Chapter 5

GENERAL DISCUSSION
Eutrophication is a natural process which if accelerated may lead to undesirable effects i.e. pollution. Eutrophication as well as pollution can be monitored using indicators of water quality. Physico-chemical features of the water bodies have for a long time been used for assessment of the quality of water. Recent studies demonstrate that zooplankton is a more useful indicator of trophic
conditions than has been generally realized (Gannon and Stemberger, 1978). Compared with phytoplankton, the zooplankton has lower densities, larger size and lesser number of species. Further the zooplankters, especially the micro-crustaceans, have comparatively longer life spans. All these features can be used to great advantage in order to employ zooplankton, particularly micro-crustaceans, as indicators of trophic status. A number of recent studies have thus examined the relationship between zooplankton abundance and trophic status of lakes (McNaught, 1975; Pederson et al, 1976; Nilssen, 1978; Gannon and Stemberger, 1978; Tevlin and Burgis, 1979; Gulati, 1983; Chapman et al, 1985).

The primary aim of the present study was to compare the species composition, distributional pattern and the relative abundance of micro-Crustacea in the zooplankton of different categories of aquatic habitats of Kashmir. Hundred waterbodies of both lotic and lentic types, broadly classified into nine different categories
viz. Lakes, Wetlands, Ponds/Pools, Roadside Ditches, Streams/Nallas, Waterflows/Fountains, Springs, Puddles and Reservoirs, were investigated for the microcrustacean communities present in them. In order to have an insight into the environmental conditions of the micro-crustaceans present in these habitats, important physico-chemical features were also studied.

Important abiotic factors which cause changes in zooplankton composition are nutrient loading, water temperature, dissolved Oxygen and salinity (Gulati, 1983). The water temperature in the different waterbodies fluctuated from 3°C in winter to 29°C in summer. A comparison of the mean annual water temperature of different categories of waters revealed that the maximum values were recorded in shallow lentic habitats like wetlands and puddles. The high-altitude lakes and lotic habitats recorded relatively lower values.

Dissolved oxygen concentration fluctuated in a wide range from complete anoxia in certain polluted waters to 20.0 mg/l. In unproductive
waters solubility of Oxygen is mainly controlled by temperature and the values close to saturation are generally observed in such waters. In case of productive waters considerable variations are however, noticed on account of different metabolic activities of the biota (Hutchinson, 1957; Yoshimura, 1938; Welch, 1952). Oxygen concentration close to saturation point was obtained in high-altitude lakes, Reservoirs, Streams/Nallas and Waterflows/Fountains which indicates their low productivity. Supersaturated values of dissolved oxygen were recorded in Valley lakes, Puddles, Ponds/Pools and Roadside Ditches in close relation with higher photosynthetic activity. In case of Springs, dissolved Oxygen was generally in unsaturated condition (mean concentration 66.9%) which is related to the underground source of water in these habitats and almost complete absence of plant communities in most of them (Maitland, 1978; Qadri & Yousuf, 1979). Hydrogen-ion concentration of waterbodies fluctuated from 6.00 in some high-altitude lakes to 9.65 in a Roadside Ditch. A comparison of the range of fluctuations in pH in the different habitats
reveals that high-altitude lakes are acidic (mean pH 6.52) except Marsar lake, where a pH of 7.54 was recorded at the time of collection in summer. In case of springs, pH was very close to neutrality, being on the alkaline side with a few exceptions. All other water categories, except Reservoirs, showed a wide range of fluctuations in the pH. Larger quantities of free Carbon dioxide were recorded in all waters except Streams/Nallas. Highest mean values were recorded in case of Ponds/Pools. A comparison of the Phosphate-phosphorus and inorganic Nitrogen content of different waters reveals that running waters contained the least quantities of Phosphate-phosphorus, whereas Ponds/Pools contained the highest. Higher quantities of inorganic Nitrogen were recorded in case of Valley lakes and Ponds/Pools whereas Springs exhibited the least quantities. Data regarding Phosphorus and Nitrogen and free Carbon dioxide were not collected for high altitude lakes.

The present data and the data collected by other workers on the physico-chemical limnology
of different waterbodies of Kashmir (Zutshi et al. 1972; Kaul, 1977; Yousuf, 1979; Zutshi and Khan 1978; Zutshi et al., 1980) explicitly reveal that the high altitude lakes are of low trophic nature, whereas other water categories are at different stages of trophic evolution. Valley lakes, Wetlands, Roadside Ditches, Ponds/Pools are at a higher trophic state. However, no single trophic level can be assigned to all the waterbodies within a category. The waterbodies which are close to human settlements show definite indications of cultural eutrophication, because they receive waste-water in larger quantities. Waters away from such settlements reveal relatively lower trophic level.

