CHAPTER 5

STUDY OF MOLLUSCA

INTRODUCTION

Wetlands are known to support varied macro-invertebrates among which molluscs form a major component. Molluscs play many important role in maintaining the general health of a water body by converting the organic matter such as leaf litter and detritus into food and in turn becoming the main source of food for higher water dependent animals. Mollusc generally feed on algae and detritus and use the higher plants for support (Ramchandra *et al.*, 2002). Thus, they are involved in recycling and transport of nutrients from one trophic level to other trophic level. This turns out to be an important link in the wetland food web (Hart and Newman, 1995; Ramchandra *et al.*, 2002). These macroinvertebrates are known to behave in a different manner in response to the fluctuating water levels and changing water cover (Tronstad *et al.*, 2005).

Mollusca is a large group of animals having diverse shapes, sizes, habits and occupy different habitats (Subba Rao, 1989). Based on their habitat preference, molluscs can be categorized into aquatic and terrestrial communities. Although the molluscs are common components of the benthic communities, their role in the dynamics of an aquatic ecosystem and their contribution to biomass production is not understood. The fresh water molluscan habitats are taxonomically impoverished with information when compared to the marine habitats. Marine molluscs have received more attention because of their aesthetic and gastronomic appeals (Subba Rao, 1989) while, freshwater molluscs because of their drab colours have attracted less attention. However, freshwater molluscs have been known to play significant role in the public and veterinary health (Welch, 1952) and thus need to be explored more extensively and scientifically.

As far as the molluscs are concerned, they are directly under the influence of architecture of plants and periphyton substrate and they reflect changes in the local factors such as hydroperiod or water chemistry and physico-chemical variations caused by adjacent land use patterns (Andrew and Michael, 2009).

The water quality in a wetland has direct impact from agriculture runoff, municipal waste water and recreational developments. More distant activities in water shed also ultimately influence the end receiving waters. These factors in turn have been reported to affect species composition and abundance of gastropod and freshwater mussel communities (Pip, 2006) *i.e.* molluscan diversity.

Among the freshwater molluscs snails are mobile grazers or predators, whereas bivalves are attached bottom living filter feeders. Both groups have specialized profusely in certain freshwater systems. The snails play various roles as agricultural pests and as vectors to many parasite species. Larvae of many bivalves are parasitic on fishes. Due to their feeding mode, molluscs can help in maintaining water quality but they also tend to be susceptible to pollution (UNEP, 1992). Thus, they are also the robust indicators for biological assessment of wetlands (Doherty *et al.*, 2000) as they respond quickly to changes in physical, chemical or biological parameters (Stansly *et al.*, 1997).

In a review on predation studies of molluscs, Dillon (2000) reported that, multiple taxa consume freshwater gastropods and predator effects vary among gastropod species based on shell shape and strength. Lodge *et al.* (1987) found ample evidences of strong predation effects of fish and crayfish on freshwater gastropod. The presence of predators is a strong control on local gastropod abundance across the lake habitat.

Selection of habitat by waterfowl and their food habits suggests that aquatic macro-invertebrates are important factors in determining avian use of marsh area (Murkin and Kadlec, 1986). Many wintering birds are known to feed primarily on aquatic invertebrates (Bolduc and Afton, 2003) including molluscs. Water fowls such as Coot (*Fulica atra*), Pochards, Goldeneye and many other benthos feeders probably depend on mollusc for their calcium requirement (Stanczykowska *et al.*, 1990). This is recognized especially during breeding season of birds when calcium and protein requirement increases (Ankney *et al.*, 1980; Perrins, 1996). Eeva and Lehikoinen (1995) have related decline in molluscan density due to acid rains with the decline in breeding success of birds. However, the concept of the mutual relationships between birds and mollusc is the subject of recent studies, which started around 1986 (Stanczykowska *et al.*, 1990). Thus mollusc gain special importance when ecology of wetland birds is studied (Ramchandra *et al.*, 2002).

