CHAPTER II:

MOLLUSCAN DENSITY AND DIVERSITY

INTRODUCTION:

In any ecosystem the trophic cascade plays an important role. In freshwater ecosystem, the prey and the predator have reciprocal effect on each other. This results in the dynamics of ecosystem and alters the abundance, biomass, and productivity of a population or community across more than one food web link (Pace *et al.*, 2001, Hodgson, 2005). Wetlands are known to support both the land and the water invertebrates, among which molluscs form a major part of the macroinvertebrates. In wetlands the macroinvertebrates play an important role as they convert and transport nutrients from one component of the water body to another, influencing nutrient cycle. This process is important as it maintains the general health of a water body. Further, they convert the organic matter such as leaf litter and detritus into food and in turn become the main source of food for higher aquatic animals. This turns out to be an important link in the wetland food webs (Hart and Newman, 1995; Ramchandra *et al.*, 2002). These macroinvertebrates are known to behave in a different manner in response to the fluctuating water level and changing water cover (Tronstad *et al.*, 2005).

Macroinvertebrates can also be the robust indicators for biological assessment of wetland (Doherty *et al.*, 2000) as they respond quickly to changes in physical, chemical or biological parameters (Stansly *et al.*, 1997). Research on selection of habitat by waterfowl and their food habits suggests that aquatic macroinvertebrates are important factors in determining avian use of marsh areas (Murkin and Kadlec, 1986). Many wintering water birds feed primarily on aquatic invertebrates (Bolduc and Afton, 2003). The macroinvertebrates are highly diverse group of organisms, which include mollusc; the soft bodied animals covered with a hard calcareous shell. Mollusc generally feed on algae nd detritus and use the higher plants for support (Ramchandra *et al.*, 2002). The mollusc form a major component of food of waterfowls such as Coot (*Fulica atra*), Pochards, Goldeneye (*Bucephala clangula*) and many other benthos feeders (Stanczykowska *et al.*, 1990). Thus, freshwater molluscs constitute an important part of the ecosystem and many aquatic animals thrive on them. They provide proteins as well as calcium especially during breeding period (McCann, 1939; Ankney *et al.*, 1980; Perrins, 1996), they gain special importance when ecology of wetland birds is studied (Ramchandra *et al.*, 2002). Accoding to Eeva and Lehikoinen , (1995) decline in molluscan density due to acid rains brings down 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).

Like Birds, Molluscs are also reported to be extremely vulnerable to habitat degradation, over-exploitation, and predation; the factors, which have affected freshwater ecosystems worldwide in recent past (Revenga and Kura, 2003). Certain gastropod species such as *Pila*, also serve as an indicator of the water quality (Revenga and Kura. 2003). With the changing season; the water cover/level, dissolved oxygen, pH and other factors like calcium and chloride concentrations in the water are expected to change significantly. This may create either a favourable or an unfavourable environment for the immediate dependent biota like the producers, and in turn, the primary consumers like the mollusc.

The calcium is the most vital component for Mollusc as they are able to assimilate $CaCO_3$, to build their shell (Wäreborn, 1970). The level of calcium in the surrounding environment should have a direct effect on the shell building of the mollusc. The present study evaluates the seasonal variations in species richness and density of mollusc at the four wetlands. Here, an attempt has been made to find out the influence of seasonal climate changes on the density of mollusc as well as its correlation to abiotic factors.

MATERIALS AND METHODS:

During each visit molluscs were collected using a corer of about 11 cm height and 9 cm of diameter for benthic molluscans. The corer was inserted at three field stations the soil collected was sieved and the molluscs were collected, as described by Michael (1986); Tronstad *et al.* (2005). At the water bodies with more vegetation a sieve was directly dipped in the water and swept to collect mollusc with vegetation. The molluscs were preserved in 4% formalin and identification was done as per the key provided by Subba Rao (1989). The data for 3 months is pooled into 4 seasons Summer, Monsoon, Postmonsoon and Winter. The density of the mollusc is calculated on the basis of the area of the corer (Cylinder), which was inserted in the soil for the collection of mollusc as individuals/ m^3

Density = No. of mollusc/area of the corer as:

Further the Mean, standard error of mean (SEM) and One-way ANOVA (Fowler and Cohen) with No posttest for density of mollusc for four seasons was performed using GraphPad Prism version 3.00 for Windows, (GraphPad Software, San Diego California USA). The pearson correlation is carried out using SPSS 7.5 software for windows.

