CHAPTER-II
REVIEW
OF
LITERATURE
Limnology

During the last century elaborate investigations on ecology of different types of fresh water ecosystems such as lakes, ponds, wetlands, rivers and streams revealed different facets of limnology. During that period extensive studies of true limnological characters were undertaken especially since 1970 onwards. To review the whole literature within the boundaries of this work is impossible, therefore, the review which follows is restricted to last few decades of the last century.

Reid (1961) described a lake to be hard water type if total hardness exceeded 40mg CaCO$_3$/l; with low or no free Co$_2$, high bicarbonate, alkalinity and a pH of 7.5-8.5. According to him such lakes have high buffering capacity.

Zutshi (1968) studied the morphometry, transparency, thermal stratification, water and sediment chemistry and distribution and structure of macrophyte communities of four valley lakes viz. Dal, Anchar, Hokersar and Mansbal. The author, while working on Dal lake, reported an increase in Ca$^{++}$, Mg$^{++}$ and K$^+$ in the lake sediments on passing from the mouth of inflow channel towards the centre of Hazratbal basin and also reported about the sparse vegetation in the vicinity of Telbal Nallah and luxuriant towards the centre. Vollenweider (1968, 72) worked out in detail the primary production and eutrophication of lakes and flowing waters with particular reference to phosphorus and nitrogen.
Zutshi and Vass (1971) conducted a study on the nutrient budget of Dal Lake sediments and reported quantities of phosphorus and nitrogen nearly $3.7 \times 10^2$ and $7.2 \times 10^2$ tons respectively and this may be one of the reasons for rich weed growth in Dal Lake. This is attributed to cultural eutrophication as a result of sewage and waste going into the lake waters.

Zutshi and Vass (1973) on the basis of water analysis data demonstrated the changing trophic status of Dal and Anchar lakes. The levels of COD and BOD were found to be progressively increasing. This study for the first time established the importance of long term data in determining the extent of pollution in the investigated lakes.

Zutshi and Khan (1978) classified the Kashmir lakes into three main types viz. the Valley lakes, the forest lakes and the mountain lakes. They have compared these lakes with respect to limnological features like the origin, topography drainage, area, maximum water depth, transparency of water, thermal stratification, period of the ice cover, qualitative and quantitative analysis of plankton and fish population. The authors also investigated the importance of outflow in reducing the salt accumulation.

In a series of papers, Zutshi and Vass (1978), and Trisal and Koul (1983) provided extensive data on different aspects of Dal lake ecology. It was established beyond any doubt that the lake was undergoing far reaching changes in its environment due to discharge of large quantities of wastes from human settlements, agricultural fields and houseboats, which is reflected by excessive growth of aquatic weeds, deterioration of water quality and increased level of biological productivity.

According to Prescott (1969) the rise in pH during summer was related to phytoplankton activity.
According to Thomas (1969) addition of phosphate-phosphorus brings about an eutrophication mechanism by increasing bacterial content, increase in oxygen demand and increase in growth of algae.

Munawar (1970 a, b) in his contribution on limnological studies of fresh water ponds in Hyderabad held that exceptionally high values of CO$_2$ and Po$_4$-P were a result of liberation of Po$_4$ from the ferric complex in the absence of oxygen.

Vashist and Dhir (1970) studied the seasonal distribution of freshwater Zooplankton in four tanks of Chandigarh and observed that temperature has a marked influence on the distribution and seasonal abundance of crustacea, while distribution and abundance of rotifers are controlled by temperature as well as hydrogen-ion concentration.

Powers et al. (1972) observed that in lake Shagwa the algal growth was stimulated by the treated waste waters and reported that the phosphorus supplied by this waste water was the cause of eutrophic status of this lake.

According to Marshal and Falconer (1973 a,b) nitrates and ammonia show a close relationship with each other and to the amount of oxygen and the number of algae present. They also postulated that the high alkalinity, high pH, increase in dissolved solids, chlorides, sulphates and oxygen depletion in deeper waters, all contribute to eutrophication of lakes.

Stewart and Markello (1974) studied the seasonal pattern of nutrient distribution in six western New York lakes. They observed high concentration in winter and low levels in summer. A similar pattern of nutrient distribution
was observed by Heron (1961), Duthie (1965) and Maulood and Boney (1981) in similar water bodies.

Forsyth and McColl (1975) reported that the presence of Euglenophyceae indicates the nitrogen rich organic matter in the lake sediments.

Vashist and Sharma (1975) studied the ecology of a pond in Ambala city and noted fluctuation in physico-chemical factors in relation to the abundance of phytoplanktonic organisms.

Bohra (1976) studied relationship between temperature, pH and dissolved oxygen in freshwater reservoirs situated at Jodhpur, India. It was observed that only temperature and dissolved oxygen showed a linear relationship with each other. Burns (1976) while working on temperature, oxygen and nutrient distribution pattern in lake Erie (USA) observed that nitrate and nitrite levels decrease during summer while ammonia remained more or less same during that period.

Bulton and Blinn (1976) made hydrological studies in lake Mary, located in San Francisco mountain volcanic field (USA) which is a long shallow eutrophic lake. Nutrient levels particularly No3-N were generally high throughout the year.

Lin (1976) opined that eutrophication causes rapid advance in the succession of aquatic ecosystem, while the eutrophication is accelerated by increase in phosphorus.

Minas (1977) examined the relationship between oxygen and nutrients under conditions of oxygen depletion and observed that their variations are due to the dynamic aspects of consumptions, production regeneration system.

Reynolds (1977) studied the seasonal algal succession and cultural eutrophication in a north temperate lake. It was pointed out that oxygen
depletion during summer months revealed eutrophic condition which was attributed to excess nutrient loading resulting from input of domestic sewage.

As per the findings of Enex (1978), the most significant increase has been registered in ammonia, nitrate and orthophosphate. Every year 5.5 tonnes of phosphorus and 88.9 tonnes of nitrogen is being drained in Dal lake from surrounding human settlements/hotels/house boats which has lead to the excessive weed growth and other related problems.

Das and Panday (1978) made investigation on physico-chemical and biological indicators of pollution of Lake Nanital. Investigations were made on the basis of physico-chemical parameters like DO, pH and total alkalinity.