Fresh water gastropod assemblages are structured by a multitude of variables at regional and local scales (Lodge *et al.*, 1987). With the help of a Nonmetric Multidimensional Scaling (NMS) multivariate analysis in watershed drainage area, correlations between gastropods assemblage structure and water conductivity, substrate category frequency and dissolved oxygen have been established by Pyron *et al.* (2009). According to this study Gastropod assemblages of lakes are not significantly different than assemblages of streams in the ordination. Local environmental variables provide explanation of aquatic gastropod assemblage structure of an area on gastropod distribution, species richness and abundance in local habitats (Perez Quintero, 2007).

In addition, macrophytes also play important role in gastropod distribution. Antoine *et al.* (2004) found differences in gastropod assemblages in wetlands that differed by types of dominant macrophytes. Macrophytes with the majority of their vegetative structure above water had higher gastropod species richness and densities than macrophytes with only under water structure. This reflects the nature of pulmonate gastropods.

In the recent past molluscs are also reported to be extremely vulnerable to habitat degradation, over-exploitation and fish production, that affects freshwater ecosystems. Certain gastropod species such as *Pila globosa*, serve as an indicator of the water quality (Revenga and Kura, 2003).

The present study evaluates the seasonal variations in species richness and density of mollusc at Yashwant Lake a high altitude Lake at 3300 ft. located in mid Satpura range of North Western Maharashtra. Here, an attempt has been made to find out the influence of seasonal changes on the density of mollusc as well as its correlation with abiotic factors.

MATERIALS AND METHODS

During the period of investigation (Dec. 2006 to Nov. 2008), benthic molluscs were collected biweekly from three stations selected at Yashwant Lake YLA, YLB and YLC. YLA is situated on east shore of the lake and is having rocky and sandy floor, least vegetation and maximum human interference, while YLB and YLC have somewhat similar characters with muddy bottom, maximum macrophytes and less human interference. YLB is situated on west shore while YLC is on South-West bank of the Lake.

A corer with 10 cm height and 8 cm radius was inserted 5 to 6 times at each field stations. The soil collected was sieved and the molluscs were collected in a separate sample bottle as described by Michael (1984) and Tronstad *et al.*, (2005). At YLB and YLC the Stations with more vegetation a sieve was directly dipped in the water and swept to collect mollusc with vegetation. The collected molluscs were preserved in 4 % formalin and carried to the laboratory for quantitative and qualitative estimation. The collected molluscs were identified as per the key provided by Subba Rao (1989).

To find out correlation of mollusc density with their habitat the physico-chemical parameters of water samples were analysed by using standard methods as per APHA (1998) and Michael (1984) (Chapter 3). The data for three months were pooled into four seasons' -summer (March, April, and May), monsoon (June, July, and August), post monsoon (September, October. and November) and winter (December, January, and February). The densities of molluscs were calculated on the basis of the volume of the corer used for the collection of soil samples using following formula:

Density = Number of mollusc/volume of the corer.

Further, the mean and standard error of mean (SEM) were used for performing one way ANOVA (Fowler and Cohen) with no post-test for analysing seasonal variations in density of mollusc across four seasons using Graph Pad Prism version 3.00 for windows (Graph Pad Software San Diego California USA). The P value for ANOVA is non significant if $P > 0.05$ (ns), significant if $P < 0.05$ (*), significantly significant (**) if $P < 0.001$ and highly significant (***) if $P < 0.0001$.

To find out the relation between molluscan density and various abiotic (chapter 3) and biotic parameters (chapters 4, 5 and 6) Pearson correlation test of statistics was carried out using SPSS 7.5 software for windows, where ** correlation is significant at the 0.01 level (two tailed) and * correlation is significant at the 0.05 level (two-tailed). The percentage density of each species was calculated as domination index (Iga and Adam, 2006) as follows

$$D_0 = \frac{na}{N} \times 100$$

Where, na = the number of individuals of species a.

N = the total number of individuals in a sample.

The value of the domination index 'Do' was divided into five classes according to Gorny and Grum (1981) as eudominant > 10.0 % of sample, dominant 5.1 – 10 % of sample, subdominant 2.1 – 5.0 % of sample, recedent 1.0 – 2.1 % of sample, subrecedent < 1.0 % of the sample.