The percentile density of each species was calculated as summation of density of each species / summation of density of total species X 100.

The p value for ANOVA is non significant if $P > 0.05$ (ns), significant if $P < 0.05$ (*), significantly significant (**) if P is <0.001 and highly significant (***) if $p< 0.0001$.

RESULTS:

All the wetlands studied had different species composition. Altogether only seven species belonging to families: Viviparidae, Pilidae, Thiaridae, Lymnaeidae, Bulinae, and Corbiculidae were found from the study sites in the semi arid zone of Gujarat. Out of these *Bellamya bengalensis, Thiara granifera, Lamellae consobrinus,* and *Indoplanorbis exustus* were observed frequently. *Corbiula species* and *Lymnaea auricularia* were observed occasionally at WIR and *pila globosa* was observed occasionally at WIR and TIR mainly during summer when water level recedes and vegetation is exposed.

The mollusc density is seen to vary according to season at all the wetlands. No seasonal significant fluctuations are noted at WIR and HVP. (Fig.2.1). However, at TIR and MVP the significantly significant seasonal variations ($F_{3, 32}$ 1.21, $P < 0.001$) are noted. At WIR the maximum density of mollusc 5500.0 $\pm$ 401.9 Mollusc/ m^3 is noted during Post monsoon and minimum of 4033.0 $\pm$ 632.200 Mollusc/ m^3 during winter. During summer it was 4820.0 $\pm$ 358.8 Mollusc/ m^3 and in monsoon it was 5010.00 $\pm$1122.00 Mollusc/ m^3. However at TIR, unlike WIR, a significant difference ($F_{3, 32}$ 3.16, $P < 0.05$) in seasonal variations in the mean densities is observed. At TIR the trend is different compared to WIR. Highest density of mollusc 5665.0 $\pm$ 915.6 Mollusc/ m^3 is noted during Postmonsoon followed by 4566.0 $\pm$ 507.9 Mollusc/ m^3 during winter, and minimum 3298.0 $\pm$ 286.20 Mollusc/ m^3 during summer. While during monsoon it was 3995.0 $\pm$ 329.5

Mollusc/ m^3). Similarly at MVP, maximum density of 3583.0 $\pm$ 420.1 Mollusc/ m^3 is noted during post monsoon, followed by 3217.0 $\pm$ 457.1 Mollusc/ m^3 in winter. While it was minimum (2254.0 $\pm$ 152.100 Mollusc/ m^3) during summer and it was 2283.0 $\pm$ 0.0 Mollusc/ m^3 during monsoon. There is a significant seasonal difference in the density ($F_{3, 39}$ 3.850 $P < 0.05$) at MVP. At HVP there is no seasonal significant variation ($F_{3, 38}$ 2.135 $P > 0.05$). The maximum density is observed during postmonsoon (5327.0 $\pm$ 774.7 Mollusc/ m^3), followed by winter (4508.0 $\pm$ 412.9 Mollusc/ m^3), summer (3688.0 $\pm$ 478.6 Mollusc/ m^3) and minimum during monsoon (3272.0 $\pm$ 443.8 Mollusc/ m^3).

When the Pearson Correlation of mollusc density with plankton density and the physico chemical parameters (Chapter IV) is carried out (Table 2.1) it is observed that at WIR no significant correlation was established between the abiotic parameters and the mollusc density. However, the Total hardness of water (-0.4) as well as chloride (-0.42) (Fig. 2.2a) have maximum negative correlation coefficient among all the other variables. At TIR (Fig. 2.2b) a negative correlation was established between Bicarbonate alkalinity and molluscan density with the correlation coefficient of -0.54. Further, the pH at TIR is not significantly correlated with molluscan density but the correlation coefficient for pH is comparatively high with 0.42 (Fig.2.2b).

