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Community Structure of Macrophyte Associated Invertebrates in a Tropical Kole Wetland, Kerala, India

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Abstract

Aquatic macrophytes provide a good ecological niche for macro invertebrates and may occupy the littoral region of wetlands. This contribution discusses the macrophyte associated macroinvertebrate assemblage and abundance in the Maranchery Kole wetland that is part of Vembanad Kole wetland system, a Ramsar site on the west coast of India. It lies submerged under water for about six months in a year giving both terrestrial and water related properties. Six macrophyte species were observed from the four study stations of the wetland among which Hydrilla verticillata, Utricularia aurea, Eichhornia crassipes, are more common and showed maximum biomass. The macrophyte associated invertebrate community in the wetland carried out from October 2010 to September 2011 period varied widely during the pre monsoon, post monsoon and monsoon seasons. It comprised of 10 taxa belonging to insects, insect larvae, arachnids, decapods, molluscs, branchiopods, hirudinea, nematodes, isopods and, fish fingerlings. Insect larvae was found to dominate during premonsoon (34%), monsoon (36%), whereas decapods (47%) dominated during postmonsoon season. The macrophyte, Hydrilla verticillata was associated with the maximum numerical abundance (400 No/m^2) of macro invertebrates during the monsoon season. Thus the high growth and density of macrophytes in Maranchery Kole wetland was conducive for the abundance and diversity of several macroinvertebrates. This would be help in the propagation of native fish species in such wetlands involving the local self-government bodies and other people's participatory programs.

Keywords: Kole wetland, macrophytes, invertebrates, nutrients.

Introduction

Fresh water habitats are among the most valuable and threatened ecosystems[1]. They are the fragile ecosystems that are susceptible to damage even with only a little change in the composition of biotic and abiotic factors. Kole wetlands are one of the important floodplain wetlands of Kerala[2] and these ecosystems which provides answer for the livelihood concerns of the thousands of inhabitants in and around this region also support a wide spectrum of biodiversity which depends on the annual rise and fall of the floods.

It is generally known that aquatic plants provide a physically and chemically complex habitat in aquatic ecosystems, and architectural features of this habitat can act invertebrate species diversity, density and distribution[3]. Macro invertebrates perform several critical role in ecosystem by virtue of their numerical abundance, diversity and trophic significance. Macrophytes are generally found in littoral zones in lakes and rivers. The value and abundance of habitat provided by each species of macrophytes for invertebrates may vary depending on the zone they occupy[4]. While several investigation have been conducted on the spatio-temporal variability in invertebrate and macrophyte associations[5-7], few studies have been carried out in wetlands and few have specifically dealt with the issue of how changes in water level, and related environmental parameters, may influence macrophytes and the invertebrates which use them[8,9,10]. Studies were very rare in Kerala especially the macro invertebrates associations with macrophytes. Productivity and fishery potential of South west coast of India was investigated with special reference emphasis to Ramsar sites[11]. In Kole wetlands water column was reduced seasonally this spatial variation may influence habitat choices in invertebrates and result in movement between macrophyte species which may occur at different depths and have different complexities of structure. Keeping in view the importance of Kole wetlands and general dearth of literature, the present work was undertaken to assess the physico-chemical property of water, macrophyte growth and water column fluctuations on macro invertebrate abundance and diversity.

Morphometry and Geographical location: Variability is the principal feature of this wetland as it varies widely from season to season. Based on the pattern of rainfall in Kerala**,** three seasons are recognized, Monsoon (June-September) when the south-west monsoon is active, post monsoon (October-January) when the north-east monsoon become active and pre monsoon (February -May). The Kole wetland is located in the Veliamkode and Maranchery panchayats in the Malappuram district of Kerala. It is positioned at 10^0 72' N latitude and 75^0 98' E longitude, figure-1. The portion of the wetlands in the Maranchery panchayat were occupied mainly by migratory waterfowl in large numbers, while that in the Veliamkode panchayat is under paddy cultivation seasonally using chemical fertilizers and pesticides. The two areas were separated by an earthen bund. Two sampling stations (1 and 2) are seasonally flooded, and under seasonal paddy cultivation. The other two stations (3 and 4) were not under paddy cultivation and were inundated with water throughout the year. The depth varied from 2.5 m in monsoon to 0.5 m during pre monsoon.