RESULTS

Three Stations of Yashwant Lake studied have different species composition. Altogether only six species were recorded at Yashwant Lake. Of these five species belong to class Gastropod and one to Bivalvia. The gastropod species found were *Lymnaea acuminata, Lymnaea luteola, Bellamya bengalenesis, Thiara tuberculata,* and *Indoplanorbis exustus.* These 5 species were observed frequently whereas *Lamellidens marginalis* of Bivalvia was observed rarely at all the three Stations.

Seasonal variations in density of molluscs were noted at all the three Stations (Table 5.1, Fig.5.1). At YLA, maximum density was noted in postmonsoon 2405 ± 105 individuals/m^3, while minimum in winter 870.3 ± 85.2 individuals/m^3 with highly significant seasonal variations ($P < 0.0001$). During summer it was 1493 ± 64.29 individuals/m^3 and in monsoon it was 1866 ± 55.45 individuals/m^3. Maximum species richness (Table 5.2, Fig. 5.2) 5.33 ± 0.21 species was observed in post-monsoon and minimum 3.00 ± 0.25 species in winter. In summer it was 3.83 ± 0.166 species and in monsoon 4.5 ± 0.22 species. The seasonal variations in species richness was significant at $P < 0.0001$.

At YLB also maximum density was observed in post-monsoon 2944 ± 118.7 individuals/m^3 while minimum in winter (995 ± 64.29 individuals/m^3), the values were moderate in summer (1493 ± 64.3 individuals/m^3) and monsoon (1990 ± 90.7 individuals/m^3). Similarly, maximum species richness was noted in post monsoon with 5.67 ± 0.2 species and minimum in winter 3.3 ± 0.21 species. The species richness was 4.33 ± 0.2 species in summer and 5.16 ± 0.16 species in monsoon. Both density and species richness showed significant seasonal variations at $P < 0.0001$.

At YLC also maximum density of molluscs was observed in post-monsoon (Table 5.1, Fig. 5.1) with 3110 ± 124.3 individuals/m^3 while minimum in winter with 953.5 ± 76.5 individuals/m^3. The density was 1576 ± 52.55 individuals/m^3 in summer and 2156 ± 83 individuals/m^3 in monsoon. Maximum Species richness 6 ± 0.0 species was observed in post-monsoon and minimum 3.67 ± 0.21 species in winter. The species richness was 5 ± 0.26 species in summer and 5.33 ± 0.21 species in monsoon (Table 5.2, Fig. 5.2). The seasonal variations in density and species richness were significant $P < 0.0001$.

It is noted that, among the three Stations, maximum density of mollusc 3110 ± 124.3 individuals/m^3 was observed at YLC and minimum 870.3 ± 85.2 individuals/m^3 at YLA while maximum species richness was also noted at YLC with 6 ± 0.0 species and minimum 3.00 ± 0.25 species in winter at YLA.

When the percentage species dominance was calculated (Table 5.3, Fig. 5.3), it was seen that at YLA *B. bengalensis*, *T. tuberculata, I. exustus,* and *L. marginalis* were Eudominant (22, 23.9, 24.5, 12.6 % respectively), while *L. accuminata* and *L. luteola* were dominant (7.55, 9.4 % respectively). At YLB and YLC *L. marginalis* were dominant (9.5%) and other five species were Eudominant with slight variations.

When Pearson correlation of molluscs density with abiotic parameters was carried out (Table 5.4), it was observed that no significant correlation was established between density of molluscs and acidity, alkalanity, atmospheric temperature, chloride, pH, TDS, TDZ, TS and water temperature at any of the three Stations. When correlation with CO_2 and Dissolved Oxygen with molluscan density is considered, CO_2 is positively correlated at 0.05 level whereas Dissolved Oxygen negatively correlated also at 0.05 level only at YLA. Similarly PO_4^{-3} is also positively correlated with molluscan diversity at 0.05 level only at YLA. At YLB and YLC molluscan diversity shows significant negative correlation with total hardness (at level 0.05 and 0.01 respectively). The water cover is significantly correlated at YLB.