Qadri and Yousuf (1979) studied the fluctuations in physico-chemical factors of Mansbal Lake. According to authors the lake water is hard with high bicarbonate, negligible carbonate alkalinity and high pH value.

Qadri and Yousuf (2005) while studying the macrophytic distribution in Dal lake during summer observed the abundance of macrophyte species with *Ceratophyllum demersum* as the most common macrophyte in all the four basins of the lake. Further, Azolla species has been found to takeover the macrophytic community throughout the lake and thereby degrading the aesthetic quality of the lake.

Khan and Zuthsi (1980) conducted a limnological study of Nilnag lake and classified it into mesotrophic water body, undergoing gradual evolution due to human interference in its catchment area.

Toetz (1981) investigated the effect of pH and phosphate in regulating nitrate and ammonia by plankton in two Oklahoma lakes. A correlation analysis was suggested by author that $\text{NO}_3^-$ is not used by phytoplankton when $\text{NH}_3^+$ exceeds above $210 \mu g \text{NH}_4 - N$. 
Yousuf and Qadri (1981) have described the effect of various physico-chemical characteristics of water and reported temperature and hydrogen-ion concentration of water are the main factors which govern the plankton distribution.

Yousuf et al. (1984) studied abundance of cladocera during summer and winter season in Anchar lake. Authors reported inverse relationship between the free CO$_2$ and dissolved oxygen in waters.

Yousuf and Qadri (1985) studied the seasonal fluctuation of zooplankton in Mansbal Lake and observed that more than half of the total population were made by copepods.

Yousuf et al. (1986) carried out investigations to some limnological aspects of Mirgund wetland in Kashmir.

Trisal and Kaul (1983) observed high plankton peak in Hazratbal basin in spring and attributed it to untreated human excreta discharged into the lake making nitrogen and phosphorus available to the plankton.

Trisal (1985) and Pandit (1995) reported that the development of plankton would result in "bloom" occurring in conjunction with *Salvinia* on the onset of an aerobic condition with the subsequent further release of nutrients from the sediments, such conditions would make the valley lakes, which have great tourist attractions, less suitable as a recreational amenity.

Prasad and Vyas (1987) have treated *Gomphonema parvulum* as an important pollution indicator species, as it thrives best in polluted waters.

Kaul and Handoo (1987) are of the view that eutrophication of aquatic ecosystems has a regional aspect in as much as it is dependent upon the regional nutrient contribution factor viz., precipitation, natural drainage, morphology of the basins and many others. as well as their metabolism is
influenced by the complex inter-relationship climatic hydro-geographical and cultural features.

Bazaz and Kaul (1987) studied the distribution and interrelationship of phosphorus and nitrogen in water and sediments in Dal Lake revealed that sediments acted as a major sink for both the nutrients and also played a significant role in the internal phosphorus and nitrogen loading during spring and summer.

Sarwar and Zutshi (1987b) investigated periphyton communities from natural and artificial substrates of three Kashmir Himalayan Lakes (Dal, Anchar and Waskur) for species composition, seasonal changes and population dynamics. A total of 214 taxa representing 6 classes were recorded with chlorophyceae contributing maximum number of 99 taxa, whereas the diatoms were the main contributors in terms of population composition.

Sarwar et al. (1988) related higher values of conductivity, total alkalinity, Ca\(^{2+}\), Mg\(^{2+}\), chloride ammonical-nitrogen, nitrate nitrogen and total phosphorus of spring Malaknag to high biotic interferences.

Sarwar (1999) studied water quality and biological characteristics of Anchar lake. The author placed it in moderate eutrophic category on the basis of total phosphorus values and biological parameters.

Singh and Mahajan (1987) observed temperature and dissolved oxygen to be major controlling factors in the distribution of phytoplankton. The members of cyanophyceae and chlorophyceae were largely affected by nutrients. The author also observed direct relationship between silicates and diatoms.

Issac and Kaul (1989) worked out phosphorus load relationship in Dal Lake (Kashmir) and reported that 99% of the total phosphorus pool is locked up within the sediments whereas remaining 1% is distributed between macrophytic and water compartments.
Jones et al. (1989) studied the ionic composition of water bodies in Southern Nepal and observed that the ionic composition of water sampled in spring differed from that normally found in fresh water.

Nolen et al. (1989) studied the limnology and trophic state of Tenkiller Ferry lake. The lake was classified as eutrophic on the basis of high nutrient concentration, elevated levels of chlorophyll, the increasing nuisance algal bloom, and trophic state index values.

Trali (1990) has shown Dal lake to be under considerable pollution stress in terms of ammonia concentration which is on average 1.01 mg/l for the lake. The author has compared standard levels and recorded values of pollutants in water from Dal lake.

Pandith (1991) while working on the conservation of wildlife resources in wetland ecosystem of Kashmir recommended a number of measures for management and opined that the native fish (*Schizothorax* spp) has completely disappeared from the wetlands due to shallow nature and high trophic status of these biotopes.

Pandit (1996) held changes in environmental complex responsible for disappearance of *Chara* species and *Euryale ferox* from Dal Lake.

White et al. (1991) studied seasonal variations in nutrient limitation of the algal community in lake Horowhenka, New Zealand. The shortage of phosphorus was observed to be the limiting factor for the growth of algae in winter and nitrogen shortage restricted the growth in summer.

Singhai et al. (1992) while working on the seasonal variations and relationship of different physicochemical characteristics in newly made Tawa Reservoir, observed the oligotrophic nature of the reservoir.

Siva Kumar et al. (1992) investigated the physico-chemical features of Singanallur pond in Tamil Nadu and observed direct correlation between
chloride concentration and surface waters while as amount of total dissolved and suspended solids were found to have negative correlation with gross production.

Venu et al. (1993) carried out limnological survey of some water bodies of Sikkim Himalaya and observed lower production and poor planktonic growth in these systems, being attributed to a number of factors like lower temperature, poor light conditions, abiotic turbidity and speedy flow of waters.

Kanth and Bhat (1993) while studying the environmental impact of tourism in Dal lake, concluded that Dal lake was seriously affected in terms of its water quality, growth, siltation and encroachment.

