropod biomass in Painganadu area (Station II) during different seasons of study period.

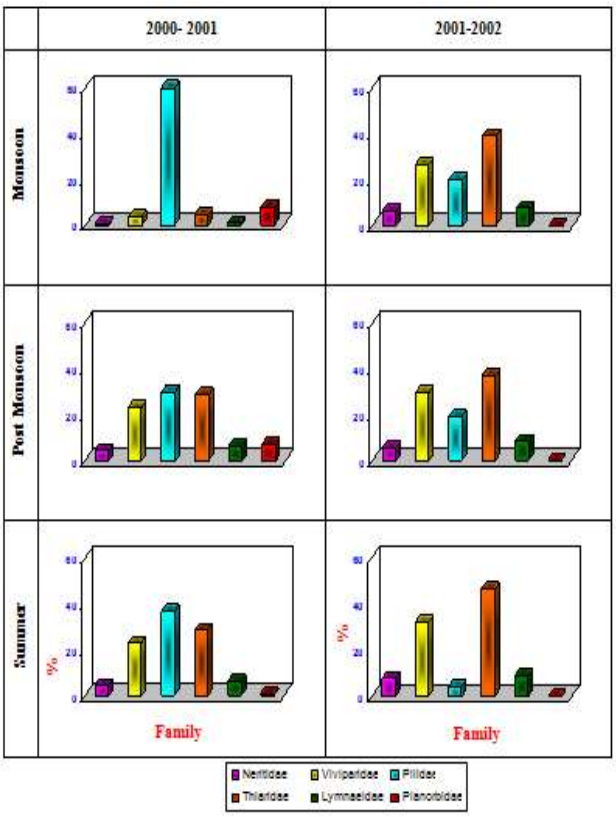

Fig. 17 . Family-wise percent composition of gastropod biomass in Paravakkottai area (Station III) during different seasons of study period.

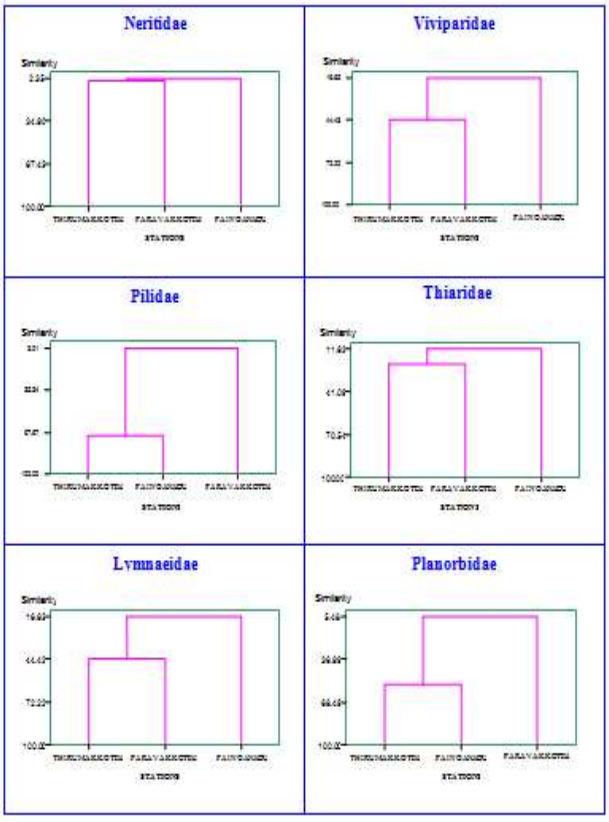

Fig. 18. Similarity between stations of Thirumeni lake with regard to the biomass of different families of gastropods in them.

population in general have been reported to have the feature of the seasonal fluctuations in their number (Davidson and Andrewartha, 1948; Odum, 1960). Raman *et al.* (1975) have found the concentration of bottom fauna was more during monsoon and post monsoon seasons, with the pre monsoon season being the lowest in number. Seasonal variation in molluscan population in the Cauvery river system (from which Thirumeni lake receives water) has been reported by Amanullah and Hameed (1996).

Sadhana and Ayyakkannu (1992) studied the seasonal variation in the population density and ecology of banded pond snail *Viviparus benghalensis* in Manikaranai regulator, Tamilnadu, India and found the highest population density during post monsoon and lowest during summer. They have reasoned that the environmental parameters influenced its distribution and abundance. Review by Seed (1976) and reports by McGrooty (1997) and Dolmer (1998) have also highlighted the importance of environmental factors to molluscan growth and survival.

It is evident that a few species of molluscs, especially, *Lymnaea luteola* and *Indoplanorbis exustus* are absent during certain seasons and reappeared during other seasons (vide Tables 1-6). Khan *et al.* (1999) have opined that this might be due to return of favourable conditions which enhanced the growth and reproduction of those species. Earlier Haque (1991) and Gaur (1994) have also reported similar findings for planktonic organisms.