It is a known fact that the crustacean community structure is shaped not only by the abiotic environment but also by the biological interactions such as interspecific competition for food and space within the group and also with other planktonic components like Rotifera. With this aspect in mind, the rotifer communities and the macrophytic associations of the waterbodies were also investigated.
In most waterbodies which were studied during the present investigations it was found that Rotifera was qualitatively as also quantitatively more important group of zooplankton than micro-Crustacea. It was represented by seventy species and contributed more than half of the total population of net zooplankton. Micro-Crustacea was represented by a total of sixty-four species. Qualitatively Cladocera was the second dominant group with 44 species but quantitatively Copepoda with 20 species was more important in most of the waters.

In temperate lakes, it is common to find that the structure and function of the zooplankton communities are altered by eutrophication (Gannon, 1981) with typically an increasing predominance of cyclopoids and in particular of smaller cladoceran species (Gliwicz, 1974; Patalas, 1975). Oligotrophic systems are typified by populations of calanoids, whereas eutrophic lakes usually exhibit larger populations of cladocerans and cyclopoids (Patalas, 1975; McNaught, 1975; Richman and Dodson, 1983; Gulati et al, 1982; Gulati, 1983, 1984). The present
data are in conformity with the findings of these workers. Calanoids were well represented in the high-altitude lakes all of which are oligotrophic to ultraoligotrophic in nature. Increased importance of cyclopoids and cladocerans was noticed in valley lakes, Ponds/Pools, Roadside Ditches and a few springs which exhibited relatively advanced trophic structure as is evident from the abiotic features.

Anderson (1974), while working on 340 lakes and ponds of Canada found the mean number of crustacean species per lake or pond to be 5.27, of which 2.66 were cladoceran species and 2.35 were copepod species. In an earlier study (Anderson, 1971), he reported that the number of copepod species was generally higher in lakes than in ponds, whereas the number of cladoceran species was highest in ponds. The present data revealed a mean of 5.33 crustacean species per waterbody of which 3.53 species were cladocerans and 1.79 copepods. Thirty-five waterbodies, most of them being springs did not record any micro-crustacean species and if these waters are not included in the statistical analysis, then the mean number of
micro-crustaceans per waterbody increases to 8.2 of which 5.4 are cladocerans and 2.8 copepods.

Quality and the quantity of macrophytes in freshwaters is influenced by the nutrient concentration in the water. As such waters poor in nutrients were having low macrophyte populations whereas waters rich in nutrients such as wetlands, valley lakes, wetlands, ponds and a few springs were densely populated by the macrophytes. Aquatic vegetation may provide shelter for numerous zooplankton species including micro-Crustacea and may also alter the species composition by changes in its biomass (Smyly, 1958; Straskraba, 1965).

The diversity of zooplankton species has been found to be higher in macrophyte infested waters (Shireman and Martin, 1978; Fryer and Forshaw, 1979; Eillets, 1981) than in waters without vegetation (Nordlie, 1976 and Fryer & Forshaw, 1979). The data obtained from the different waterbodies of Kashmir confirm this view. The diversity of species of Copepoda and
Cladocera as well as Rotifera was maximum for densely vegetated waterbodies like Ponds/Pools, Valley lakes, Wetlands and certain limnocrene springs and the minimum in case of Reservoirs and High-altitude lakes.

Generally the number of copepod species collected in a sample was less than five. However, in Anchâr lake & Wular lake, the large natural freshwater bodies of Kashmir, as many as eight copepod species each were recorded in a single collection. Forty-three waterbodies did not reveal any copepod species at the time of sampling. An interesting point to note was the presence of as many as 14 copepod species in a single collection from a small puddle Shala-Dob (S.No. 91) during spring season. The abiotic features of this waterbody did not show much difference from most of the other waterbodies. The waterbody had a rich population of submersed macrophytes which might be providing a good habitat for the various species present (Fryer & Forshaw, 1979). All the species recorded almost a uniform density and no species was more dominant. Although the high species diversity of copepoda might have been influenced by the rich
macrophyte population some other unknown environmental factor might also be responsible for such a species diversity.