Figure 2.1: The density of mollusc in different season at four wetlands studied from February 2005 to May 2007.

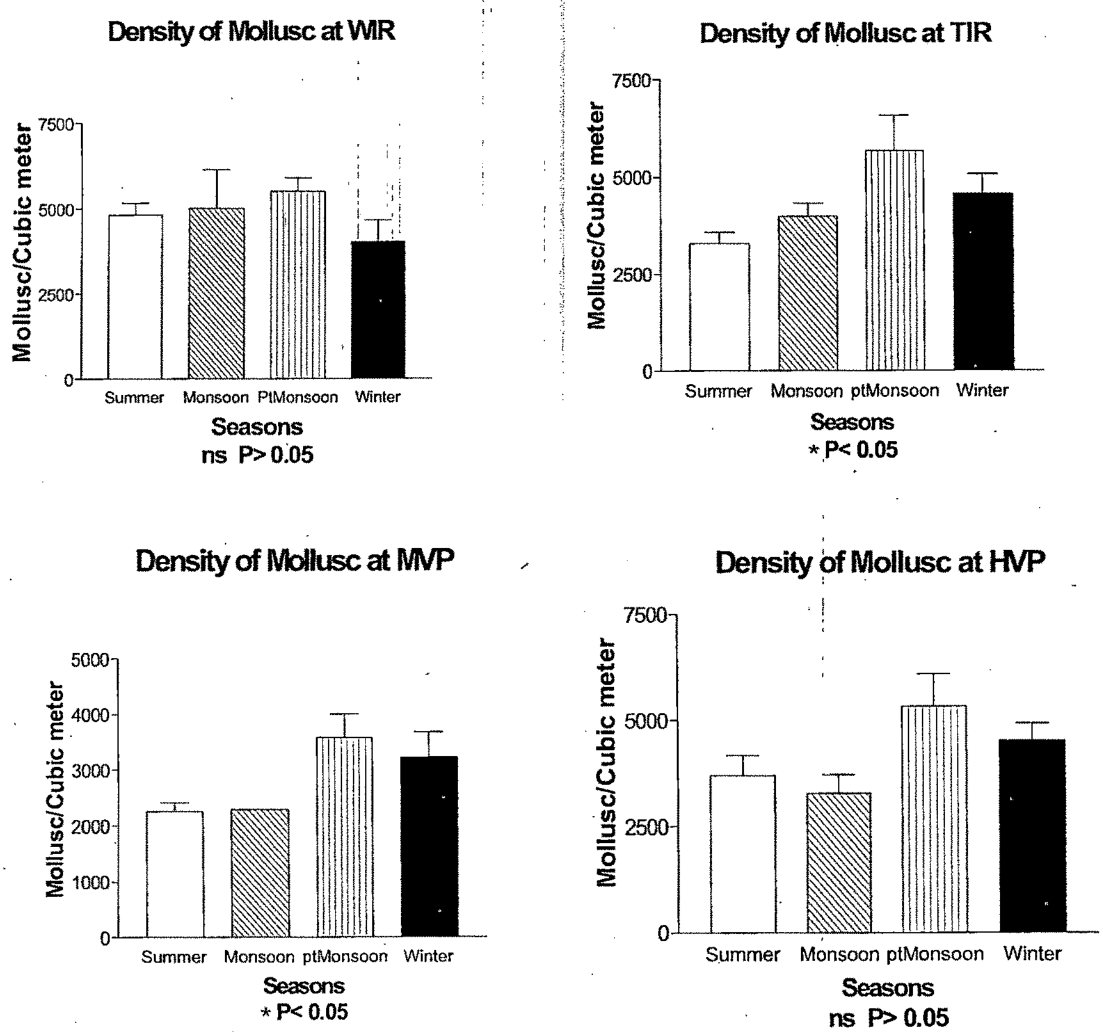


Table 2.1: Pearson Correlation of mollusc density with abiotic parameters and plankton density at WIR, TIR, MVP and HVP.

