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Full Length Research Paper

Diversity and distribution of Mollusca in relation to the physico-chemical profile of Gho-Manhasan stream, Jammu (J & K)

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The present communication is aimed at assessing the molluscan diversity and distribution under the impact of some physico-chemical variables on them in Gho-Manhasan stream (a distributory of Chenab), Jammu (J & K). The study involved bottom sampling for 12 months (June, 2010 to July, 2011) from the banks of the stream and registered a total of 11 taxa of freshwater molluscs from class Gastropoda and Bivalvia representing 54.453 and 45.546% of the total population of molluscs. Numerically, *Pissidium mitchelli* (Bivalvia) was the most abundant taxa followed by *Melanoides tuberculata* (Gastropoda). *Lymnea luteola*, *Bellamya bengalensis*, *Physella acuta*, *Gyraulus ladacensis* showed less frequent appearance whereas *Lamellidens corrianus* and *Corbicula cashmeriensis* were recorded as rare taxa. Analysis of the data revealed that the physico-chemistry of the stream exercised profound effect on the diversity and distribution of the malacofauna. Significant changes in molluscan assemblages were primarily due to changes in the stream water quality. Coefficient of correlation (r) between molluscs and physico-chemical parameters revealed significant relationship with bivalves.

Key words: Physico-chemical profile, distributory, gastropoda, bivalvia, malacofauna and correlation.

INTRODUCTION

Molluscs are extremely important communities of many ecological communities. They prove immensely beneficial both economically and medicinally (Wosu, 2003). They have been important to humans throughout history as a source of food, jewellery, tools and even pets. Fresh water molluscs play significant role in public and veterinary health (Supian and Ikhwanuddin, 2002). Some fresh water snails are vectors of diseases of humans and livestock, serve as the intermediate hosts for a number of infections such as helminth diseases caused by trematodes (Abd El-Malek, 1958; Dazo et al., 1966; Barbosa and Barbosa, 1994; Brown, 1994; Karimi et al., 2004; Cañete et al., 2004; Kazibwe et al., 2006; Mostafa, 2009). The ecology of these organisms is considered to be affected by environmental factors like physico-chemical parameters (Garg et al., 2009), availability of food, competition, predator-prey interactions (Williams, 1970; Harman, 1972; McMahon et al., 1974; Lassen, 1975; Ofoezie, 1999), substrate architecture (Kershner and Lodge, 1990) and macrophytes (Bronmark, 1985; Costil and Clement, 1996; Ofoezie, 1999).

Although, molluscs are common components of the benthic communities, understanding their role in the aquatic ecosystems and their contribution to biomass production is deficient (Supian and Ikhwanuddin, 2002). Realising the ecological importance of this scantily explored phylum, the present work was undertaken to enlist the molluscan wealth of Gho-Manhanhasan stream in Jammu and to perceive the impact of some physico-chemical variables for a period of one year (July, 2010 to June, 2011). Further, the results obtained can make an effective contribution to holistic water quality assessment and the riverine management studies.

MATERIALS AND METHODS

Study area

Gho-Manhasan stream Figure 2, located at 32.56°N and 74.95°E in

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Figure 1. Map showing the study area.

Jammu (J & K), is a distributory of River Chenab, traverses through the Gho-Manhasan area supporting small villages along its sides. The stream has a great diversity of both flora and fauna (Figure 1). The molluscs constitute an important component of the macrobenthic invertebrate community of the stream (Bangotra, 2012). The stream is surrounded by agricultural fields along its entire length which affect the physico-chemistry of the stream (especially during monsoons) hence its inhabitants. Moreover, the stream receives sewage, domestic waste water and also faces anthropogenic pressure such as fishing, washing of clothes and utensils, cattle bathing, construction activities as stated by Bangotra (2012).