Logaswamy et al. (1993) studied the physico-chemical parameters of two reservoirs, upper Aliyar and lower Kadampari in Tamil Nadu. The upper reservoir was found heaving higher amount of nutrients than the lower Kadampari reservoir.

Hudec et al. (1995) studied the human impact on eutrophication and extinction of Jastericie Lake. They reported that the main reasons of extinction were unwanted human activities both in micro water sheds of lake and directly on lake itself.

Kobbia et al. (1996) made studies on qualitative and quantitative fluctuations of phytoplankton biomass in three different aquatic habitats of Nile, Egypt in relations to physicochemical characters. The authors revealed that the phytoplankton are directly dependent upon physico-chemical characteristics of water.

Enderlein and Yousuf (1999) while working on river Jhelum in year 1998, pointed out that the biodiversity in Kashmir valley has been severely reduced by oxygen consuming pollutants, turbid waters due to high erosion and by impoundments.
Kundanger (1999) studied the distribution and periodicity of euglenoid population in relation to physico-chemical features. The author reported a close relationship between chloride, nitrogen, free CO₂ and euglenoid populations.

Parveen and Yousuf (1999) while studying Cladocera population in Dal lake, Kashmir reported *M. micrura* and *D. longispinna* to be mainly restricted to polluted waters of Brarinambal basin of Dal lake while as *Pleuroxus denticulatus, Camptocercus* sp., *Acroperus harpae*, *Alonella* sp., *Alona quandriangula, A. rectangular* and *A. affinis* were totally absent from the floating garden areas, indicating that these species avoid the polluted waters.

Keto and Petra (2000) described the recovery of formerly heavily eutrophicated Vesijiarvi, a lake in Southern Finland. The shift was attributed to the decrease in nutrient concentration, increase in water transparency and to the elimination of extremely higher pH values.

Pandith (2002) revived in detail the ecology of Dal lake ecosystem and proposed various conservative measures to be adopted to save the lake from further deterioration. Heavy nutrient input from point and non-point sources from Srinagar city and Dachigam-Telbal sub-catchment and other human settlements has lead to rapid trophic evolution of the lake.

Pandit and Yousuf (2003) while studying the trophic status of six Kashmir Himalayan lakes observed that the rotifer community increased qualitatively as well as quantitatively from oligotrophic to mesotrophic waters and then towards eutrophy.

Bhat and Pandit (2003) while studying phytoplankton dynamics in Anchar lake during 2000-2001 reported the abundant growth of phytoplankton during summer and a very low growth during winter and attributed it to the accelerated cultural eutrophication.
Kumar and Tripathi (2004) while studying the zooplankton diversity in some ponds of Durg Bhilai city of Chattisgarh state reported that *B. calyciflorus, B. falcatus, B. rubens, B. plicatilis* and *Testudinella* species as most abundant rotifers, indicating the eutrophic nature of the water body.

Siraj *et al.* (2004) while studying the physico-chemical parameters of Nigeen lake, Kashmir revealed that the significant population density of Cladocera is related with nutrient enrichment vis-à-vis higher density of other biotic communities including bacteria and decaying organic matter. The nutrient enrichment within the vicinity of floating gardens has led to the dominance of cladocera species and deterioration of the water quality of the lake.

Siraj *et al.* (2006) while studying the physico chemical parameters of Dal lake, Kashmir revealed that the water near the floating gardens was more enriched with nutrients due to increased level of chloride, phosphorus, nitrogen and conductivity. Further the zooplankton community around these gardens revealed differences in species composition and abundance from the open water areas of the lake.

Lindstrom *et al.* (2004) and Eilers (2005) while working on periphyton communities revealed that there was a prominent spatial variation in species composition and diversity, which showed a close correlation with water temperature and nutrient concentration.

Shazia *et al.* (2006) while studying ecology of Khushalsar lake revealed that seven fungal genera belonging to two different classes of division Mycotina were isolated but non of the fungal species isolated belonged to pure aquatic group indicating eutrophic environment of the lake.

Rashid and Pandit (2006) while studying periphytic floral communities of seven water bodies of Ladakh in relation to physico chemical characteristics of water revealed that diatoms were the most abundant periphyton at the study sites.
Fish

The occurrence and abundance of fish in a given environment depends of the number of conditions. In an aquatic ecosystem the quality and quantity of materials necessary for its survival, physical and chemical components of its environment control the distribution of fish.

Every individual fish has a parasite infra community that is sensitive to environmental stress and many trophic levels. The interaction of these parasite infracomunities and the health of the fish are closely related with abiotic and biotic components of the ecosystems. During the last century tremendous work has been done but the review that follows is restricted to last few decades and contains only the important publications.

Amin and Burns (1975) while analyzing an ecological data pertaining to host and seasonal association of *Acanthocephalus parksdei*, observed that parasitic load was related to host species, host size, age, sex, concurrent infections, collection site and seasons.

Henricson and Jan (1977) studied the seasonal abundance and distribution of *Diphyllobothrium dendriticum* and *D. ditremum* in the Arctic char, *Salvelinus alpinus*. The incidence and mean intensity of infection for *D. dendriticum* and *D. ditremum* were 83.2% and 8.8% and 93.7% and 45.0% respectively.

Gruninger *et al.* (1977) while working on macroparasites of fish, examined 397 specimens of fish and recovered 32 species of parasites representing 22 families and 26 genera. (Trematodes, Cestodes, Acanthocephala and Nematodes).

Kuperman (1977) studied fish diphyllobothriasis in the Rybinsk reservoir, percentage of infection was 54% in Pike, 66% in Burbot, 48% in perch, 2.5% in Ruffe and 1.5% in Walleye.
Audryuk (1979) studied the seasonal dynamics of acanthocephalan infection of *Wallago attu*. It was observed that infections peaked in April and May.

Muzzall and Wilbur (1979) studied seasonal occurrence and host-parasite relationship of *Neoechinorhynchus saginatus*. The study was carried from June 1975 to July 1976 and March 1977-December 1977. It was observed that prevalence was 44% or higher in all months sampled.