	WIR	TIR	MVP	HVP
Acidity	-0.07	-0.29	0.01	0.16
Bicarbonate Alkalinity	-0.33	-0.54**	-0.02	-0.06
Calcium Hardness	-0.08	-0.34	0.03	0.07
Chloride	-0.42	-0.09	-0.27	-0.10
Carbondioxide	0.16	0.19	0.31	-0.14
Dissolved oxygen	0.22	0.33	-0.27	0.09
Total Hardness	-0.40	-0.31	-0.09	0.05
Nitrite	0.09	0.14	-0.24	-0.19
Nitrate	-0.05	0.13	-0.23	-0.14
pH	0.38	0.42	-0.31	0.00
Hydroxyl Alkalinity	0.12	0.01	0.43**	0.13
Plankton	-0.05	-0.01	0.02	0.16
Phosphates	-0.06	-0.29	-0.20	-0.29
Salinity	-0.29	-0.09	-0.27	-0.10
TDS	0.06	-0.22	0.03	-0.46
Temperature	-0.27	0.14	-0.18	0.29
TS	-0.28	-0.31	-0.12	-0.43
TSS	-0.29	0.22	-0.09	-0.19
Water cover	-0.09	0.26	-0.12	-0.09

***- Significance at the level of 0.05**
****-Significance at the level of 0.01**

Table 2.2: The occurrence of the species at all the wetlands:

Speices	WIR	TIR	MVP	HVP
Bellamya bengalensis	Dominant (81%)	Dominant (86.2%)	Frequent (22.0%)	Dominant (66.6%)
Thiara granifera	Rare (12.6%)	Absent	Dominant (64.7%)	Rare (5.9%)
Lamellae Consobrinus	Rare (6.3%)	Rare (8.8%)	Absent	Absent
Indoplanorbis exustus	Absent	Rare (8.8%)	Rare (13.2%)	Frequent (27.3%)

Dominant: 50-100%
Frequent: 20-50%
Rare: < 20%

Figure 2.2a: Correlation between abiotic factors and mollusc from February 2005 to May 2007 at Wadhwana Irrigation Reservoir.

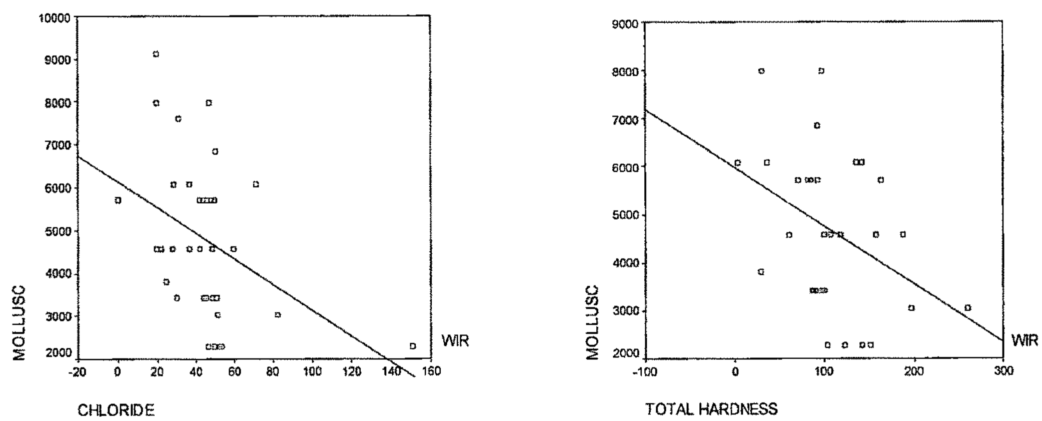


Figure 2.2b: Correlation between abiotic factors and mollusc from March 2005 to March 2007 at Timbi Irrigation Reservoir.