Collection of molluscs

Collection of molluscs was done from 4 littoral sites of the stream by collecting bottom samples by quadrant method using Ekman's dredge having an area of 232 cm^2. The samples were put into separate polythene bags and were brought to the laboratory for further studies. The samples were washed in the laboratory and the molluscs were isolated using sieve no. 40 with 256 meshes/cm^2 and preserved with 70% ethyl alcohol. Preserved samples of molluscs were identified with the help of Ward and Whipple (1959), Pennak (1978), Tonapi (1980) and Adoni (1985). The abundance of these organisms was calculated as number per square meter by applying the following formula:

N= O/A.S x 10,000 Welch (1948)

Where, N = no. of macrobenthic organisms/m^2; O = no. of organisms counted; A = area of metallic sampler in square meter; S = no. of samples taken at each stations.

For the analysis of physico-chemical parameters, the water samples were collected from 4 littoral sites of the stream and were brought to the laboratory for further experimental study. pH was measured using portable pH meter (Hanna model) at the study site. Dissolved oxygen, free carbon dioxide, carbonates and bicarbonates, chloride, calcium and magnesium were measured by following procedure recommended by APHA (1985). Physical parameters like water temperature, depth, transparency and velocity were also measured every month during the study period.

Statistical analysis

Statistical analysis of data was done using Margalef's Richness index (d′), Shannon-Weiner index (H′), Simpson's Dominance index (D) and Pielou's equitability index (J).

RESULTS

The data presented in the present manuscript comprises of the average of the actual number of molluscs/m^2 collected monthly from the 4 selected study sites.

A total of 1330.5 molluscs from two classes, viz., Gastropoda (7 species) and Bivalvia (4 species) were collected during the present study contributing 54.453 and 45.546% to the total annual molluscan count (Table 1 and Figure 3). Class Gastropoda included *Bellamya bengalensis* (Lamarck, 1822), *Melanoides tuberculata* (Muller, 1774), *Lymnea accuminata* (Lamarck, 1822), *Lymnea luteola* (Lamarck, 1822), *Physella acuta* (Draparnaud, 1805), *Gyraulus ladacensis* (Nevill, 1878) and *Indoplanorbis exustus* (Deshayes, 1834) whereas class Bivalvia comprised of *Pissidium mitchelli (Prashad)*,

Figure 2. Views of Gho-Manhasan stream showing natural habitat of molluscs.

Sphaerium indicum (Deshayes, 1854), *Corbicula cashmeriensis* (Desh.) and *Lamellidens corrianus* (Lea, 1834). *P. mitchelli* was found to be quantitatively richest taxa followed by *M. tuberculata* which is clearly depicted in Table 1 and Figure 4. The seasonal variations in the population density of molluscs is depicted in Figure 5 which shows that *M. tuberculata*, *L. accuminata*, *P. mitchelli* and *S. indicum* were collected frequently as compared to *B. bengalensis*, *L. luteola*, *P. acuta*, *G. ladacensis* and *I. exustus* and to the rarely recorded *C. cashmeriensis* and *L. corrianus.*

Peak in the population of gastropods was observed during March, 2011 whereas their lowest number was recorded during December, 2010. On the contrary, increase in population of bivalves was observed in winter with their maximum number during December, 2010 and their complete absence was recorded from April, 2011 to June, 2011. An overall decline in their population was also observed during rainy season (July, 2010 to September, 2010). The details of the physico-chemical parameters with range and standard deviation are shown in Table 2. Table 3 shows the correlation coefficient (r) values between physicochemical parameters and the population of gastropods and bivalves revealing significant correlation of bivalves with the stream water quality. This implies that the observed significant change in molluscan assemblages was due to the alterations in the abiotic factors.

DISCUSSION

In this piece of work, predominance of gastropods was registered over bivalves which is in agreement with Sharma et al. (2009) who also recorded similar predominance of gastropods while studying the distribution and ecology of some fresh water molluscs of the Jammu division of J&K state.

In consonance with the findings made in the present work, Subba (2003) reported ten freshwater molluscs from Ghodagodhi Tal Area (Kailali district) which included *B. bengalensis* f. *typica*, *Pila globosa*, *I. exustus*, *Lymnaea accuminata* f. *typica* and *L. accuminata refeseens*. Hussein et al. (2011) also recorded 13 snail species (9 families) from Qena Governorate, Upper Egypt represented by *Bellamya unicolor*, *M. tuberculata*, *Lymnaea natalensis*, *Physa acuta*, *Gyraulus ehrenbergi* and others.