Maximum number of cladoceran species for any waterbody was 24 in Anchar lake followed by 20 in Dal lake and 18 in Khushal Sar and Wular lakes. All these waterbodies were comparatively voluminous, had higher quantities of nutrients and were richly vegetated. Roadside Ditch (SN No. 42) also recorded 18 species of cladocera. This waterbody was also characterised by dense vegetation and was rich in nutrients. In comparison to this waterbodies 20, 33, 34, 40, 46, 52, 54, 55, 56, 71, 83 and 97 are generally devoid of macrophytic flora and harboured only a single species each of cladocera. Forty-six waters, most of them being springs did not reveal any cladoceran species at the time of sampling. These waterbodies did not reveal any phytoplankton as well and were also devoid of any macrophyte population. Like micro-Crustacea, the maximum number of Rotifera species (i.e. 53) was recorded in the valley lakes and the minimum for the reservoirs and the high-altitude lakes.
Species diversity index in aquatic ecosystems with respect to habitat heterogeneity, latitude, altitude, productivity of habitats, degree of competition among species and rate of pollution has been discussed by a number of workers (Patalas, 1964; Anderson, 1971, 1974; Patalas & Salki, 1973; Keller & Pitblado, 1984; Chengalath et al, 1984). A measure of diversity widely used by ecologists is the Shannon-Wiener Index as outlined in Brower and Zar, (1977). Analysis of the present data showed habitat complexity to be the determining factor for higher species diversity. Maximum species diversity index for total zooplankton ($H' = 1.31$) was recorded in case of valley lakes. Wetlands occupied the second position with diversity index of 1.22. Reservoirs, Puddles, Springs and High-altitude lakes with very simple habitats having low nutrient contents and little aquatic vegetation showed very low values for species diversity [$H' 0.39$ to $0.52$] Fig.6]. When the diversity index was calculated separately for Cladocera, Copepoda and Rotifera, same trend of increasing values with increasing trophy and
habitat complexity was noticed. Species diversity of Cladocera was highest for valley lakes \(H'^{0.36}\) and lowest for Reservoirs. Wudnag, a limnocrene spring, recorded the highest cladocera diversity values \(H'^{0.62}\) in close relation to the habitat complexity produced by vegetation. In case of Copepods, higher values of species diversity were recorded in case of wetlands \(H'^{0.25}\) and valley lakes \(H'^{0.27}\), whereas Puddles, Reservoirs and High-altitude lakes showed very low values \(H'^{0.10}\) and the least diversity index \(H'^{0.08}\) was recorded for waterflows/ fountains. Just like micro-Crustacea, highest rotifer diversity \(H'^{0.67}\) was recorded for the valley lakes. Wetlands also showed very high values.

Altitude also plays an important role in the species diversity of aquatic and terrestrial animals. A change in mean atmospheric temperature corresponding to 1° in latitude has been shown to occur with a rise of about 100 meters in elevation. Thus plants and animals of almost Arctic characteristics are sometimes found near the equator (Curtis, 1979). A comparison of the
species composition of different lakes and ponds/pools located at different altitudes in the valley of Kashmir also indicates the influence of altitude on the diversity. Least diversity values were recorded in the high-altitude waters, whereas the highest values were recorded in the low altitude ponds and lakes.

A dramatic drop in the species number at altitudes above 3550 m ASL has also been reported by Dumont & Velde (1977). Lair and Koste (1984) found low diversity in lake Studer - an extreme biotope with low nutrient content.

Fryer (1980) and Chengalath et al (1984) observed a distinct decreasing tendency of species diversity with increasing acidity. The high-altitude lakes of the valley showed either neutral or acidic pH. The species diversity in these habitats was comparatively lower than the valley lakes where the pH was always in the alkaline range and the nutrient content was relatively higher.

Sorensen index of similarity was also employed for assessing the differences in species
composition of various categories of waterbodies. A comparison of the cladoceran species composition in the water categories indicated very high similarity between Valley lakes, Ponds/Pools and Wetlands. Copepod fauna showed higher values of similarity in case of valley lakes, Ponds/Pools, Roadside Ditches and Puddles. Similarity indices of Rotifera were higher among Valley lakes, Ponds/ Pools, Roadside Ditches and Wetlands. The similarity in the micro-crustacean fauna in these habitats is attributable to their much similarity in the abiotic features like water temperature, pH, dissolved oxygen content and nutrients. These habitats show similarity in their macrophytic associations as well.

As is evident from the data on similarity indices of Cladocera, Copepoda and Rotifera (Tables 15, 22 & 33 respectively), Reservoirs stood isolated from all other categories and showed very low values of similarity index. This could be due to abrupt fluctuations in their water levels and other abiotic features.