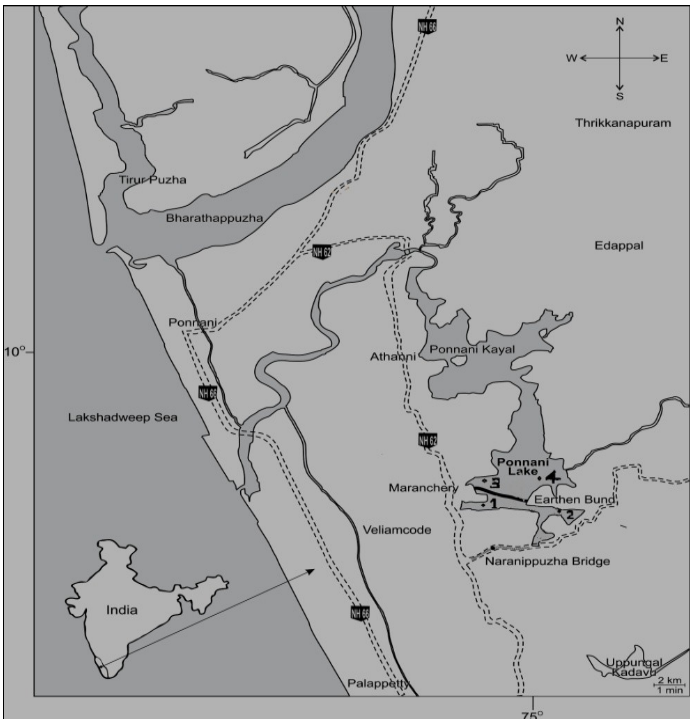

Figure-1
Field map of Maranchery wetland

Material and Methods

Monthly field collections were made from the four stations during October 2010 to September 2011. Temperature was measured by a 0-50^0C precision thermometer. Surface water samples were collected in replicates for estimating pH, total dissolved solids (TDS), alkalinity, dissolved oxygen (DO), hardness, as well as the inorganic nutrients, No_3-N, No_2-N, Po_4-P and ammonia. All analysis were based on standard procedures[12-14]. SPSS version 11.0 was employed to analyse (analysis of varience: ANOVA) and correlation between water quality parameters.

Macro invertebrate sampling and sample processing: Macro invertebrates associated with each macrophyte species were sampled using a 500 µm mesh net, attached with a 25cm x 25 cm diameter quadrate. Replicate samples were taken randomly from monospecific patches of macrophyte species. The mesh net was placed carefully over the macrophytes, a draw-string at the mouth of the net pulled tight and plant material was cut gently approximately 5 cm above the substratum at water level with scissors. The mouth of the net was then turned upward, and lifted out of the water and the contents washed into a plastic bag[15]. In the laboratory, the wet weight of total plant sample was determined. From that, 50gm plant samples were screened, sorted and identified for invertebrates to the lowest possible taxa according to standard literature with the help of a stereoscopic microscope[16-18]. Macrophytes were identified with the help of available field keys and floras (Flora of Madras Presidency[19]).

Results and Discussion

Environmental parameters: The water level in the wetland dropped by 0.5 m from December 2010 to May 2011 in Station 1 and 2, then rose again in June above, 2.0 m. Whereas, depth of water column lowered from 2.5m to 1m in dry period in Station 3 and 4, figure-2. ANOVA result of depth of the water body showed that it was significant at 1% level between seasons (F=81.14) and stations (F=12.40). Water temperature followed the water level changes, inversely, with temperatures rising from December to May (34^0C) and then falling in June (30^0C). pH showed a well marked seasonal variation, where the maximum values were recorded in post monsoon season in Station 4, while minimum values were observed in pre monsoon season in Station 1, represented in figure-3. The pH values ranged from 5.0 to 7.5. The fluctuations observed in the pH could be linked directly or indirectly to macrophyte abundance which at the time of decomposition released high amount of carbon dioxide resulting in low pH[20].

The TDS ranged from 51.0 ppm to 430 ppm. The total dissolved solids comprise mainly of inorganic salts and small amount of organic matter. A positive correlation (r^2=0.911) significant at 1% level emerged between TDS and pH. Seasonal variation of TDS was very prominent, represented in figure- 4 similar finding with regards to seasonal variation of TDS have been reported in Ravindra Sarovar (Gaya)[21]. The lowest mean value of alkalinity was recorded at 19 mg/L in monsoon period and highest of 68 mg/L during post monsoon period, represented in figure-5. ANOVA of TDS and alkalinity was significant at 1% level between seasons during the study period. A negative correlation coefficient was observed between the alkalinity and total dissolved solids. Total alkalinity were influenced not only by climatic factors such as temperature and rainfall but also by paddy cultivation practices such as liming and fertilization[22]. Alkalinity may also be caused due to evolution of carbon di oxide during decomposition of organic matters[23].