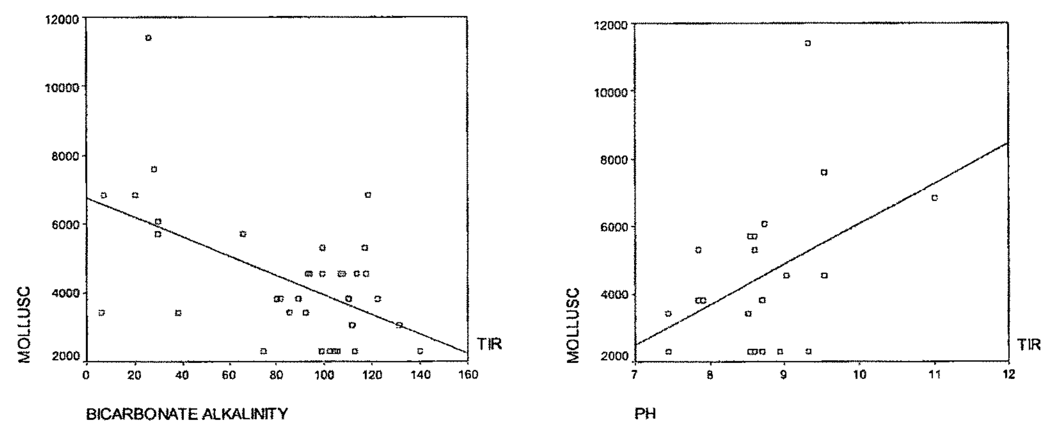


Figure 2.2c: Correlation between abiotic factors and mollusc from March 2005 to March 2007 at Masar Village Pond.

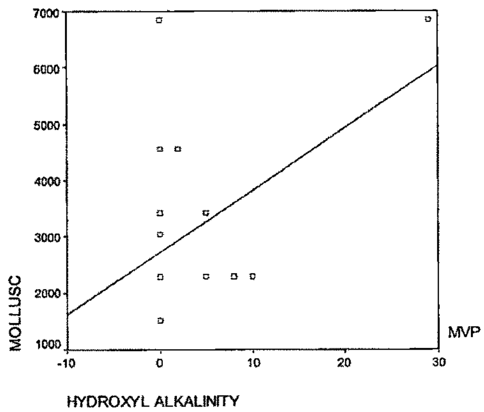


Figure 2.2d: Correlation between abiotic factors and mollusc from March 2005 to March 2007 at Harni Village Pond.