When the total species occurrences of micro-Crustacea in the waterbodies are taken into
consideration (Tables 2 & 3; Fig. 10), it was found that out
of the 532 species occurrences of micro-Crustacea,
353 were due to Cladocera and 179 due to Copepoda.
Rotifera was responsible for 687 species occurrences (Fig. 10).
A perusal of the data reveals that about 32% of
the total occurrences was only by sixteen zooplank-
ton species, including *Eucyclops serrulatus*,
*Canthocamptus staphylinus*, *Chydorus sphaericus*,
*Ceriodaphnia reticulata*, *Acroperus harpæ*, *Daphnia
pulex*, *Simocephalus vetulus* (Micro-Crustacea),
*Colurella uncinata*, *Euchlanis dilatata*, *Lecane (M.)*
*Closterocerca*, *Asolanchna priodonta*, *Polyarthra
vulgaris*, *Trichotria tetractis*, *Keratella quadrata
K. cochlearis* and *Lepadella patella* (Rotifera). All
these species occurred in 20% or more than 20%
waters.

*Chydorus sphaericus* (Cladocera), *Eucyclops
serrulatus* (Copepoda), *Euchlanis dilatata*, *Lecane (M.)*
closterocerca*, and *Colurella uncinata* (Rotifera)
were the most widely distributed species in the
waterbodies. *Chydorus sphaericus* occurred 26 times
with *Eucyclops serrulatus*, 23 times with *Euchlanis
dilatata*, 22 times with *Colurella uncinata* and 27
times with *Lecane (M.)* closterocerca. *Eucyclops
serrulatus occurred 26 times with Euchlanis dilatata, 27 times with Lecane (M.) closterocerca and 22 times with Colurella uncinata. Euchlanis dilatata occurred 20 times with Colurella uncinata and 25 times with L. (M.) closterocerca. C. uncinata occurred 18 times with L. (M.) closterocerca. In sixteen waterbodies, all the five species were recorded together. In other waters, generally more than two species from this characteristic group – the five species (at least one of these being always a crustacean species) co-occurred and formed the main feature of the zooplankton. However, in case of High-altitude lakes, only C. sphaericus was present from this group.

Alona affinis and Alona guttata which are present in 17 and 10 waterbodies respectively co-occurred in just three waters. Alona rectangula was present in 19 waters and co-occurred with Alona affinis in 8 waters and with Alona guttata in 7 waters. Alona intermedia occurred in six waters, out of which it co-occurred with Alona rectangula in five waters. The latter showed affinity with Ceriodaphnia reticulata which was present in 23 waters and the two co-occurred in 15 waters.
Acroperus harpae occurred in 20 waterbodies out of which it co-occurred 15 times each with Chydrorus sphaericus, Eucyclops serrulatus and Lecane (M.) closterocerca. Colurella uncinata, which was recorded in 30 waters, co-occurred with A. harpae only 9 times and Daphnia pulex, which was recorded in 20 waters, co-occurred with this species only six times. Alonella exiqua, Diaphanosoma brachyurum, Ephemercyporus barroisi, Ilyocryptus sordidus, I. spinifer, always co-occurred with A. harpae wherever they appeared. Bosmina coregoni was recorded only in five waters and always co-occurred with its allied species (B. longirostris) which was more widely distributed being present in 15 waters. B. longirostris co-occurred 14 times with Chydrorus sphaericus and 13 times each with Eucyclops serrulatus, Euchlanis dilatata and L. (M.) closterocerca.

Polyarthra vulgaris and Diaphanosoma brachyurum avoided each other. Yousuf and Cadri (1986) have also found P. vulgaris to be avoiding waters characterised by D. brachyurum, Daphnia pulex and Arctodiaptomus n. sp. showed no co-occurrence.
Among the three species of Ceriodaphnia, *C. reticulata* was having the widest distribution being recorded in 23 waterbodies. *C. laticaudata*, present in nine waters, co-occurred with the dominant species in six waters, whereas *C. quadrangula* was present in only three waters and co-occurred with *C. reticulata* twice and with *C. laticaudata* only once.

*Chydorus reticulatus* was recorded from seven waterbodies and co-occurred with *Chydorus sphaericus* six times. In the *Pleuroxus* group, all the three species had a limited distribution.