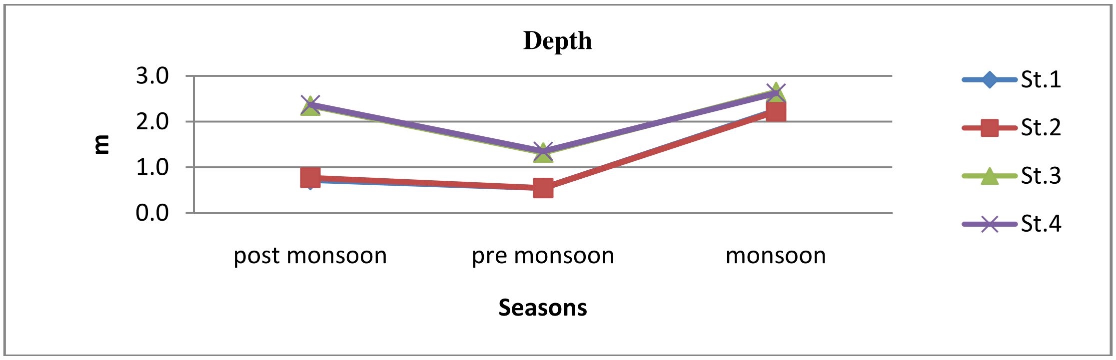

Figure-2
Mean seasonal variation of Depth

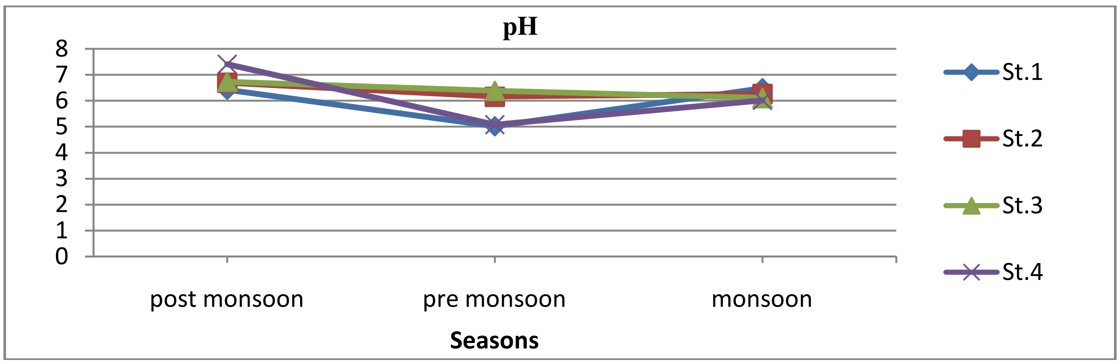

Figure-3
Mean seasonal variation of pH

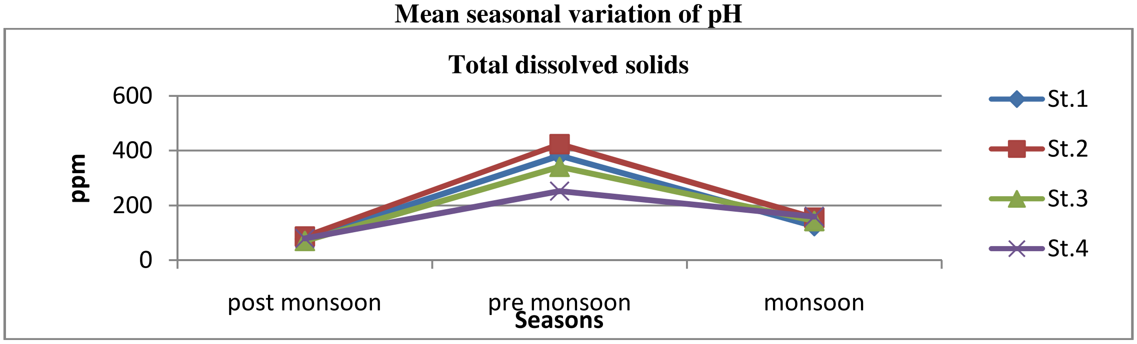

Figure- 4
Mean seasonal variation of Total dissolved solids

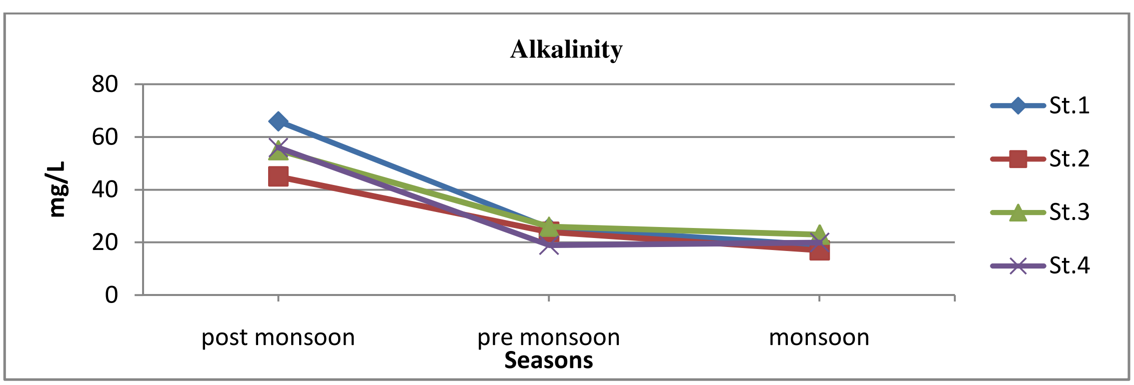

Figure-5
Mean seasonal variation of Alkalinity

The dissolved oxygen (DO) ranged from 5.8 mg/L to 7.0 mg/L. DO level exhibits wide variation during pre monsoon period (4.2mg/L to 8.3mg/L) while monsoon and post monsoon period, depicted in figure-6. The ANOVA of dissolved oxygen showed that variations between stations were significant at 1% level (F= 6.16). The lowest value of dissolved oxygen (4.2 mg/L) was recorded in the *Eichhornia crassipes* stand. During the study period, the values of DO concentration were not lower than 4 mg/L, below which the hypoxic conditions would make vulnerable for macro invertebrate existence and in Station 4 floating plants like *Eichhornia crassipes* may eliminate oxygen from the water column and promoting reduction process in the medium[24,25].