The abundance of the malacofauna was observed to be favoured by the environmental conditions prevailing in the stream including abiotic and biotic components. Garg et al. (2009) also attributed the richness of molluscs observed in Ramsagar dam to the cumulative effect of alkaline nature of water, high calcium contents and the presence of macrophytic vegetation.

The highest gastropod count recorded during March, 2011 from the stream corresponds with Diab (1993) who reported higher snail abundance in Spring and low in Summer in Beheira Province. The presently recorded low count of gastropods agrees with El-Kady et al. (2000) who also recorded lowest number of snails during winter (January and February) in Sinai Peninsula. Supian and Ikhwanuddin (2002) reported that *M. tuberculata* is the commonest and most wide-ranging member of the family Thiaridae, found in almost any kind of freshwater. Peak in the population of *M. tuberculata* recorded during October, 2010 is in agreement with Hussein et al. (2011) who reported that this species showed a maximum cohort of small-sized individuals in October, 2009. According to Pointier et al. (1993), maximum reproduction of this species took place between June and November in France. Flores and Zaffaralla (2012) also cited Thiaridae as the most persistent and abundant macroinvertebrate family. Contreras-Arquieta (1998) reported that members of Thiaridae are quick colonizers, tolerant to habitat diversity and variability due to a very strong and thick shell; many forms are parthenogenetic females capable of multiplication in a short time, viviparous, operculate and have average longevity of five years. Highest count of *P. acuta* recorded in March, 2011 finds support from Hussein et al. (2011) who also reported a March-May peak in their population.

Strzelec and Królczyk (2004) indicated that many gastropod species are tolerant to most physico-chemical parameters and their occurrence is affected by the quality of bottom sediments and abundance of vegetation and reported that the most suitable substrate for snails in rivers is a sandy bottom covered with thin layer of organic silt. Lacoursiere et al. (1975) and Vincent et al. (1982) suggested that gastropod variability may be explained by

Figure 3. Molluscan fauna of Gho-Manhasan stream.

abiotic factors like depth, current and sediments. Jurkiewicz-Karnkowska (2011) opined that low food quality, especially in many semi-permanent habitats, could constrain the development of molluscan communities.

Temperature seems to be an important factor for the distribution of molluscs as gastropods showed a positive correlation (Table 3). Bivalves, however, exhibited a negatively significant correlation with water temperature. Further, temperature plays an important role in abundance of *Lymnaea* sp. (Cañete et al., 2004). Michael (1968), Dutta and Malhotra (1986) and Malhotra et al.

Table 1. Seasonal abundance of molluscan density in Gho-Manhasan stream from July, 2010 to June, 2011.