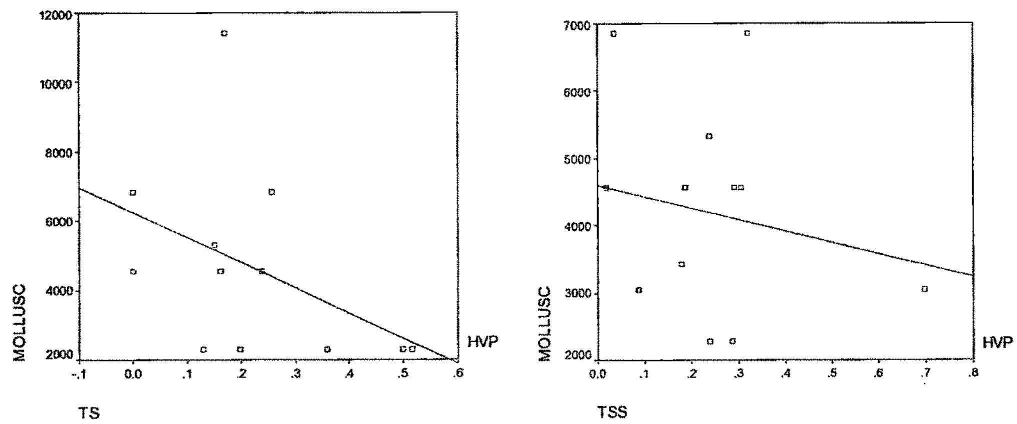
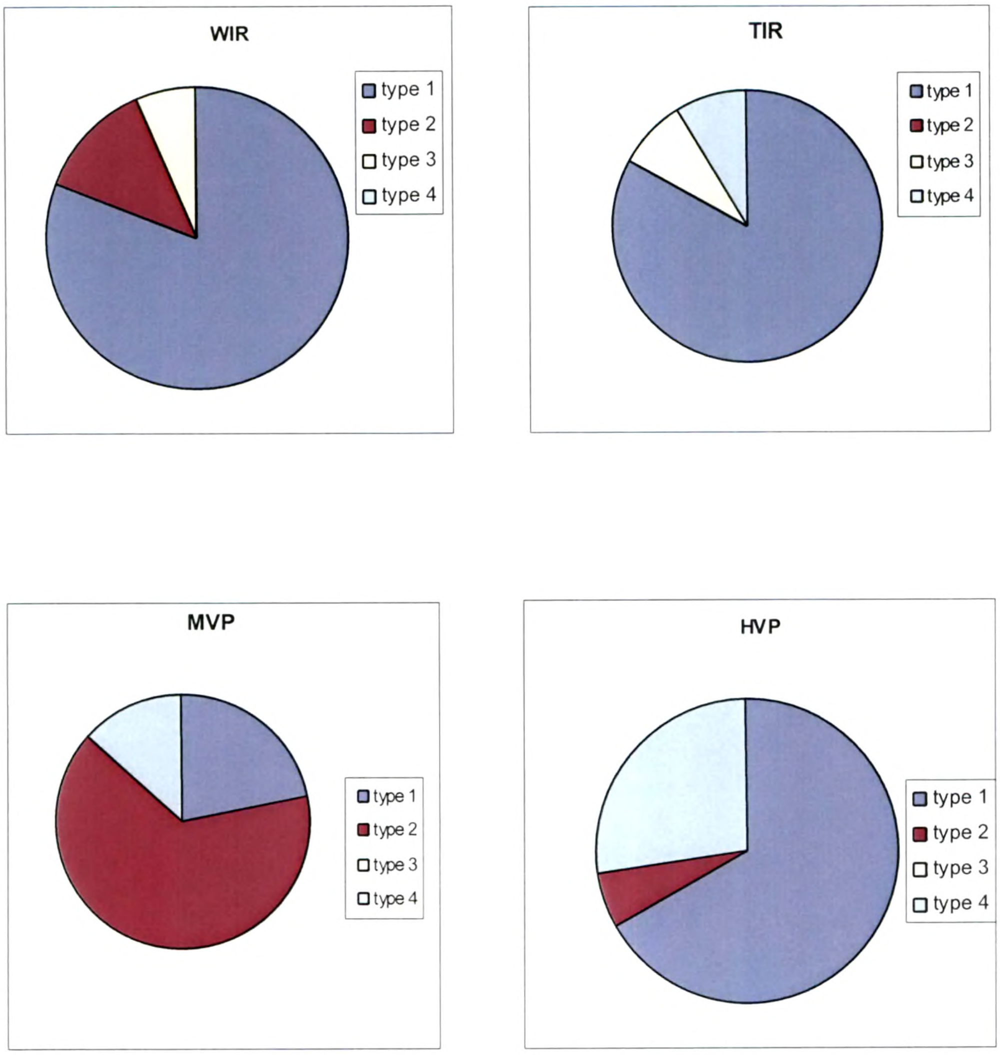


Figure: 2.3: The mollusc species dominance at four study sites during February 2005 to May 2007.



Type I: B. bengalensis, Type II: T. granifera. Type III: L. Consobrinus, Type 4: I. Exustus

At MVP (Fig. 2.2c), a positive correlation between mollusc density and the Hydroxyl alkalinity was established with the correlation coefficient of (0.43). At HVP (Fig. 2.2d) no such significant correlation was established between any parameters, but the TDS and TS have high Pearson correlation with the coefficient of -0.46 and -0.43 respectively. When the percentile species dominance is calculated (Table 2.2) it is seen that at three out of four study sites *Bellamya bengalensis* is the dominating species with the dominance of 81% at WIR, 86% at TIR and 66% at HVP while at MVP (22.0%) it is only frequently observed. At MVP *Thiara granifera* is the dominating species with 64.7%. It is rare at WIR (12.6%) and HVP (5.9%) and was totally absent at TIR. The third species *Lamellae consobrinus* was rare at WIR (6.3%) and TIR (8.8%) and was completely absent at MVP and HVP. The *Indoplanorbis exustus* was often seen at HVP (27.3%) while rarely at TIR (8.8%) MVP (13.2%) and it was absent at WIR. *Pila globosa, Corbiula species* and *Lymnaea acuminate* were found occasionally and hence are not included in percentile dominance.