The nutrients represented by nitrate-nitrogen, nitrite-nitrogen, phosphate- phosphorus and ammonia were low, in all the study stations but showed marked variation between seasons, which is represented in figure- 7, 8, 9, and 10. Nutrients showed same trend between seasons except nitrite-nitrogen. ANOVA showed that nitrate-nitrogen and other nutrients like, nitrite, ammonia, and phosphate were significant at 1% level between seasons. A negative correlation significant at 5% level (r^2= -0.163) emerged between phosphate and total dissolved solids. Among the nutrients, nitrite values were the lowest with mean of 0.02 µmol/L for the wetland, that of phosphate was 0.13 µmol/L and that of nitrate was 0.003 µmol/L. Studies shows that to reach equilibrium among nitrogen compounds in the water medium at least 0.03mg/L of nitrite,<1.1 mg/L of nitrate and 2.6 mg/L of phosphate-phosphorus is recommended[26]. In this study all compounds were below the limits recommended. In addition, macrophytes have the ability to store nitrogen and phosphorus in reserve organs after fruiting stage, which varies according to species, locality and season[27]. A positive correlation coefficient significant at 5% level (r^2= 160) was observed between nitrate and water temperature, that with nitrate and pH significant at 1% level (r^2= 0.249) and also with alkalinity (r^2=0.502) significant at 1% level. The concentration of nutrients increased in pre monsoon period with decrease in macrophyte density that may be due to the extensive farming activities in the adjacent paddy fields. More over in premonsoon period migratory birds were common in this area, bird droppings was also one of the reason for increased phosphate concentration. Similar observation was also reported from Ujani wetlands[28].