Among *Daphnia* species, *D. pulex* had the maximum distribution occurring in 20 waterbodies. Among *Brachionus* species, *B. quadridentatus* was the most widely distributed species being recorded from 15 waters and was always associated with *Chydorus sphaericus*. It co-occurred 14 times with *Eucyclops serrulatus* and 13 times with *Lecane (M.) closterocerca* but with the other species of the characteristic group, the number of co-occurrences was lesser (9 & 11 respectively).
Keratella group was represented by four species of which *K. cochlearis* was the most widely distributed species in 24 waterbodies followed closely by *K. quadrata* which occurred itself in 20 waters. The two species co-occurred 11 times.

*Keratella quadrata* co-occurred nine times with *Keratella tropica* which was present in 10 waters. *Keratella cochlearis* co-occurred 16 times each with *Chydorus sphaericus* and *Eucyclops serrulatus*.

*Mesocyclops leucharti* which was present in 10 waters co-occurred only 4 times with *Eucyclops serrulatus* and six times with *Chydorus sphaericus*. It was much more associated with *Ceriodaphnia reticulata* co-occurring 8 times with this species. It was least associated with *Scapholeberis kingi*, *Pleuroxus trigonellus*, *Graptopleberis testudinaria*, *Daphnia pulex* and *Alona affinis*. Seven species of micro-Crustacea and 13 species of Rotifera occurred only once. These included: *Alona* sp., *Alona* n.sp., *Camptocercus* sp., *Ilyocryptus spinifer*, *Moina macrocopa*, *Polyphemus pediculus*, *Eucyclops agilis* (micro-Crustacea), *Anuraeopsis coelata*, *Brachionus bidentata*, *Cephalodella* sp.2, *C. exigua*. 
Colurella adriatica, Dicranophorus sp., Filinia peileri, Gastropus stylifer, Keratella hiemalis, Lepadella sp., Macrochaetus sp., Proalinopsis sp. and Trichocerca multicrinis (Rotifera).

The occurrence and abundance of micro-Crustacea varies according to the response of the different species to environmental conditions. A number of attempts have been made to determine the relation between trophic status of lakes and zooplankton colonizing them (Litynski, 1925; Bowkiewicz, 1938; Patalas & Patalas, 1966; Radwan, 1976). On the basis of data collected during the present study it becomes clear that most of the micro-Crustacea did not show any ecologically definitive limits between different categories of aquatic systems. However, some species were restricted to certain characteristic habitats. For example, Echinisca triserialis was restricted to eutrophic waters only, being present in Khushal Sar, Dal, Wular, Mirkund, Yus Trag, HMT crossing, Dumbail Narabal and Mustafa Abad.

Diaphamosoma brachyurum has been reported to avoid low pH (Fryer and Forshaw, 1979). Present
study revealed that it was restricted in its distribution, being present only in Valley lakes. *Polyphemus pediculus* was found in high-altitude Loolgul lake at a pH of 6.00. Here it constituted a dominant crustacean, contributing 35% to the total zooplankton. Keller and Pitblado (1984) also recorded the increased importance of *Polyphemus pediculus* among acidic waters. Hutchinson (1967) and Frey (1969) suggested that *Bosmina coregoni* is replaced by *Bosmina longirostris* with increasing trophic status of a waterbody. But Gulati (1972) found no evidence of replacement of *B. coregoni* by *B. longirostris* during eutrophication in Dutch lakes and according to Beattie et al (1978) both of them are concurrent in highly eutrophic lakes. The present data indicate the presence of both the species in meso-eutrophic waters. However, the density of *B. coregoni* was insignificant as compared to the other species.

The distributional pattern of *Ceriodaphnia laticaudata* in the different waters reveals its affinity for oxygen-poor waters. The species formed as much as 71% of the zooplankton population in
the polluted Doolebagh spring during summer when the water was totally anoxic in this waterbody. *Daphnia pulex* also appears to tolerate wide fluctuations in Oxygen concentration and was absent only in case of Reservoirs and Waterfows/Fountains. *Daphnia similis* was recorded in eutrophic waters as has also been reported by Hutchinson (1967).

*Alona intermedia* was restricted in its distribution to the valley lakes and wetlands only, being completely absent in High-altitude lakes, Reservoirs, Waterfows/Fountains, Streams/Nallas and Roadside Ditches. It was also very rare in Ponds/Pools and Springs. Although *Alonella excisa* has been reported to be common, widespread and eurytopic species (Fryer & Forshaw, 1979), the present investigations indicated that the species had a limited distribution and was absent in the high-altitude lakes, reservoirs, waterfows/fountains and puddles. *Alonella exigua* was restricted to lakes only, whereas *A. nana* was most restricted in its distribution in the *Alonella* group, being being recorded from only two limnocrene springs - Beehama and Wudnag.
Chydorus sphaericus, the most widely distributed species throughout the world (Chengalath, 1982), was found to be very widely distributed species in Kashmir waters and was absent only in Reservoirs. Chydorus reticulatus was present generally in eutrophic waters with rich macrophytic populations. However, it was also recorded in Indernag spring, which is devoid of macrophytes but had a rich algal population.