Williams (1979) worked out the seasonal occurrence of *Glaridacris laruci* and *G. catostomi* (Cestode). It was observed that incidence and population of parasites increased during spring and autumn and decreased in February and July.

Mills (1980) observed that the survival of the digenean fish trematode *T. versotrema* is reduced by any deviation from an optimum temperature of approximately 23° C and with increasing temperature the rate of egg production rises progressively faster to a higher peak up to 29° C but falls to zero by 35° C.

Sous (1980) observed that the changing high levels of water would lead to the maximum density of a trematode population of fishes.

Boomker *et al.* (1981) studied the pathology of Bothriocephalosis in the common carp and reported that this parasite was responsible for death of *Cyprinus carpio* in commercial farms.

Brandt *et al.* (1981) studied the occurrence and treatment of Bothriocephalosis in the common carp, *Cyprinus carpio*.

Chubb (1982) maintained that there were many differences in interpreting the relationship between fish parasite communities and pollution, and that the association of heavy metals in acanthocephalans formed an exception to this, but suggested further research is needed to study the effect of pollutants on parasite.
El-naffar et al. (1983) studied the helminth parasites of some lake fishes. The prevalence of infection due to cestodes and acanthocephalans was 65.7% and 80% respectively.

Granath et al. (1983) while working on the seasonal dynamics based on thermally altered and ambient temperature locations on the mosquito fish *Gambusia by Bothriocephalus* species revealed that the cestodes were observed during summer months. Densities rose sharply in the fall and peaked by early winter.

Narsimhamurti and Kalavati (1984) while working on the gills of *Channa punctatus* observed that the fishes collected from the polluted tanks had no infection due to the presence of high alkalinity, low O₂ and increased turbidity. On the other hand the fishes collected from the unpolluted tank possessed the infection. Infection was observed to be minimum during winter months having temperature 18-25°C while as maximum infection was observed in summer months in the temperature range of 35-42°C. The maximum infection was recorded in the mature fish.

Pojmanska (1985) while analyzing the seasonality of incidence and maturation of *Caryophyleus laticeps* in Bream with regard to thermal factor observed that parasitic recruitment occurred mainly from September to May causing autumn and spring infection peaks and the main period of egg production was from May to September.

Rai (1986) while discussing the pathogenic significance of the Proteocephalidian and Bothriocephalidian parasites from siluroid freshwater fishes, observed that the parasites caused extensive damage, in the form of marked denudation of the mucous membrane, broken villi, heavy infiltration with cells, copious congestion of blood vessels in mucosa and submucosa. The author opined that the infection could lead to the lower production of fish.
Agarwal (1986) while studying the dynamics and regulation of endohelminths of three fish hosts namely, *Clarias batracus*, *Channa punctatus* and *Colisa lalia*, recorded a relatively higher incidence, intensity and density during the summer months.

Leong (1986) worked out the prevalence and mean density of metazoan parasites of cyprinid fishes. It was observed that the prevalence and mean density were highest during the early part of the wet season and in some the maximum was recorded in later part of the wet season.

Riggs *et al.* (1987) studied the seasonal abundance dispersion and prevalence of *Bothriocephalus achielognathi* in three species of fish. A two and a half year study (Sept. 1980-March 1983) revealed that infra population and prevalence differed vis-à-vis site, season, species and size of the hosts.

Camp and Joseph (1989) studied the population biology of *Allocreadium lobatium* (trematode) in *Semotilus atromaculatus* and observed the peak levels of prevalence and mean intensity during winter and summer. Mainly immature worms were found in autumn, but by summer only gravid worms were found.

Dhar and Peerzada (1989) studied the seasonality of three helminth parasites in *Schizothorax niger* in Wular lake. The three parasites *Diplozoon kashmiriensis*, *Adenoscolex oreini* and *Pomphorhynchus kasmirensis* showed three seasonal peaks in summer, winter and spring respectively and correlated the variations to the fluctuations in water temperature. The same authors in (1992) in the same water body observed seasonal occurrence and maturation of *A. oreini* (Cestode).

Faith and Norris (1989) studied the environmental factors underlying variation in distribution and abundance of common and rare freshwater macro invertebrates. Their results showed high correlations for additional physico-chemical variables, particularly relating to water chemistry. The additional
important correlates revealed by the analysis of the rare taxa suggested that there must be differences in the set of environmental variables that are related to patterns of distribution and abundance of rare versus common taxa.

Fontaine and Labelle (1989) observed the effect of temperature on the larval development of swim bladder nematode of eels. They found that at 20-22° C, the eggs hatched in water, released second stage larvae surrounded by the cuticle of the first stage. At a temperature varying from 1 to 13° C during the experiment, the larvae did not grow in cyclopidae and died after about a month.

Jellyman (1989) studied the occurrence of nematode infection in freshwater eels and correlated the infection with eel size, occurrence of amphipod host and dietary change. The decline in incidence of infection with increasing eel size was because of similar decline in occurrence of amphipod host in the diet. Similarly, an increasing infection rate from spring to summer was also thought to be because of dietary changes.

Karimov (1989) studied the peculiarities of the infection of *Schizothorax intermedius* with *Paradiplozoon schizonthorazi* in connection with sexual maturity and egg production.

Morandi and Ponton (1989) observed that the seasonal cycle of Proteocephalan cestode (*Coregonus lavaretus* L.), presents a period of sexual maturity between June and September. Studies of the life cycle, in laboratory conditions showed the importance of first host densities (Cyclops) for the success of infestations as well as of factors such as egg maturity and water temperature.

Munro *et al.* (1989) while studying *Pomphorhynchus laevis* (Müller) observed that parasites in flounder maintained in seawater, 50% seawater and 100% seawater showed similar population, microhabitat and reproductive
characteristics to those observed in the field. They suggested that increased salinity has negligible effect on established parasites in the short term, and therefore, the salinity may not form a barrier to the survival and dispersal of the River Thames parasite when the flounder return to sea.

Silan and Maillard (1989) classified several aspects of *Serranicotyle labracis*, ectoparasite of teleostei and observed the behaviour of the hosts, maturity and sex as main factors determining the extent of infestation.

Surainoa (1989) described the ontogeny of the *Philocorydoras platensis* (Monogenea) and confirmed through microscopical observations that the penetration path of the parasite is the opercular opening of the host.