Name of organism	Jul, 2010	Aug, 2010	Sep, 2010	Oct, 2010	Nov, 2010	Dec, 2010	Jan, 2011	Feb, 2011	Mar, 2011	Apr, 2011	May, 2011	Jun, 2011	Total org/m^2	APC
Phylum – Mollusca														
Class - Gastropoda														
Family – Viviparidae														
Bellamya bengalensis	0	0	0	2.25	0	0	0	11.25	33.75	18	0	0	65.25	4.904
Family – Thiaridae														
Melanoides tuberculata	24.75	31.5	29.25	103.5	18	29.25	29.25	11.25	18	6.75	0	0	301.5	22.660
Family – Lymnidae														
Lymnea accuminata	13.5	2.25	0	9	24.75	0	38.25	27	0	4.5	20.25	2.25	141.75	10.653
L: luteola	0	0	2.25	4.5	0	0	0	0	4.5	0	0	0	11.25	0.845
Family – Physidae														
Physella acuta	2.25	0	0	0	0	0	0	4.5	90	0	0	0	96.75	7.271
Family – Planorbidae														
Gyraulus ladacensis	0	0	0	4.5	0	0	0	2.25	6.75	15.75	0	27	56.25	4.227
Indoplanorbis exustus	0	15.75	0	0	0	0	0	0	0	0	13.5	24.75	54	4.058
Total Gastropoda	40.5	49.5	31.5	123.75	40.5	29.25	67.5	56.25	153	45	33.75	54	724.5	54.453
Class – Bivalvia														
Family – Sphaeriidae														
Pissidium mitchelli	11.25	6.75	15.75	15.75	69.75	108.75	108	128.25	27	0	0	0	491.25	36.922
Sphaerium indicum	2.25	0	2.25	11.25	18	36	20.25	13.5	0	0	0	0	103.5	7.779
Family – Corbiculidae														
Corbicula cashmeriensis	0	0	0	4.5	0	0	0	0	0	0	0	0	4.5	0.338
Family – Unionidae														
Lamellidens corrianus	0	0	0	0	6.75	0	0	0	0	0	0	0	6.75	0.507
Total Bivalvia	13.5	6.75	18	31.5	94.5	144.75	128.25	141.75	27	0	0	0	606	45.546
Total Mollusca	54	56.25	49.5	155.25	135	174	195.75	198	180	45	33.75	54	1330.5	

APC = Annual percent contribution.

(1996) also recorded a positive correlation between molluscs and temperature, while a negative correlation between temperature and molluscs was noticed by Ricker (1952), Shrivastava (1956) and Vasisht and Bhandal (1979). This study revealed that molluscs were negatively correlated with depth of the stream. A similar negative correlation between water depth and some molluscs (*Cleopatra bulimoides*, *Theodoxus niloticus*, *Succinea cleopatra* and *Bulinus truncatus*) was reported by Hussein et al. (2011).

The results obtained in this survey revealed a positive correlation of malacofauna with transparency (Table 3). To our knowledge, the mussels are well known for their filtering ability which enhances water clarity of the aquatic media. Mcivor (2004) also discussed the potential

Table 2. Mean ± SD of the physico–chemical parameters recorded from the Gho-Manhasan stream.

Parameters	Minima	Maxima	Mean ± SD
Air temperature (°C)	11.0	39.0	14.75 – 0.21 ± 36.1 – 3.03
Water temperature (°C)	9.0	28.0	9.0 – 0 ± 28.37 – 3.20
Depth (cm)	8.8	48.0	10.75 – 1.51 ± 32.65 – 10.06
Transparency (cm)	2.4	48.0	5.5 – 0.19 ± 32.50 – 10.06
Speed (m/s)	0.11	0.41	0.16 –0.01 ± 0.33 – 0.05
Dissolved oxygen (mg/l)	4.4	22.0	5.5 - 0.48 ± 20.5 – 2.63
pH	6.8	8.1	6.87 – 0.07 ± 7.57 – 0.41
Free Carbon dioxide (mg/l)	0	14.0	2.36 – 0.92 ± 10.0 – 2.83
Carbonate (mg/l)	0	24.0	13.0 – 0 ± 24.0 – 3.0
Bicarbonate (mg/l)	189.1	884.5	337.02 – 12.41 ± 756.4 – 143.8
Calcium (mg/l)	8.82	64.96	11.02 – 0.56 ± 60.13 – 11.47
Magnesium (mg/l)	17.98	69.98	21.86 – 1.04 ± 66.21 – 6.43
Chloride (mg/l)	15.96	79.84	16.46 – 1.41 ± 73.84 – 8.64

Table 3. Correlation coefficient (r) between molluscs of Gho-Manhasan stream with some physico-chemical parameters.