When the biotic parameters are correlated with density of mollusc the total density of phytoplankton and zooplankton are negatively nonsignificantly correlated while, total density of birds at YLA and YLC are negatively significantly correlated at r = -0.44 and -0.42 respectively at .05 levels. Nitrate and Nitrite were positively significantly correlated at all the three stations. Transparency was negatively significantly correlated at 0.01 level at all the three stations. TSS was positively significantly correlated at 0.01 level at all the three stations. Density of birds at YLA and YLC are negatively significantly correlated at 0.05 levels.

Table: 5.1 Seasonal variations in Density of Molluscs (individuals/m^3) at Yashwant Lake during December 2006 to November 2008

Station with F value	Winter	Summer	Monsoon	Ptmonsoon
YLA $F_{3\ 20}$ 65.33	870.3 ± 85.2	1493 ± 64.29	1866 ± 55.45	2405 ± 105
YLB $F_{3\ 20}$ 90.47	995 ± 64.29	1493 ± 64.3	1990 ± 90.7	2944 ± 118.7
YLC $F_{3\ 20}$ 108.6	953.5 ± 76.5	1576 ± 52.55	2156 ± 83	3110 ± 124.3

Table: 5.2 Seasonal variations in Species richness of Molluscs (no. of species) at Yashwant Lake during Deccember 2006 to November 2008

Station with F value	Winter	Summer	Monsoon	Ptmonsoon
YLA $F_{3\ 20}$ 20.78	3 ± 0.25	3.88 ± 0.17	4.5 ± 0.22	5.33 ± 0.21
YLB $F_{3\ 20}$ 25.92	3.3 ± 0.21	4.33 ± .21	5.16 ± 0.17	5.67 ± 0.21
YLC $F_{3\ 20}$ 24.76	3.67 ± 0.21	5 ± 0.26	5.33 ± 0.21	6.00 ± 0.00

Table: 5.3 Percentage species dominance of molluscs at Yashwant Lake during December 2006 to November 2008.

Sr. No.	Name of the species	*Station YLA*		*Station YLB*		*Station YLC*	
1	*Lymnaea accuminata*	Do.	7.55	Eu.	20.7	Eu.	23.1
2	*Lymnaea luteola*	Do.	9.4	Eu.	16.2	Eu.	22.1
3	*Bellamya bengalensis*	Eu.	22	Eu.	17.8	Eu.	17.7
4	*Thiara tuberculata*	Eu.	23.9	Eu.	19	Eu.	15.6
5	*Indoplanorbis exustus*	Eu.	24.5	Eu.	16.7	Eu.	12.9
6	*Lamellidens marginalis*	Eu.	12.6	Do.	9.5	Do.	8.6

Do: Dominant, Eu: Eudominant

Figure: 5.1 Seasonal variations in Density of Total Molluscs (individuals/m^3) at YLA, YLB and YLC of Yashwant Lake during December 2006 to November 2008

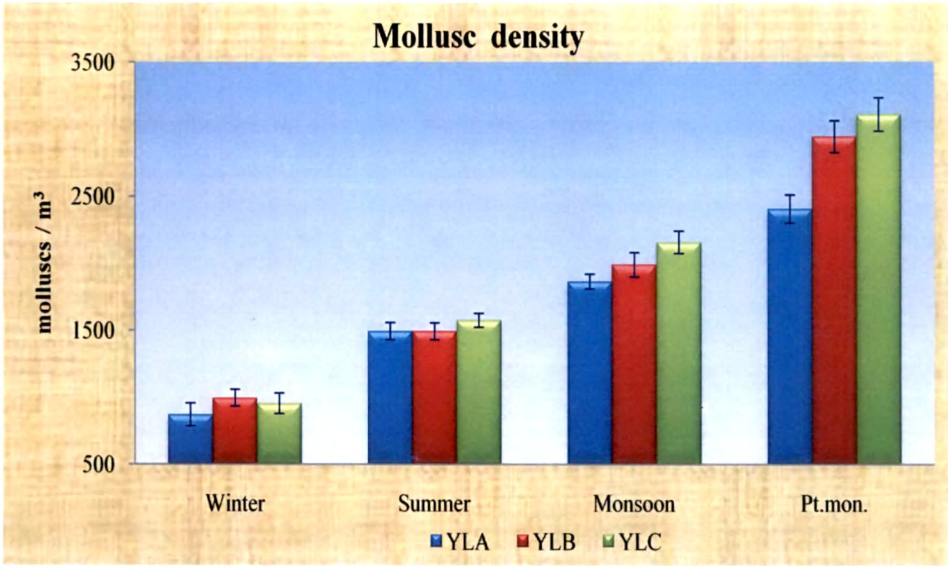


Figure: 5.2 Seasonal variations in species richness of Total Molluscs (no. of species) at YLA, YLB and YLC of Yashwant Lake during December 2006 to November 2008