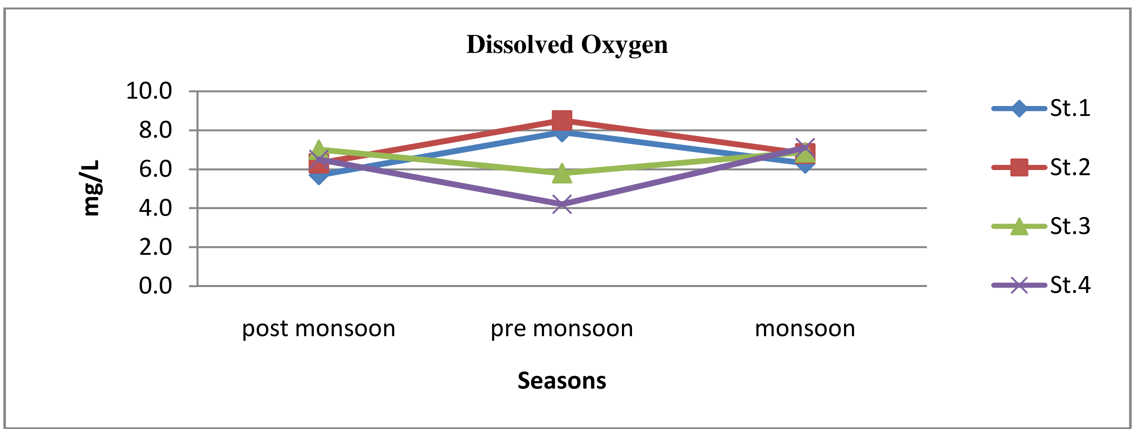

Figure-6
Mean seasonal variation of Dissolved Oxygen

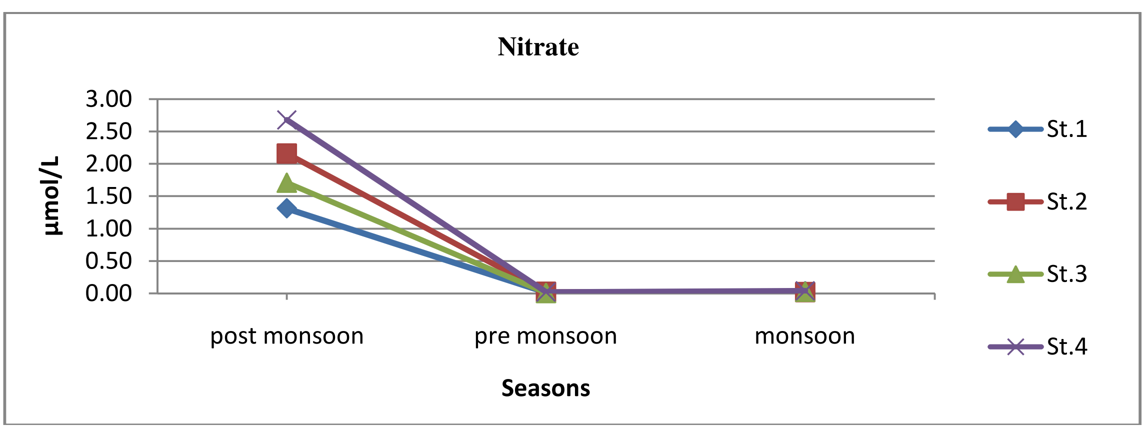

Figure-7
Mean seasonal variation of Nitrate

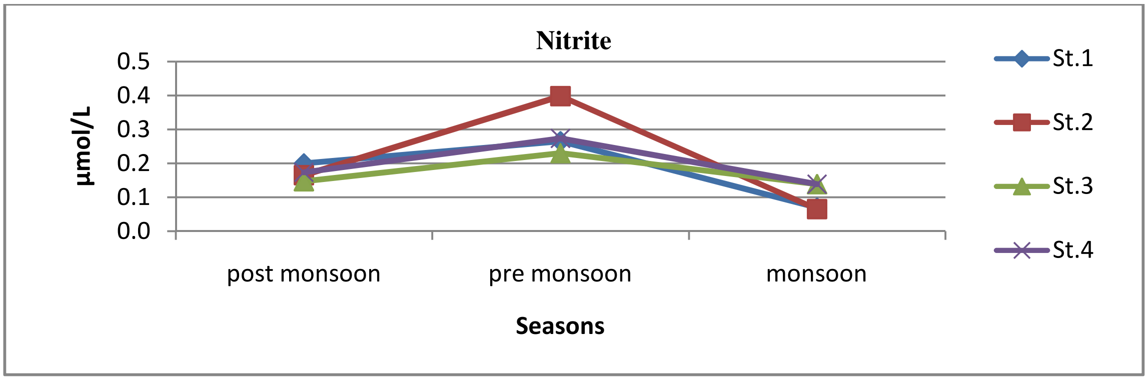

Figure-8
Mean seasonal variation of Nitrite

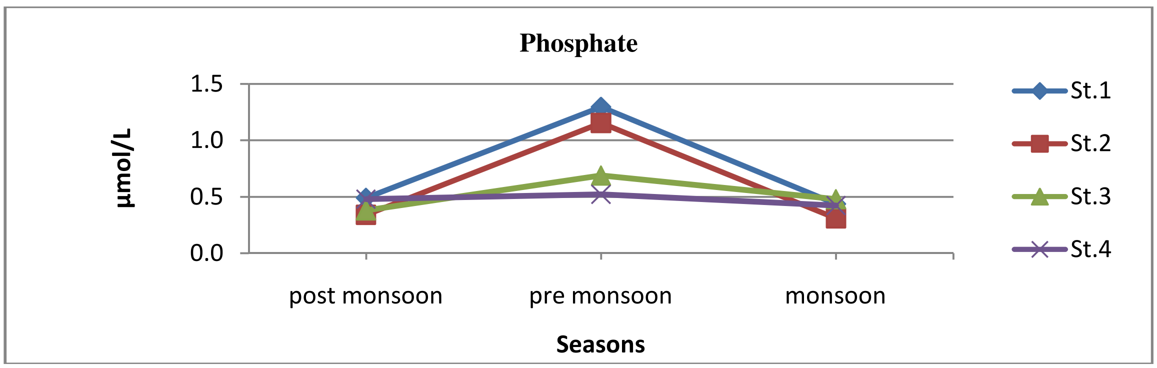

Figure-9
Mean seasonal variation of phosphate

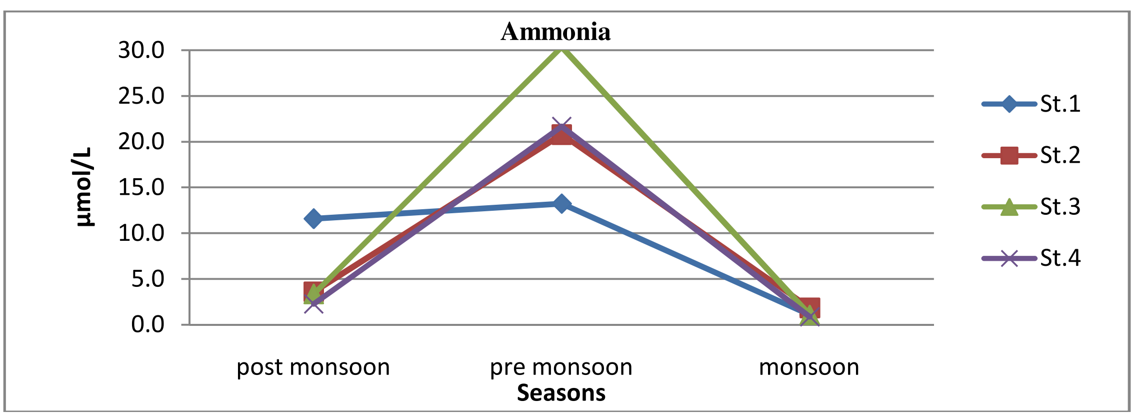

Figure-10
Mean seasonal variation of ammonia

Macrophyte density and distribution: The total plant biomass ranged from 60 to 260 g/m^2 fresh weight with a mean value of 185g/m^2 and showing specific variation in four stations, represented in figure -11. The biomass of macrophytes increased in monsoon season. Increase in water level and moderate nutrient conditions of the wetland may lead to prolific growth of macrophytes in monsoon. Six prominent macrophyte communities sampled: the macrophyte *Hydrilla verticillata, Utricularia aurea* collected from Station 1 and 2. Nymphaceae was common in Station 3, *Nymphaea pubescens* and *Nymphaea stellata* were common in monsoon and post monsoon period whereas *Nymphoides indicum* collected during pre monsoon period. Station 3 had the least biomass of plant material. *Eichhornia crassipes* were sampled from Station 4 and were moderately high in the biomass in three seasons. There was a striking contrast between the macro invertebrate populations in the stations with dense macrophyte growth and those with sparse macrophyte growth. Same phenomena with benthic invertebrates growing on *Eichhornia* sp. in lake Kariba observed by Mhlanga and Siziba[29].