Parameters	Gastropoda	Bivalvia
Water temperature	0.11794	-0.81949*
Depth	-0.02545	-0.32164
Transparency	0.263124	0.37901
Velocity	-0.20228	-0.55863*
Dissolved oxygen	-0.07476	-0.202
pH	0.18796	0.76517*
FCO_2	-0.17703	-0.30251
CO_3^{2-}	-0.16176	0.69611*
HCO_3^-	0.40366	0.35283
Ca^{2+}	-0.02713	0.31325
Mg^{2+}	0.11542	0.48197
Cl^-	0.1272	-0.13325

*Marked correlation was significant ($p < 0.05$).

role of fresh water mussels as “living biofilters” due to their key participation in removal of suspended particulate matter in the river ecosystems. As per his findings, the filtration rates of mussel populations in four British rivers indicated that mussel filtering removed between 7 and 30% of the particulate matter in a parcel of water travelling 10 km downstream.

The stream flow exerts greater influence on the distribution of these macrobenthic invertebrates which was concluded from this work as both gastropods and bivalves were negatively correlated with the stream velocity (Table 3). Appleton (1978) also described water flow in lotic environments as the most important factor for explaining the longitudinal distribution of the snails that are the intermediate hosts of *Schistosoma* spp. In a survey conducted by Giovani et al. (2005), the water flow and rainfall were designated as variables responsible for the distribution of population of *Physa marmorata* and *M. tuberculata.*

The pH recorded in the stream ranged from slightly acidic to highly alkaline and furnished a weakly positive relationship with gastropods, whereas a strongly significant correlation with bivalves as depicted in Table 3. However, a very weak and insignificant negative correlation between molluscs and pH recorded by Garg et al. (2009) suggests that molluscs were found to be independent of fluctuations with respect to pH value. The findings of Martins-Silva and Barros (2001) revealed that acidic pH is unfavorable to the occurance of molluscs.

Positive correlation of bicarbonate alkalinity with both the classes of molluscs and a significant correlation between carbonates and bivalves indicate that the alkaline

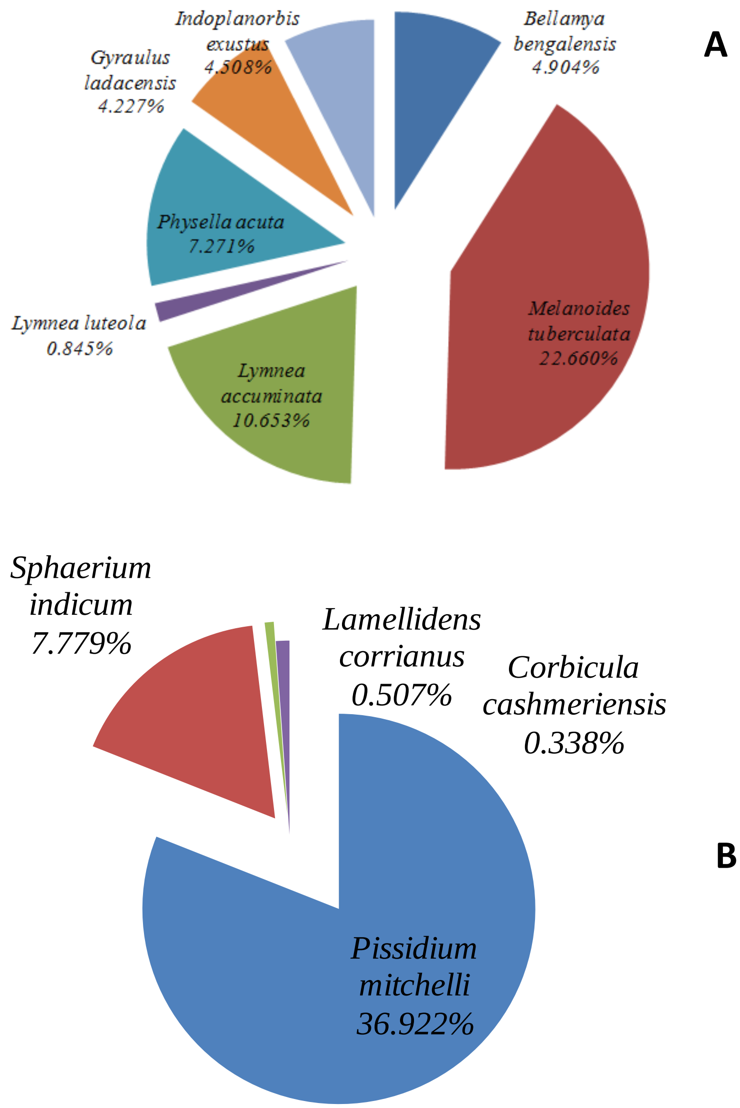

Figure 4. Pie chart showing annual percent contribution of different gastropods and bivalves to the total molluscan population.