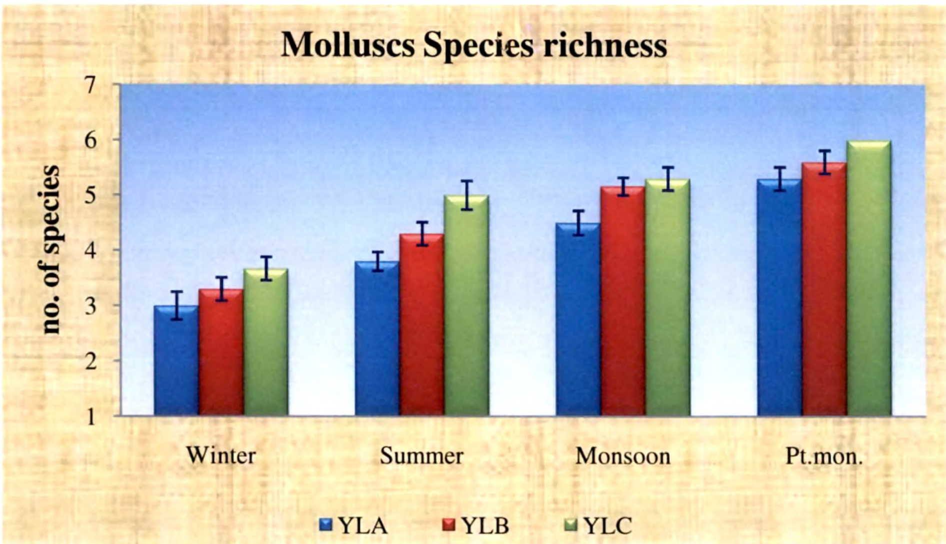
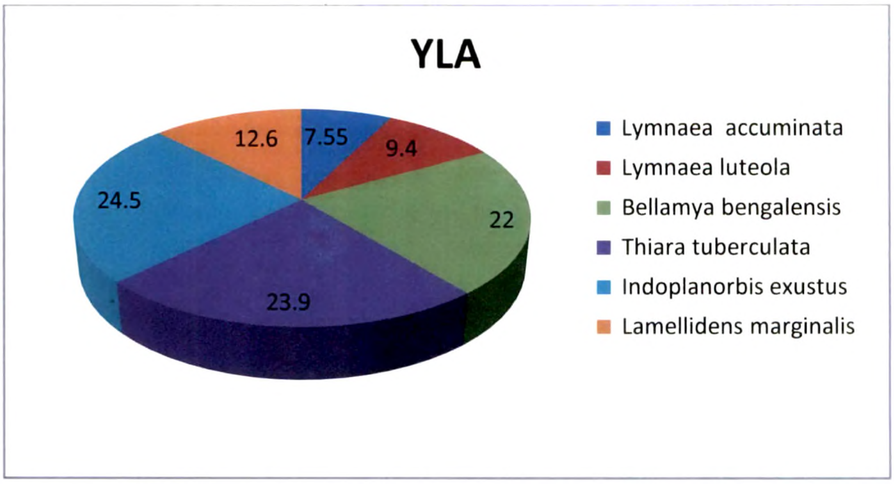
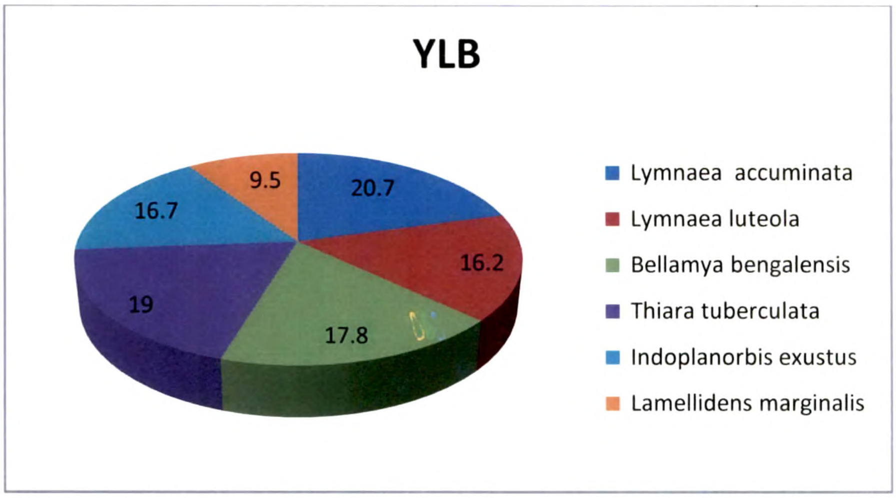