Zaman and Leong (1989) studied seasonal abundance of the parasites in *Clarias batrachus* and its relationship to the maturity of the host. The peak prevalence and mean intensity was observed in two wet periods of the country (Malaysia). Maximum number of parasites were observed in after spawning period (September-November).

Khidr (1990) studied the population dynamics of *Enterogyrus cichlidarium* (Monogenea) and observed the highest prevalence and mean intensity in spring. He also observed that the prevalence and intensity of the infection rose significantly with increasing size of the host.

Magdy (1990) studied physico-chemical parameters of lake Manzala and revealed that nutrient loading increased three fold over the past two decades, which affected the lake ecology. In response to this the fish community of lake evolved from a brakish (mixed species) to a freshwater dominated one.

Marek (1990) estimated hazards to fish management due to heavy metals in aquatic environment of the river Baryoz basin.

Wanstall *et al.* (1990) investigated the distribution of *Pomphorhynchus laevis* in the alimentary canal of naturally infected stone roach. Younger fishes were
less often and less heavily infected in terms of number of parasites with the parasites being larger in older fish. It was concluded that the small size of the stone roach precludes it from being preferred host for this parasite.

Wells and Coe (1990) studied the effect of *Gyrodactylus colemanensis* and *G. salmonus* (monogenea) on the fry *Onchorhynchus mykiss*. The experimentally induced infection was found to cause changes in mucus cell density in epidermis covering the caudal fin.

Koskiwaara *et al.* (1991) studied the monogenean parasites of gills (Dactylogyrids) of *Rutilus rutilus*. Increase in the infection was correlated with the eutrophication.

Nie and Kenndy (1991) investigated the seasonal changes in population of *Protocephalus macrocephalus*. No seasonal pattern in prevalence and abundance was observed. Another study carried by same authors in the same year (1991) on a nematode of European eel. The prevalence of infection was correlated with the seasons.

Rao and Rao (1991) studied the effect of ecological factors on the intensity of helminth parasites in Blecker, *Congresox talabanoides* and observed that high temperature and low rain fall increased the incidence of infection while as low temperature and high rainfall had reverse effect on the infection levels of helminth infection.

Steedman and Robert (1991) studied the degradation accompanying agricultural and urban development is associated with black spot disease in variety of fish species in Southern Ontario streams.

Guegan *et al.* (1992) analyzed seven predictor variables: host age, number of drainage basins, number of sympatric Cyprinid species, host diversity, association with mainland forest, host ecology and monogenean biological
labelling for variability of Dactylogyrid monogenean gill ectoparasite species richness in 19 west African cyprinid fish species.

Muzzal (1993) correlated the changes in parasitic fauna with the age at different times and localities from the Pere Marquette River and lake Michigan (USA).

Molly and Holland (1994) studied the helminth parasites of brown trout and sea trout from the west coast of Ireland. It was observed that the host age significantly influence the indices of infra Community structure.

Dorueu et al. (1995) while studying the fish-helminth associations from Arctic char in Loch Rannoch discussed the results in terms of effect of ecological factors on transmission of helminth parasites to their hosts and the evolution of host-parasite associations.

Konovalov (1995) reviewed the applicability of parasites as indicators of host biology, with special reference to Oncorhynchus nerka under the headings: fish parasites as ecological indicators at the subpopulation level; parasite indicators and extinct ichthyofauna; parasites and their population dynamics in host populations.

Malloy et al. (1995) studied the population biology of Pomphorhynchus laevis in brown trout from two lakes in the west of Ireland. Utilizing a logistic regression model, parasite size, season and site of host capture emerged as particularly significant factors, which contribute to the maturation of eggs in parasites.

Nie (1995) investigated communities of intestinal helminthes in carp in 6 lakes in the highlands of southwest china and related helminth species richness to lake area and host parasite coevolution as the lakes are ecologically and geographically isolated.
Dockray et al. (1996) revealed the effect of elevated summer temperature and reduced pH on metabolism and growth of Juvenile rainbow trout (*Onchorhynchus mykiss*) on unlimited ration.

Szekely and Molnar (1996/97) surveyed the parasite fauna of some important fish species of Hungary. Despite the abundance of birds acting as definitive hosts, many of the helminth parasites common in lake Balaton were absent from Kis-Balaton probably because of the lack of intermediate hosts or due to differences in other ecological factors.

Balling and Pfeiffer (1997) compared infection frequency of perch and roach with eye flukes at various locations around lake Constance. Significant location depend differences in infection were revealed for all combinations of host and parasite.

Marcogliese and Cone (1997) studied metazoan macro-parasite communities in American eels with relation to effect of fluctuations in pH on parasite distribution. The result supported the hypothesis that parasite communities are good indicators of environmental stress and biodiversity. The same authors in the next year (1998) compared the richness and diversity of macro-parasite communities among eels from Nova Scotia, the U.K. and Australia and stated that parasite communities have had more time to evolve and/or that tropical conditions have promoted parasite speciation in Australian eels.

Mo et al. (1997) studied the seasonal occurrence of Gyrodactylus (monogenea) on brown trout (*Salmo trutta*) and Atlantic salmon. It was noticed that both prevalence and intensity of parasites increased and decreased correspondingly with the rise and fall in water temperature.

Overstreet (1997) gave an overview of the usefulness of fish parasites as monitors of environmental quality and contamination. Species richness, intensity of selected species, host resistance, other hosts involved in lifecycles.
and other factors were all related to site and contaminating discharge of organic toxicants, metal pollutants and pulp and paper mill effluent.

Sithithaworn et al. (1997) reported seasonal pattern of infection in cyprinid fish in northeast Thailand. The results indicated the seasonal variation in metacercariae was a common phenomenon in areas with both high and low endemicity of infection.

Lorenzeni and Balarini (1997) worked on the presence of *Acanthocephalus clavula* and *Cyathocephalus truncatus* in *Salmo trutta* L. in the Nera river basin and correlated parasite presence with some morphohydrological parameters of the sampling station such as depth, flow rate and distance from the source.