DISCUSSION:

In the present study, carried out in the semi arid zone of central Gujarat, low species diversity of mollusc was observed. In Lacustrine and Riverine habitats different Species of mollusc are known to occur (Subba Roa, 1989). In the dry deciduous forest of Semi Arid zone of Central Gujarat (Jambughoda Wildlife Sanctuary) which has both lacustrine and riverine habitats, only thirteen species of mollusc have been reported (Anonymous, 2006). In the present study seven species were reported, the density of the said species was always high. No significant changes in the molluscan density over different seasons are observed at WIR and HVP. After Narmada inundations, WIR is retaining water almost all throughout the year (Plate III.B), while HVP is receiving sewage water from the residential area (Plate XII) close to the water body. At both the places though water level decreases, the water cover is not affected much and hence show no significant fluctuations in the density of mollusc. At TIR and MVP floods during monsoon had washed away the earthen dam draining water from the reservoirs (Plate VIII.A and IX.B). These two wetlands are known to dry up partially during summer. This affects the water level as well as water cover resulting in the decline in molluscan density during summer. The seasonal drying of the wetland is expected to lead to more diverse habitat conditions while the perennial wetlands may support the same density of the resident species of organisms throughout the year. Further, according to Balla and Davis (1995) the change in the water level and water cover favours the species richness. The present study also suggests that the change in the water cover (TIR and MVP) brings about a significant change in the density of mollusc whereas the fluctuations in the water level have no significant influence on the molluscan density. The highest density at all the wetlands is observed during the post monsoon, during this time the water level is high favouring the growth of the vegetation and probably the breeding performance of molluscs. The temperature is also favourable during postmonsoon.

At MVP and TIR it is observed that the lowest densities of mollusc occur during summer. In the semi arid zone of India, the summer temperature remains around 40°C, occasionally reaching upto 44-45 °C. At TIR and HVP the sun being high results in decline in water cover. Due to this the molluscs either aestivates or die. Several empty shell accumulate at receding water margins. The decline in mollusc population is associated with seasonal drying of wetlands (Balla and Davis, 1995). MVP dries off partially during the peak summer with only 20% of water cover. At TIR drying starts during early summer when water is released for the irrigation purpose resulting in decline in water cover. As the pond area decreases because of drying, the molluscs (e.g. Apple snail) are known to move towards the water (Darby *et al.*, 2002). Thus, the decrease in the mollusc density at MVP and TIR is because of drying of wetland which might have caused the movement of the mollusc towards the deeper water to aestivate.

Many species of waterfowls feed on mollusc (Stanzykowska *et al.*, 1990; Nisbet, 1997; Grimmitt *et al.*, 1998) and large number of migratory population of waterfowls visit WIR during winter (Padate *et al.*, 2008). This is the period when molluscan diversity is lowest at WIR. During winter the ambient temperature in the area falls bellow 10 °C. again forcing mollusc to hibernate/move to deeper soil. The birds like Godwits, Ibises, Spoonbill and Openbill Storks known to feed on mollusc (Cramp and Simmons, 1977; Urban *et al.*, 1982; Ali and Ripley, 1983) are few of the major species probably benefited because of their long beaks in collecting mollusc from deeper soils. Thes species inhabit WIR in large number

(Chapter I Group 3,). The lowest density of mollusc at HVP is found during monsoon, when water level is high which leads to the submergence of the vegetation, required for the growth and attachment of the mollusc (Boycott, 1936; Macan, 1950) as well as the hiding place for them (Bronmark, 1985). This results to further decline of molluscan density. According to Macan (1950), a good mollusc habitat should have fair but not excessive rooted plant growth. The moderate habitat increases the diversity and density of the mollusc. Major part of HVP is covered with submergent and emergent vegetation. Here, molluscs are collected by sweeping the net across the vegetation and as during monsoon water level is high the molluscs are submerged at the lower levels. Among all the species of birds visiting HVP the population of birds like Coots, Jacana and Moorhens are higher (Chapter I, Group I).