Figure: 5.3 Percentage Dominance of molluscs Species at YLA, YLB and YLC of Yashwant Lake during December 2006 to November 2008





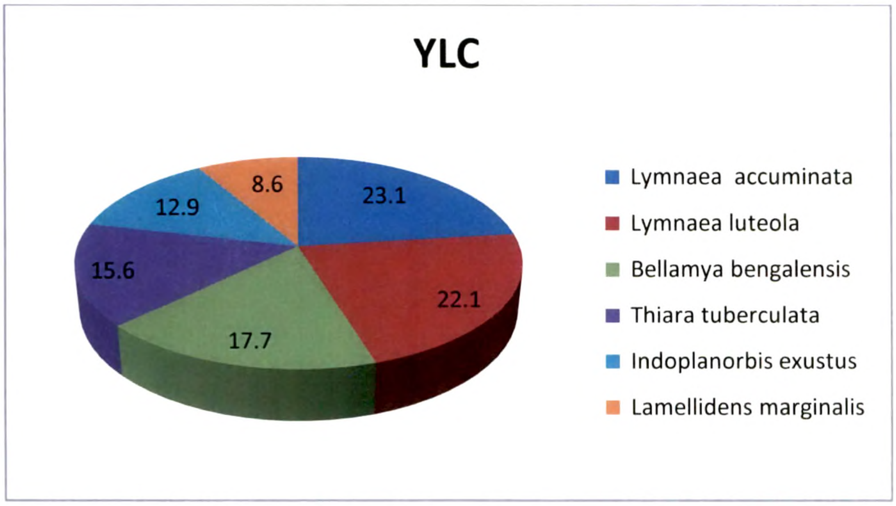


Table: 5.4 Pearson correlation of molluscs density with abiotic and biotic parameters at YLA, YLB and YLC of Yashwant Lake during December 2006 to November 2008

Sr. No.	Parameter	YLA	YLB	YLC
1	Acidity	-.100	-.190	-.145
2	Alkalinity	-.172	-.275	-.210
3	AT°C (atmospheric temperature)	.365	.252	.228
4	Chloride	-.208	-.383	-.347
5	CO_2 (Carbon Dioxide)	.418*	.312	.348
6	DO (Dissolved Oxygen)	-.454*	-.357	-.394
7	NO_2 (Nitrates)	.514*	.443*	.538**
8	NO_3 (Nitrites)	.525**	.461*	.484*
9	pH	.126	-.019	.004
10	PO_4 (Phosphates)	.476*	.384	.334
11	TDB (Total Density of Birds)	-.444*	-.341	-.424*
12	TDP (Total Density of Phytoplankton)	-.085	-.360	-.282
13	TDS (Total Dissolved Solids)	-.151	-.309	-.197
14	TDZ (Total Density of Zooplankton)	-.121	-.279	-.209
15	TH (Total Hardness)	-.382	-.482*	-.559**
16	Transparency	-.659**	-.694**	-.692**
17	TS (Total Solids)	.262	.063	.240
18	TSS (Total Suspended Solids)	.672**	.499*	.703**
19	WT° C (Water temperature)	.085	.034	-.040
20	WC (Water Cover)	0.261	0.429*	0.352

* *Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

DISCUSSION

In the present study, carried out at higher altitude "Yashwant Lake" in Satpura range, low species richness of mollusc was observed. Different species of molluscs occur in Lacustrine and Riverine habitats (Subba Rao 1989). In the dry deciduous forest of Satpura, which has both lacustrine and riverine habitats, fifteen species of mollusca have been reported (Magare, 2007). These include six species recorded at Yashwant Lake with additional 9 species of dry deciduous forest of Satpura.