Seasonal variation in composition and abundance of macro invertebrate: The relative composition of macro invertebrate communities associated with macrophytes in the Maranchery Kole wetland were typically dominated by insect larvae in premonsoon and monsoon seasons (34% and 36%) whereas in post monsoon season decapods were dominated (47%) which is represented in figure- 12, 13, and 14. More over in premonsoon period the entire composition of invertebrate was poor (8 groups) comparative with post monsoon and monsoon season (10 groups). The other groups majorly observed in Maranchery Kole wetland were arachnids (Acari and spiders), molluscs, branchiopods, ostracods, hirudinea, nematodes, isopods and fish fingerlings. The result showed that macrophyte abundance and water column depth significantly affect the macroinvertebrate abundance and composition.

The numerical abundance of insect larvae diversity was maximum in monsoon period in all 4 Stations, depicted in figure-15. In this study abundance of invertebrate is closely related to hydrological periods and the oxygen depletion, which causes a decrease in total abundance of invertebrates, is found at low water period. Among the aquatic insects larvae the highest number (400 No./m^2) was associated with *H. verticillata* and *U. aurea* (240 No.m^2) from Station 1 and 2, which were completely below the water surface during the sampling period also this plant having long dissected leaves. In Station 3 pre monsoon period, *N. indicum* plant contributed least number of aquatic insect larvae (20No./m^2). The floating, undissected leaves (*N. Alba and N. stellata*) harboured the lowest numbers of aquatic insect larvae (30 No./m^2) in monsoon and post monsoon periods. *E. crassipes* contributed 180No./m^2 in monsoon period and 75No./m^2 in premonsoon period. The numerical abundance of aquatic insect larvae communities observed during the study is presented in figure-16. A similar trend was observed in insect community compared to larval community. Station 1showed higher abundance (160 No./m^2) in monsoon period and Station 3 showed least abundance (16 No./m^2) in post monsoon period.