Clarkson et al. (1997) studied the prevalence of Asian tape worm *Bothriocephalus achielognathi* in the gastrointestinal tracts of native cyprinid fishes from the little Colorado river, revealing varying rates of prevalence and infra population levels. Maximum prevalence was 28% in hump back chub and 80% in speckled dace, with infra populations as high as 46 and 28 respectively.

Davydov and Isaeva (1997) worked out on the juncture between hydroparasitology and aquatic toxicology observed that the invasion of fishes by parasites and toxicants under pollution are inter correlated.

Anderson and Buchmann (1998) experimentally infected rainbow trout with *Gyrodctylus* at three temperatures. The population growth was positively correlated with temperature in initial part of investigation. The decline in parasite population after reaching peak levels was thought to be caused by host response.

Baldamona and Pronin (1998) studied the seasonal dynamics of infection of salmonids with *Echinorhynchus salmonus* and *E. truttae* (Acanthocephala) in
Baikal lake. The seasonal occurrence of the parasitic infection was correlated with cyclic trophic connections between definitive and intermediate host.

Cardoso and Saraiva (1998) studied the distribution and seasonal occurrence of Nematode, *Anguillicolla crassus*. Infection and/or reinfection occurred during the summer, parasite reproduction occurred throughout the year but preferentially in the autumn.

Majidah and Khan (1998) studied the population dynamics of 9 species of helminthes from fishes in Wular lake. Positive correlation was observed between parasite population and temperature.

Pietrock *et al.* (1998) studied ecology of fish helminth *Proteocephalus* from Oder River. Changes in the amount of suspended particulate matter in water were identified as the main cause of seasonal occurrence of parasites.

Dove (1998) studied the impact of exotic fresh water fishes on the native fishes of Australia, with reference to parasitism particularly *Bothriocephalus acheilognathi* and concluded that transfer of parasite from exotic to native fishes can have severe consequences for native fishes.

Knopf *et al.* (1998) observed that at low temperature of water the development and viability of larva of *Anguillicola crassus* in *Anguilla anguilla* was retarded, while in case of adult worms mortality increased and growth and reproduction decreased.

Landsberg *et al.* (1998) reported that the parasites of the fish are an indigenous component of healthy ecosystem. Environmental parameters which may affect parasite abundance, richness, prevalence and diversity can be divided into three categories:

a) the physical and chemical characteristics of the water and sediments external to fish.
b) the internal physiological environment to the individual fish and
c) the presence and absence of benthic invertebrates, many of which
serve as intermediate hosts.

The authors observed that the parasites of fishes are useful
biomarkers and appeared to be more sensitive to environmental
stressors than the fish themselves.

Landry and William (1999) investigated the influence of physico-chemical
factors on the prevalence and intensity of nine parasite taxa and related
parasite abundance to the habitat effects on intermediate host and parasite life
cycle dynamics rather than hypoxia related suppression of parasites immune
system.

Khan (1999) studied the effect of polychlorinated biphenyls on the health of
winter flounder, using length mass relationship, haematological values,
histopathology and parasitism as bioindicators of stress. Anomalies were more
prevalent in samples collected nearest to the contaminated sites than in those
collected farther away.

Roberts and Barnhart (1999) while studying the effect of temperature, pH, and
\( \text{CO}_2 \) on transformation of the glochidia of \textit{Anodonta suborbiculata} on fish host
and in vitro, found low temperature facilitating successful encystment and
transformation of the parasitic glochidia larvae of unionid mussels on fish
hosts. The larvae were present on hosts from January through March, when
water temperature was low. They found that the \% transformation success of
attached glochidia in laboratory infection on fish hosts was significantly
higher at 10°C than at 21°C.

Caspeta \textit{et al.} (2000) studied the seasonal variation in the occurrence and
maturation of nematode \textit{Rhabdochona} and observe highest prevalence and
mean intensity in April and June. Gravid female nematodes with mature eggs were present throughout the year, with the lowest occurrence in September.

Koie (2000) described the life cycle and seasonal dynamics of *Cucullanus cirratus* (Nematode) in Atlantic cod.

Lee and Khan (2000) studied the length weight/age relationship, food and parasites of Atlantic cod (*Gadus morhus*). Generally, the prevalence and abundance did not differ greatly between locations either spatially or temporally.

Trejo *et al.* (2000) while working on seasonal distribution of *Acanthocephalus maculatus* in lake Gutierrez observed that pattern of infection showed seasonality, with recruitment in winter and a reproductive period during spring and summer.

Tolonen and Peltonen (2000) studied the abundance and disturbance of *Dipyllobothrium ditremum* plerocoids and observed that mean abundance ranged between 103 ±71.3 in 1992-1993 to 110.9 ± 80.0 plerocercoids per fish during 1997.

Ziolkowska *et al.* (2000) while working on the occurrence of *Pomphorhynchus leavis* in correlation with the host age, observed that the younger fish hosts were more susceptible to infection as compared to older one.

Yangtingbao and Liao (2001) while analyzing the population dynamics of *Neoacanthorhynchus qiahaiensis* from Qinghai lake China, observed that difference in the mean abundance, mean intensity and prevalence were not statistically related to season but likely to be related to the temperature recorded at the bottom of the lake.

Sebelova *et al.* (2002) studied the comparative haptorial morphology of four species of *Diplozoon* from the gills of chub *Leuciscus cephalus* exposed to
different levels of water pollution at two sites of river Morava, Czech Republic. They recorded abnormalities in the attachment clamps of the parasites in the light of conditions of environmental stress.

Kadlee et al. (2003) investigated the parasites common to three fish species from Morava River Czech Republic under flood conditions. It was concluded that parasites common to three different host species responded in different ways to environmental change.

Pietrock and Marcoglies (2003) gave an overview of research work on the effects of natural variables and pollutants on survival and infection of free-living stages of endohelminthes. A number of abiotic factors like temperature, salinity, oxygen, hardness, light and depth were recorded to affect the survival and infection of free living stages in aquatic systems.

Schludermann et al. (2003) investigated changes in diversity and richness pattern of endoparasites of barbell (Barbus barbus) from some selected river stretches in Austria in relation to heavy metal contents in the aquatic system. Pomphorhynchus leavis was found to be the most sensitive individual for heavy metals in aquatic system.