At Yashwant Lake though only six species were reported, their density was always high. The highest density at all three stations of the lake were observed during the post monsoon. Thus indicates that the high water level, moderate photoperiod and temperature favour the growth of the macrophytes which provide food and shelter, the two basic needs of life and thus probably enhance the breeding performance of mollusc. In post monsoon the maximum density of mollusca observed at YLC may be due the presence of the macrovegetation. Macrovegetation is required for the growth and attachment of the molluscs (Boycott, 1936; Macan, 1950) as well as for hiding their larvae (Bronmark, 1985). According to Macan (1950) a good mollusc habitat should have fair but not excessive rooted plant growth. Eutrophication has adverse impact on mollusc (Alfred, 2002). The moderate habitat is expected to increases the diversity and density of molluscs. Major part of YLC is covered with submergent and emergent vegetation. Local gastropod occurrence patterns are under the influence of multiple variables including the architecture of available habitats. Brown (1997) showed that gastropods have preferences for macrophyte species with broader leaves. Such architecture is present at the YLC.

When YLB and YLC are compared with YLA, the YLA has minimum population of molluscs. YLA has rocky shore with few macrophytes.

A significant association exist between gastropods and sand and clay sediments, perhaps due to the film of algae on this kind of substratum (Iga and Adam, 2006). Present study confirms this association at YLC where the clay is present and density and diversity of mollusc is maximum while at YLA, there is least clay and the density and diversity of molluscs is least.

YLA has high anthropogenic pressures as the site is used for cleaning utensils and washing cloths. Lowest density of the molluscs occurs in the area with higher anthropogenic pressure (Collinson, 1995; Williams *et al.*, 2004). According to these authors those water bodies that are subjected to less anthropogenic pressures have provided a refuge for many freshwater species.

The molluscan density has also been correlated with pond area. If the Pond area decreases due to drying, the mollusc (e.g. Apple snail) move towards the water (Darby *et al.*, 2002). As the water cover declines, several dead empty shells accumulate at receding water margins (Plate 6). Among YLA and YLC, in summer, the population of mollusc was high at YLC, the station with least anthropo-pressure. The muddy shore of YLC is avoided by locals hence some macrophytes could survive. The impacts of predation and competition on local assembleges vary with study system.

During winter, the ambient temperature in the area fall below 10°C, again forcing the molluscs to hibernate/move to deeper soil. Further, many species of waterfowls feed on molluscs (Stanzykowska *et al.*, 1990; Nisbet, 1997; Girmmitt *et al.*, 1998) and large number of migratory population of waterfowls visit water bodies during winter (Padate *et al.*, 2008). The birds like Godwits, Ibises, Spoonbill and Openbill storks known to feed on molluscs (Cramp and Simmons, 1977; Urban *et al.*, 1982, Ali and Ripley, 1983) are few of the major species probably benefited because of their long beak in collecting molluscs from the deeper soils. Hence, at Yashwant Lake, located at higher altitude, waders are probably benefited. These species of birds are observed in winter at YLB and YLC. In the present study, the negative significant correlation is observed between total density of molluscs and total density of birds at YLA and YLB (Table 5.4).