So, it can be concluded that the variations in climatic, water quality and edaphic factors are the probable causes for seasonal variations in molluscs in Thirumeni lake.

Microhabitat Preference

Emergent or free floating plants are the favoured microhabitats for most of the gastropod species in Thirumeni lake (vide Tables 13 - 18), while the shore line i.e. the littoral zone of the lake are for the *Pila* spp. Rao (1984) has stated that all the Indian freshwater molluscs are herbivores. Pip (1991) has also found the richness of gastropod species to be closely associated with macrophytes.

Patchy association of the molluscan fauna with aquatic vegetation has been reported by Kolekar (1996). Shanmugam (1997) has also reported the percent occurrence of snails to be more in places of thick vegetation. Painter (1999) has also stated that the macroinvertebrate distribution with regard to coleoptera, odonata and mollusca in freshwater ditches are significantly correlated with macrophytes distribution. Kumar and Kumar (2002) have found the molluscs of Lymnaeidae and Planorbidae to be found among profuse growth of vegetation. They have further stated that the aquatic vegetation manufacture and provide food, shelter and a suitable site for oviposition to the molluscan fauna. According to Edgar and Robertson (1992) the molluscs select vegetation cover to minimize predation and solar radiation. Olbarria *et al.* (2001) while studying the patterns of distribution and temporal variation of trophic groups within a benthic mollusc assemblage of a tropical shore (eastern tropical Pacific) found the herbivores to dominate in sheltered places.

So, it can be inferred that a greater variety of specific microhabitats suitable for the individual molluscan species is an important factor that resulted in enhancing molluscan diversity, at Thirumeni lake.

Influence of Water Quality and Soil Factors on Gastropods

Levels of pH and bicarbonates in the lake water have been found to be the most important variables has they entered into the multiple regression equation to predict the density of gastropods in Thirumeni lake (vide Table 19), while the variations in the biomass of gastropods could best be explained by variation in water pH and soil potassium levels (vide Table 20).

Masthanamma *et al*. (1979) have stated that pH is an important factor for the distribution of molluscs. Mitra *et al*. (2002) have reported the pH to have a considerable role in determining the community structure of macrobenthic molluscs. Earlier Adholia *et al*. (1990) have also reported the macrobenthos population to have correlation with trends in biochemical and limnological parameters.

Kumar and Gupta (2002) have also found significant correlations between molluscan biomass and soil nutrients *via* their effects on the primary producers on which the molluscs depend, since an increase in the biomass of molluscs with an increase in the biomass of macrophyte was observed. Kumar and Singh (1998) have stated that wide fluctuation in the water level drastically affected the benthic population in Mansanjore Reservoir, India. They have found the maximum benthic macrofaunal populations to occur in soft bottoms having more amount of organic matter than bottoms having hard substratum and low organic matter, particularly that of molluscs have been found in the zone of maximum abundance of submerged vegetation. Sarkar (1989) has stated that the occurrence and abundance of benthic macrofauna is controlled by their trophic level, fertility of soil, base exchange capacity and wide fluctuations of hydro biological parameters.

Singh and Munshi (1992) have found the water temperature, dissolved oxygen, calcium and total hardness to be correlated with the density of *Pila*

globosa and *Bellamya benghalensis* in a tank at Japalpur, India. Pandey *et al*. (1994) have found in the Kawar lake the range of physico-chemical properties of water *viz*., conductivity (460-740 mohms./cm), pH (6.65-7.08), dissolved oxygen (2.15-6.77 mg/l), bicarbonate (115.5-285.0 mg/l), calcium (52.80-124.32 mg/l), nitrate (0.42-0.82 mg/l) and phosphate (0.011-0.067 mg/l) and of soil *viz*., conductivity (202.5-246.25 mohms./cm), total calcium (545.19-746.74mg/100g), and organic matter (921.32-28.81%), seem to be suitable for growth and propagation of gastropods. They have further found that the seasonal fluctuation and spatial distribution of molluscs to have significant and positive correlation with macrophytes.

In the present study, a station-wise variation in molluscan population has been found. According to Olive and Dambach (1973) such station- wise variations are a reflection of bottom beds. According to Ram and Radhakrishna (1984), the distribution and occurrence of molluscs are related to stagnant or flowing nature, depth, surface area, aquatic vegetation, and dissolved calcium in the water bodies investigated. Harding and Winterbourn (1995) observed that the benthic assemblages change with physico-chemical gradients along with the ecological gradients. So, the variation in depth and the aquatic vegetation could possibly be the reason for differences in the gastropod population due to stations in the present study.

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