Vidal et al. (2003) studied the effect of pollution on the infection intensity of parasites in Mayan cat fish (Ariopsis assimilis) from chetumal Bay Mexico. The results showed that pollution has a detrimental effect on parasite infection intensity.

Williams and Mackenzie (2003) presented an update review on criterion used for selecting marine parasites as indicators or monitor species. It was proposed that parasites must either be exceptionally sensitive or exceptionally resistant to environmental change so that significant change in their number can be used as early warning of deteriorating conditions before the majority of organisms are seriously affected.
Choudhry et al. (2004) studied seasonal parasites of four native and seven non-native fishes from the little Colorado River (LCR) Arizona, and observed intensity of *ornithodiplostomum* species and *Bothriocephalus achielognathi* were positively correlated with length of native species. Abundance of *Bothriocephalus achielognathi* was found to be highest in fall and lowest in summer. It was also observed that the helminth infracommmunity species richness was highest in the native host.

Sures (2004) presented a review on the use of parasites in monitoring environmental pollution. It was proposed that parasites could be used as effect individuals and as accumulation indicators because they can provide valuable information about the chemical state of their environment through their presence or absence.

**Amphibia**

Amphibians have survived on the planet for some 350 million years but worldwide populations have shown declining trend just in the last two decades. As the amphibians have permeable, exposed skin and eggs that may readily absorb toxic substance from the environment, the quality of water in which they live can affect their growth, development and survival. A number of amphibian protection and conservation programmes have been launched worldwide but yet more is to be done to safeguard the integrity and existence of amphibia. For the last two decades large number of studies have been done in this direction but herein only the important publications are given in the review hereunder.

Butler and Blum (1963) in laboratory experimental conditions proved that salamanders on exposure to extremely high levels of UV-B radiations (orders of magnitude above current levels) developed extra limbs.

Olsen (1974) while working on the lifecycle and ecology of animal parasites, proved *Bufo viridis* is the only host of *Polystoma integerrimum* in Jordan with
prevalence of 16%. In Europe, however, it has a wide range of hosts. On the other hand, Vojtkowa (1989) while working on the occurrence of the representatives of the class monogenea in amphibians in Europe reported *Polystoma integerrimum* to parasitize *Rana esculenta* from the Czech Republic. It was also reported from the *Bufo viridis* inhabiting the former USSR and Poland.

Everard (1975) reported the trematode *choledocystus intermedius* and the nematodes *Ochoternella* species and *Oswaldocruzia mazzai* in cane toads from Northern Trinidad.

Madi (1976) while studying systematic and morphological studies on digenetic trematodes from some aquatic vertebrates isolated four trematodes (*Gorgoderina vitelliloba, prosotocus confusus, pleurogenoides tacapansis* and *Haematolechus variegates*) from *Rana bedriagae* and *Bufo viridis* in Azraq area.

Ernest and Ernest (1977) listed the helminthes infecting native turtles of the United States.

Prudhoe and Bray (1982) while working on platyhelminth parasites of amphibia, London, reported the occurrence of genus *Nemototaenia* in Palearctic, Oriental and Australian regions infecting anuran families Bufonidae, Hylidae and Ranidae, plus the Saurian families Gekkonidae, Varanidae and Scincidae in the Palearctic region.

*Mesocoelium monas* has been recovered from *B. marinus* and is evidently a common parasite of neotropical populations of *B. marinus*, with prevalence rates varying from as low as 2% (Goldberg *et al.*, 1995b) to a high as 93% (Wong and Bundy, 1985).

Herbold and Moyle (1986) and Moyle (1996) analysed for invasive species and habitat destruction, invaders are more likely to integrate into communities and extirpate native species in permanently altered habitats than in pristine
environments. The authors quoted an example of the American bull frog (*Rana catesbiana*) which has got accidentally and intentionally introduced throughout the world as they are more likely to become established in and extirpate native amphibians in man-made and heavily disturbed environments.

Baker (1987) provided a synopsis of the Nematodes parasitic in herps of the world.

Fernando (1989) while working on parasitic burden, isolated two adult digenetic trematodes (*Pleurogenoides stromi* and *Pleurogenoides compactus*) from *Rana ridibunda* in Saudi Arabia.

Aho (1990) presented and explored mechanisms influencing the patterns and the processes of helminth community organization in herps.

Sessions and Ruth (1990) during his explanation for naturally occurring supernumerary limbs in amphibians, observed numerous limb abnormalities and cysts (metacercariae) caused by a trematode parasite in population of Pacific tree frogs (*Hyla regilla*) and the Santa Cruz long toad salamander (*Ambystoma macrodactylum croceum*). Experimental implantation of metacercariae sized resin beads into the developing limbs buds of the African clawed frog (*Xenopus laevis*) resulted in limb malformations similar to those observed in the wild (Sessions and Ruth, 1990).

Dyer (1991) listed many of the helminth parasites of amphibians from Illinois and adjacent Midwestern states.

Andrew *et al.* (1992) provided a checklist of helminthes in Bull frogs (*Rana catesbiana*) in North America.

Anderson (1992) proved *Rhabdias bufonis* has a heterogonic life cycle that alternates between parasite hermaphroditic generations and free living generations which has both males and females.
Rhabdias bufonis inhabits all areas of the world where its host species of frog and toads occupy. Further, it is most common in the European toad and frog habitats (Goater and Ward, 1992).

UV-B radiations, a known immuno-suppressor may also weaken amphibian defense mechanisms against disease, making Ribeiroia infection more likely to occur (Tevini, 1993).

Blaustein et al. (1994) opined that many species of amphibians do not venture far from where they were hatched and thus also function as monitors of local conditions.

Goldberg et al. (1995 a, b) reported the Rhabdias species from B. marinus are Rhabdias fuelleborni from Brazil and Guatemala, and R. sphaerocephala from Mexico, Costa Rica, Bermuda, Jamaica, Brazil and Paraguay.

Vojtkova and Roca (1995, 1996), In two review papers summarized all the previous records of helminth infections among the European amphibians with a total of 48 digeneans, one monogenean (Polystoma integerrimum), 39 larval stages of digenea, and a single cestode (Nematotaenia dispar).