The fundamental biogeographic principles hold that the larger lakes support more gastropod species. This is confirmed by studies of Carlson (2001). The data obtained in the survey by Oertli *et al.* (2002), showed a positive correlation between gastropod species richness and pond surface area ranging from 6 to 94,000 m^2. However, with reference to number of taxa Gee *et al.* (1997) claimed correlation with pond's surface area, but a statistically significant correlation was found with the percentage of macrophyte cover in the pond. Yashwant Lake has surface area of 0.39 Sq. Km. and six species of molluscs were observed with maximum species richness observed in post monsoon when the water cover was maximum. The species composition at all the three stations was different. *B. bengalensis* is present at all the three stations. This species is abundantly distributed throughout India and is common in the western zone (Subba Rao, 1989). *B. bengalens* was population was maximum at rocky YLA minimum at muddy YLC. While *Lymnaea* was observed maximum where macrophytes are maximum *i.e.* at YLC. According to Lodge and Kelly (1985) gastropod population size depends on macrophyte abundance, if the macrophyte richness drastically decreases, the population of *Lymnaea* decreases up to 99%. Maximum population of *Indoplanorbis exustus* was found at YLA where washing and cleaning activities are common. *I. exustus* is reported to harbour several parasites (Subba Rao, 1989). Thus, this species thrives at YLA, the sandy and rocky habitat. To evaluate the relationship of this species and its population further studies should be carried out. *Thiara tuberculata* population was also maximum at station YLA. Hence it also seems to be well adapted to the sandy and rocky habitats.

It is known that the phytoplankton serve as important food resource for the molluscs. However, when correlation is considered no strong relationship was found between the molluscs density and the phytoplankton density in the present study. This indicates that phytoplankton density is not the only limiting factor for molluscs in the water body studied. There might be several other factors producing collective influence over the populations of molluscs. The quality of the bottom sediment and the physical and chemical parameters of water are likely to influence gastropod distribution in a reservoir.

Calcium is the most vital component for molluscs as they are able to assimilate $CaCO_3$, to build their shell (Wareborn, 1970). Species associated with the sediments (e.g. bivalve) show better calcium concentrations than the species associated with macrophytes (e.g. gastropods) (Gerald and Linda, 1983). Calcium is an essential requirement for the successful growth and development of gastropod molluscs. Hence, in accordance with all shell bearing molluscs, it has been long established that fresh water gastropods have a fundamental physiological requirement for calcium in order to complete development successfully (Russell-Hunter, 1964; Mc Mahon, 1983, Dillon, 2000). Lack of calcium may lead to restriction of reproduction in certain mollusc species (Wareborn, 1970). In present study the density of mollusc and calcium in water in the form of Total hardness is negatively significantly correlated. Evaluation of calcium in water and soil needs further investigation. The hardness in the form of $CaCO_3$ is thought to be an important factor which could affect growth of mollusc as the shell building depends on the amount of the $CaCO_3$ (Mackie and Flippance, 1983). For Yashwant Lake, when the correlation between the mollusc density and total hardness (Table 5.4) is carried out high correlation is noted with significant value only at YLC only. Not only with reference to calcium but in relation to water chemistry also, local and regional distribution of gastropod species differs (Boycott, 1936; Dussart, 1976;

Savage and Gazey, 1987). The other factors, such as habitat area (Bronmark, 1985) also play important role in determining distribution.

The periphyton, the base of the diet of molluscs, is dependent on biogenic elements in water. Periphyton depends on nitrate concentration. Thus, the positive correlation between the gastropod densities and nitrate concentration in water may explain alimentation relationships (Iga and Adam, 2006). Further, several species appear to be restricted in distribution among the ponds by unsuitable water chemistry parameter values, the most significant of these being total dissolved solids, pH and total alkalinity but in present study no significant correlation is established between them and mollusc density.

The degradation of freshwater environments, eutrophication, drainage and cutting out of macrophytes in many European countries have led to extinction or threatened extinction of species like *Anisus vorticulus, Planorbis carinatus*, *Segmentina, etc.* (Drake, 1998; Serafinski *et al.,* 2001; Jueg *et al.*, 2002). Today there is no such degradation problem at Yashwant Lake but as the spot is developing as tourist place it may create anthropogenic pressures. Hence for the conservation of biodiversity of the lake proper steps should be undertaken.

The molluscs are important biota of the inland wetlands and may be helpful for determining the habitat quality of wetland. During the present study, the relation of the molluscs with the soil characteristics could not be studied. Further detail study on this aspect may give interesting results regarding the molluscan density and diversity and help in determining the best abiotic/biotic predictor of the mollusc density and diversity in this high altitudinal Lake in semiarid zone of Maharashtra that forms part of Satpura range.