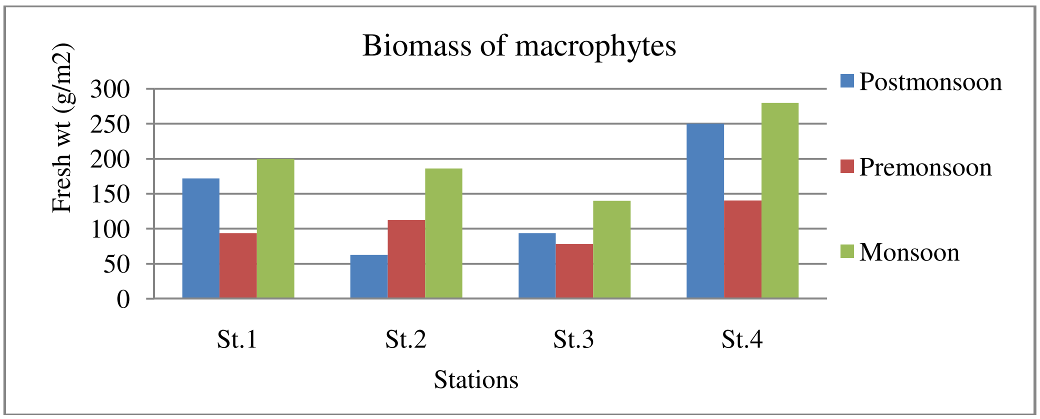

Figure-11
Mean seasonal variation of macrophytes biomass

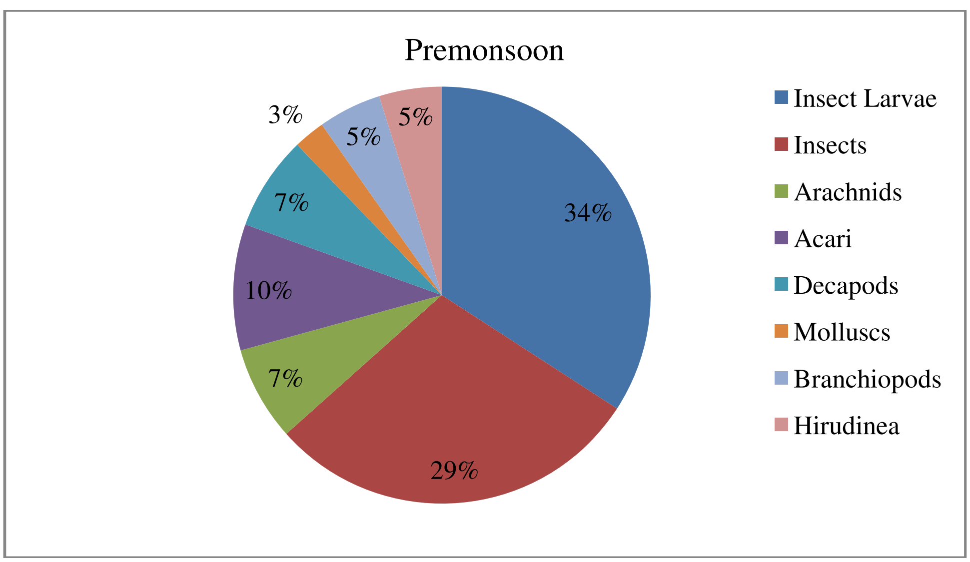

Figure-12
Mean seasonal variation of macro invertebrates in pre monsoon period

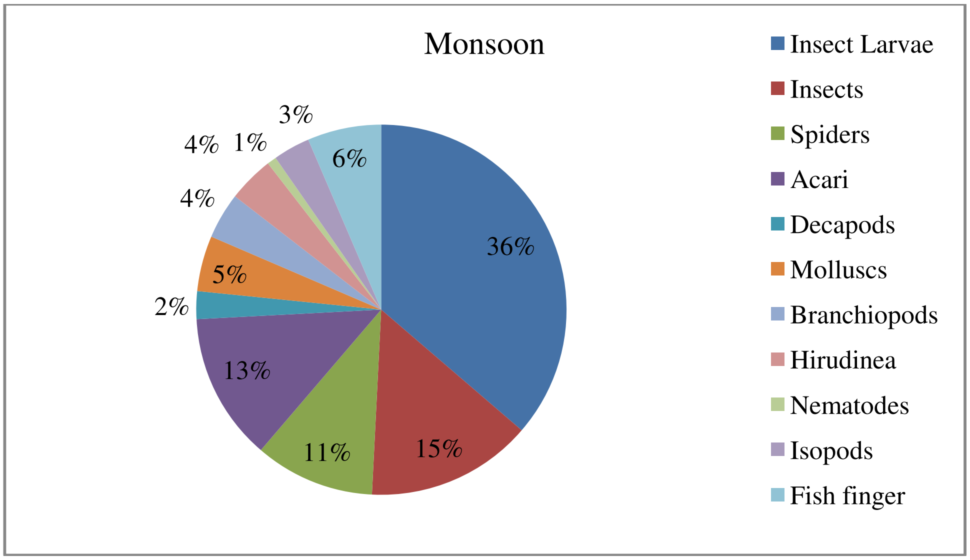

Figure-13
Mean seasonal variation of macro invertebrates in monsoon period

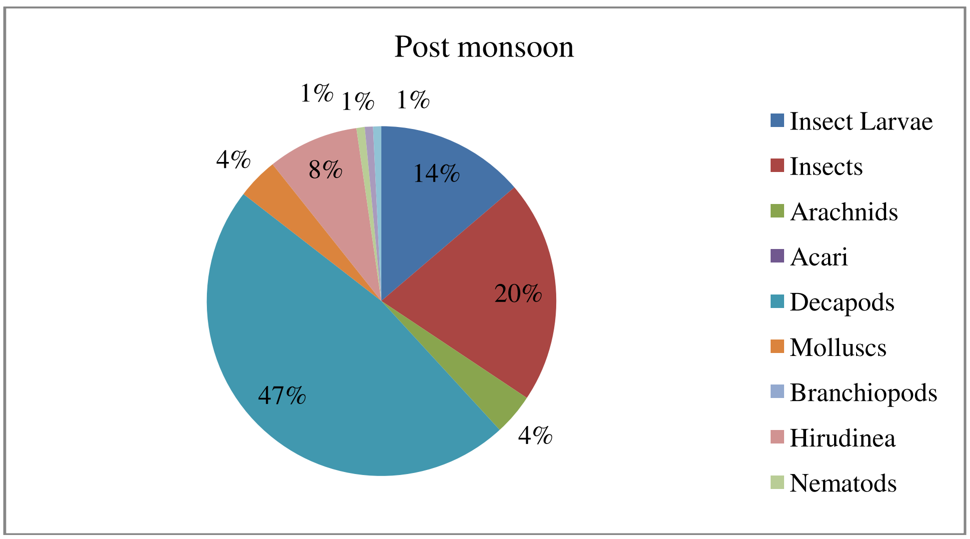

Figure-14
Mean seasonal variation of macro invertebrates in post monsoon period

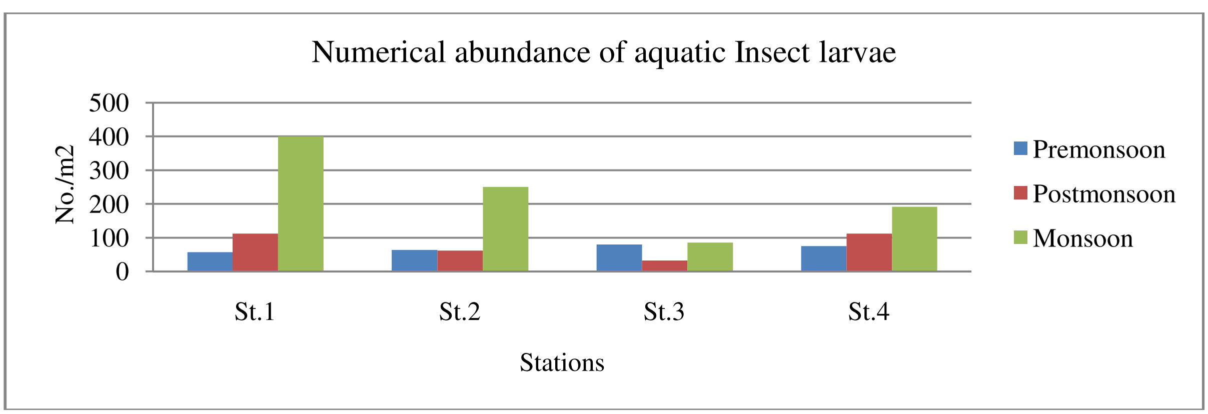

Figure-15
Mean seasonal variation and numerical abundance of aquatic insect larvae associated with macrophytes

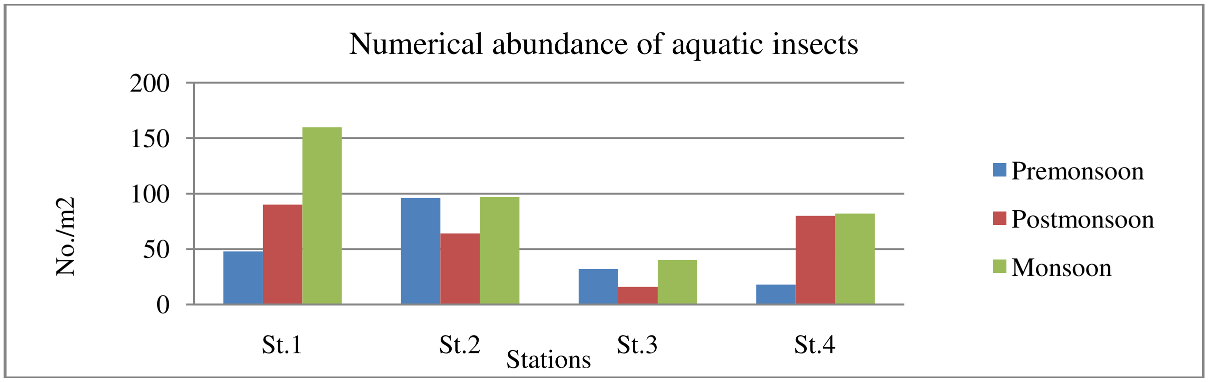

Figure-16
Mean seasonal variation and numerical abundance of aquatic insects associated with macrophytes

The large number of macro invertebrates on the submerged species *H. verticillata* and *U. inflate* may be due to the fact that submerged species represent a suitable well-illuminated substrate in the water column unlike the floating vegetation (*N. albaa, N. stellata and N. indicum*) that is less inhabitable for epiphytic organisms because of the emergence of upper sides of leaves and the shading caused by floating leaves[30]. Similar studies showed that, the architecture of macrophytes itself may significantly affect the colonization by phytophilous invertebrates, the abundance of which is often greater on plants with dissected leaves than on plants with undissected leaves[31,32].

Conclusion

From the results, the high diversity of macro invertebrates in Maranchery Kole wetland was due to the availability of macrophytes which provides shelter, varied niches and comparatively clean physico-chemical conditions of water. Very little information is available on the macro invertebrate diversity of wetlands especially which were associated with macrophytes. From the preceding review, it is marked that the composition and distribution of macro invertebrates in wetlands is governed by physical, chemical and biological factors which need to be taken into consideration in any study of macro invertebrates. In addition, it may be said that the composition and distribution of macro invertebrates is a reflection of the wetland health and thus can be used as further studies.

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