The species composition at all the sites is different. The presence of *Bellamya bengalensis* at all the four sites indicates that the species is well acclimatized with the semi arid zone. *Bellamya bengalensis* is abundantly distributed throughout India and is common to occur in the western zone (Subba Roa, 1989). However, *Thiara granifera* is dominating at MVP. Some of the Thiridae species have high tolerance to brackish habitat (Subba Roa, 1989) and at MVP during late winter and early summer brackish conditions are resulted (Chapter IV). As MVP is only about 15-20 km from Mahi River Estuary, which show one of the highest tidal fluctuations in the world, the underground influence of such tide on water of MVP cannot be ignored. *Indoplanorbis exustus* is mainly found only at HVP. Among the four wetland studied, HVP is the only site polluted with sewage water. *I. exustus* is reported to harbour several parasites (Subba Roa, 1989). Thus, this species thrives in the HVP water with sewage inputs. The relationship of this polluted water with *I. exustus* needs to be evaluated.

Further, it is known that the phytoplankton serve as an important food resource for the mollusc. However, when correlation is considered no strong relationship was found between the mollusc density and the phytoplankton density in the present study (Details in Chapter III). This indicates that phytoplankton density is not the only limiting factor for mollusc in the water bodies studied. There might be several other factors producing collective influence over the populations of molluscs.

Calcium is needed by the mollusc for different physiological processes as well as the building of the shell. Lack of calcium may lead to restriction of reproduction in certain mollusc species (Wareborn, 1970). However, in the present study there was no significant relationship between the density of mollusc and calcium in water in the form of Calcium Hardness. Evaluation of Calcium in water and soil needs detail investigation. The Hardness in the form of $CaCO_3$ is thought to be an important factor which could affect the growth of mollusc as the shell building depends on the amount of the $CaCO_3$ (Mackie and Flippance, 1983). In the present study when the correlation between the mollusc density and the total hardness is carried out it is noted that only at WIR (Fig. 2.2a) total hardness had highest correlation value. However, at TIR (Fig. 2.2b) a negative correlation is established between molluscan density and bicarbonate alkalinity. It has been suggested by Mackie and Flippance (1983) that high bicarbonate concentrations will bring about the higher buffering characteristic feature and hence will favour the mollusc density. Further Dillon and Benfield, (1982) have reported that the alkalinity determines the food available for mollusc. A positive correlation between mollusc density and hydroxyl alkalinity suggests the preference of mollusc towards the more alkaline habitat like that of MVP (Fig.2.2c) and at HVP (Fig.2.2d). No such significant correlation was established with Total dissolved solids howèver the correlation factor was high.

The molluscs are important biota of the inland wetland and may be helpful for determining the habitat quality of wetland. During the present study, the relation of the mollusc with the soil characteristics could not be studied. Further detail study on the similar aspects may give interesting results regarding the molluscan density as well as diversity and that will be helpful for determining the best abiotic/biotic predictor of the mollusc density and diversity.

CONCLUSION:

Molluscs form one of the major part of the macroinvertebrates in wetlands. Many wintering water birds feed primarily on aquatic invertebrates and molluscs are the major component of their food. The present study proves that the water level of a wetland (WIR and HVP), has insignificant seasonal influence on the density of the molluscs. While the seasonal change in water cover shows significant influence in molluscan density.

Seven species were sighted during the present study. The dominating species was *Bellamya bengalensis* at three freshwater wetlands and *Thiara granifera* at wetland with partial brackish influence. The species *Indoplanorbis exustus* that hrabours pathogens is common at urbanpond with sewage input. Hence the present study reports the molluscan density and diversity and different abiotic factors that have varied influence on the molluscan density and diversity in the wetlands of semi arid zone of central Gujarat.