Graptoleberis testudinaria has been reported to have a marked preference for vegetation over which it creeps (Fryer, 1968). Present data confirm this view as the species was absent from the high-altitude lakes, Reservoirs and water-flows/Fountains.

Sida crystallina, Scapholeberis kinci, Simocephalus exspinosus, Pleuroxus laevis, Macrothrix sp. and Hyocryptus sordidus had limited distributions being absent in High-altitude lakes, Reservoirs, Waterflows/Fountains and Streams/Nallas.

Simocephalus vetulus is one of the commonest cladoceran species in the world and has been reported to be tolerant of wide range of conditions but
usually likes vegetation (Fryer & Forshaw, 1979). The present study also revealed its preference for vegetated waterbodies.

Cyclopoids were very sparse in the high-altitude lakes being represented only by *Cyclops strenuus* and *Cyclops vicinus* in these habitats. *Cyclops strenuus*, in addition to its presence in high-altitude waters, was recorded in certain polluted waters of relatively low altitudes like S. Nos. 43, 46, 47 and 92 which were having algal blooms. Hutchinson (1967) reports *Cyclops vicinus* to be a widespread plankter of European eutrophic lakes. The present study also reveals the species to be eutrophic plankter being very rare in waters poor in nutrients (i.e. High-altitude lakes). *Cyclops scutifer* is considered typical of cold waters and is very common in Canadian Arctic (McLaren, 1964; Lindsey et al. 1981) and prefers dilute waters. The present data reveals that this species was very much limited in its distribution and did not occur in the high-altitude oligotrophic waters but was recorded in relatively meso-eutrophic waters like Anchar, Nilmag and Fish-farm.
Eucyclops serrulatus which was recorded to be most widely distributed copepod during the present study was absent in high-altitude lakes and pools, reservoirs, waterflows/fountains, springs and puddles. It was also absent in highly polluted waters like that of Aali Masjid pool.

Arctodiaptomus n. sp. was mainly restricted to high-altitude lakes and pools, being found at low altitudes only in Lallaham Nalla and Shaladob puddle. Arctodiaptomus similis was restricted to eutrophic ponds and ditches having comparatively higher quantities of Phosphorus and Nitrogen especially the latter.

Canthocamptus staphylinus constituted the third most widely distributed micro-crustacean and remained absent only from waterflows/fountains. Greater numbers of this species as recorded in the acidic waters are in conformity with Lowndes (1952).

Interesting results were also obtained for the population dominance of total zooplankton. A typical bimodal pattern of population fluctuations
was recorded. The primary peak was observed in spring and the secondary peak in autumn. Such a bimodal pattern of zooplankton is strictly in accordance with the findings of Welch (1952). The cold winter always produced the lowest population abundance and the warmer period the highest. Kofoid (1903) also reports a lesser plankton production in the colder months than the warmer months. Detailed perusal of the hydrobiological data shows that temperature was the primary determinant of the seasonal abundance of zooplankton. Temperatures too high (of summers) and too low (of winters) were both unfavourable for the abundance of zooplankton. The optimum temperatures of spring and autumn contributed mostly to the seasonal peaks of zooplankton (Blancher, 1984; Vijverberg, 1980).

Seasonal abundance of Cladocera (Table 16) also showed two population peaks — in spring and autumn. Lowest populations were observed during the cold winters. Cadri and Yousuf (1980) also recorded least population density of Cladocera in winter. The group Cladocera seems to live poorly
in waters with very high (summer) and very low (winter) temperatures. Patalas (1972) also noted that the abundance of total crustaceans increases with temperature to some apparently optimum level and then declined at high temperatures. Similar results are obtained by Hall (1964) and Duncan (1970).

Copepod exhibited peak abundance during spring season. Spring onwards the abundance of Copepoda decreased through summer and autumn reaching the lowest in the cold winter.

The most dominant group of zooplankton in respect of population density was Rotifera. It exhibited a well defined bimodal pattern of seasonal fluctuations in its abundance. The primary peak was observed in autumn and the secondary peak during spring, which is in contrast with the results as obtained for Cladocera.