conditions promoted abundant molluscan populations (Table 3). Sakhre and Joshi (2003) also supported this point of view by observing the greater molluscan population in alkaline lakes as compared to acidic-lakes.

The molluscs were found to exhibit a negative correlation with FCO_2 as shown in Table 3. Similar relationship between molluscs and FCO_2 was recorded by Garg et al. (2009) for the molluscs of Ramsagar Reservior (M.P).

Both gastropods and bivalves had a negative insignificant relationship with DO (Table 3) which finds support from Garg et al. (2009) report. Cheatum (1934) and Sharma (1986) documented that some molluscs can survive in very low oxygen conditions and have noted an inverse relationship between the two.

Gastropods were observed to show a very weak negative correlation with calcium as shown in Table 3 which gets support from the findings of Hussein et al. (2011) in which calcium concentration was negatively correlated with the abundance of *B. unicolor, Succinea cleopatra, P. acuta* and *Biomphalaria alexandrina* (decreased with increasing Calcium). Georgiev and Stoycheva (2010), however, recorded a total of 28 snail species on the Samothraki Island (North-Eastern Greece) and reported their abundance in humid environment, being particularly accumulated at places where artificial sources of calcium were available. Bivalves on the contrary, were found to show a moderately positive correlation with calcium. Several authors showed that calcium concentration is an important factor in controlling the abundance and distribution of molluscs in freshwater (Boycott, 1936; Macan, 1950; Mckillop and Harrison, 1972; Dussart, 1976, 1979; Supian and Ikhwanuddin, 2002). Aquatic molluscs are known to accomplish their

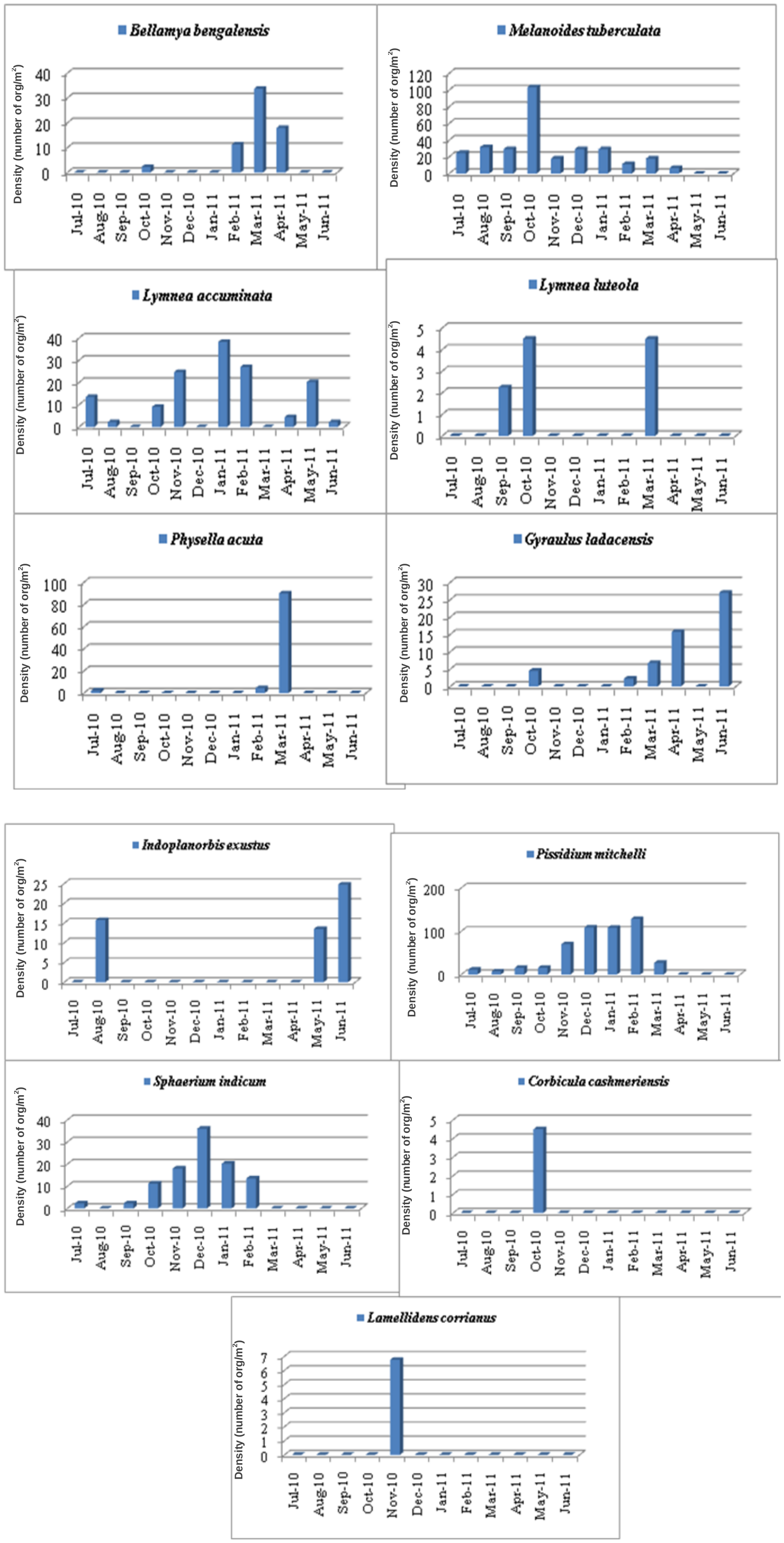

Figure 5. Seasonal variations in the density of each molluscan species (number of org./m^2) collected from Gho-Manhasan stream.

calcium requirements by absorption of calcium from the external medium (Jodrey, 1953; Kado, 1960; van der Borght, 1963) although calcium present in the food is also utilized (van der Borght and van Puymbroeck, 1966).

The correlation values presented in Table 3 reveal that chlorides and bivalves was negative. However, a positive correlation of chlorides with the gastropods suggests that the chloride content of the water body may favour their survival. The sources of chloride were the effluent and sewage discharge by residents of adjoining areas. Feema (1981) also reported high chloride content due to the discharge of contaminants like urea rich sewage. Other sources of chloride included surface run-off during monsoons and defaecation activities (human and cattle). Such conditions were considered ideal for the rapid multiplication of gastropod species. The present view is supported by Ndifon and Ukoli (1989) who also recorded frequent presence of thairid, *M. tuberculata* in environment receiving domestic sewage and animal as well as human excrements. Giovanelli et al. (2005) also associated abundance of *M. tuberculata* with faecal coliforms and high chloride concentration in the studied lotic systems.

Conclusion

The freshwater molluscs play a massive role in nature and help in assessment of ecological status of the water bodies. Being herbivores, they form the lower strata of aquatic trophic linkages and perform many other ecological activities. Hence, studies pertaining to their diversity, distribution and ecology become imperative. The results of the present study indicated that the diversity and distribution of the malacofauna of Gho-Manhasan stream, especially, a thiarid, *M. tuberculata* and bivalves intimately correlated with the physico-chemical regime of the stream. These species can be considered as bioindicators of pollution as they were found to respond prominently to nutrient inputs, discharge of sewage and excreta produced by animals and humans. A progressive increase in their number with increasing pollution load indicates that they possess great tolerance against the contaminants present in water and flourish well in their presence. Findings of the present work shall be utilized by future researchers and ecologists as supplementary information in public and veterinary health sciences, ecotoxicology, water quality assessment and river management studies.

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