Blaustein et al. 1997 in field experiments reported that salamanders exposed to natural sunlight developed significantly more deformities of the body, tail, and eyes than salamanders that were shielded from sun light.

Yildirimhan et al. (1997) during their recent investigation on the helminthes of Rana macrocnemis reported two species of trematodes, Pleurogenes caliveger and Gorgoderina vitelliloba and one monogenean polystoma species In addition Yildirmhan (1999) reported on the parasitic helminthes of Bufo viridis where he recovered Polystoma viridis, Proteocephalus species and Nematotaenia dispar as well as other nematodes and one acanthocephalan.

Quellet et al. (1997) and Hayes et al. (2002a, 2002b) reported that deformed frogs have been found in or near sources of human drinking water, and
malformed amphibians occur in agricultural areas where insecticides and fertilizers are applied extensively.

Lafferty and Kuris (1999) opined several complex stressors like parasitic infection; habitat alteration, chemical contaminants and UV-B radiations may be at least indirectly involved to affect amphibian deformity and decline.

Johnson et al. (1999) made it clear that frogs do not survive to sexual maturity, and a high frequency of amphibian larvae may die as a direct result of Ribeiroia infection, even before they develop defects.

Daszak et al. (1999) reported that pathogens are important factors that can threaten biodiversity by accelerating population declines, leading to extinction.

Johnson et al. (1999) recently observed a correlation between the trematode Ribeiroia ondatrae and limb abnormalities in a number of frog species at several sites in Northern California.

Cockell and Blaustein (2000) and Cockell (2001) reported natural events such as comet and asteroid impacts, volcanic activity, supernova explosions, and solar flares can cause temporary but large scale ozone depletion, with accompanying increases in UV radiations. However, human induced production of chlorofluorocarbons (CFCs) and other chemicals continuously deplete stratospheric ozone, exposing plants, animals, and microorganism to long term, continual doses of harmful UV-B (280-315 nm) radiation.

Ankley et al. (2000, 2002) in several experimental studies have shown that leopard frogs (Rana pipiens) exposed to UV-B radiations experienced changes in hind limb structure.

Biserkov et al. (2001) reported a new specie Polystoma macrocnemis from the Iranian log legged wood frog Rana macrocnemis (Ranidae) in Turkey.
Kiesecker et al. (2001 a) noticed an increased mortability of western toad (*Bufo boreas*) eggs in high elevation lakes in the Cascade mountains by a parasitic fungus (*Saprolegnia ferix*) during drought years and concluded large scale changes in climatic patterns could be a precursor for pathogen-mediated amphibian declines in several areas of the world.

Johnson et al. (2001 b) reported massive mortality of amphibian eggs, larvae and adults in some areas and further deformed amphibians only rarely survive to adulthood.

Kiesecker (2002) in field experiments reported that larval wood frogs held in field enclosures with two different sizes of mesh. Amphibians in enclosures with the smaller mesh, which excluded cercariae of the trematode Ribeiroia, developed normally. However, in enclosures with mesh large enough to allow cercariae to enter, severe limb abnormalities were observed.

Kiesecker (2002) after amphibian larvae exposure to both *Ribeiroia cercerie* and low level of pesticides reported increased infection decreased immune response, and a greater frequency of defects compared to amphibians exposed only to Ribeiroia.

Johnson et al. (2002) in the Western US found no connection between pesticide contamination and amphibian deformities. However, one insecticide carbaryl caused a very low incidence of missing, deformed and extra limbs in one frog species under experimental conditions (Bridges, 2000).

Blaustein and Belden (2003) after exposing amphibians to UV-B radiations reported slow growth rate, hampered the immune system, and malformations of the limbs, body and eyes as well as changes in behavior.

Daszak et al. (2003) while studying infectious diseases and amphibian population declines reported chytridiomycosis, Ranavirus, saprolegniosis and
trematode (*Ribeiroia* spp.) as causes of mortality leading to amphibian population declines.

Kuzmin *et al.* (2003) reviewed and summarized the literature on the nematode genus *Rhabdias* from herps of the Nearctic.

Luque *et al.* (2005) reported that nematodes represented 81.3% of the total species in the component community of *Bufo icterus*. The composition of the majority of parasite communities of bufonid amphibians shows a higher number of nematode species (Goldberg and Bursey, 1991a, b; Goldberg *et al.*, 1995a, b) than trematodes as observed for several ranid hosts (McAlpine, 1997).

**Birds**

The state of J&K is inhabited by a diverse fauna of water fowls. The ponds, pools, streams and particularly lakes offer a good habitat for the ducks and geese. They add much colour to the beautiful landscape and bear a significant aesthetic value for this attractive tourist centre. They are not only efficient converters of agricultural bye-products particularly of wastes into high quality meat but also provide eggs and rich manure. Besides, their feathers are used for ornamental purposes. The duck and goose reared by locals near these water bodies are likely to be infected with helminthes as their intermediate hosts are easily available to them in abundance in the form of snails, aunts, beetles, flies etc. Like amphibians, a number conservation programmes have been launched worldwide to protect and safeguard the bird fauna.

Ackert and Beach (1933), Ackert (1934), Ackert and Eisenbrandt (1935) and Kerr (1955) reported that the host resistance and immune response against *A. galli* is related to age of the host, sex, breed and indirectly to the nutritional state of the host. Chickens older than three months develop a strong resistance against *A. galli* (Tongson and McCraw, 1967). In chickens less than three
months of age, the worms mature more rapidly than in older chickens, thus influencing the prepatent period (Ackert et al., 1935 and Kerr, 1955).

Gower (1938) reported prevalence for *Zygocotyle* species from ducks collected near Augusta, Michigan spring (17.5%), summer (23%), fall (4%), and winter (10%).

Caballero (1939) found trematode (*Typhlocoelum sisowi*) in all groups of birds collected near Mexico city. However, the prevalence was low.

Larios (1944) described *Cloaco-taenia megalops* from *A. cyanoptera*, *A. discor* and the American coot *Fulica americana*, all collected in Largo de Texococo, Mexico.

Qureshi (1950) reported incidence of helminthic infection in the avian hosts.

Schiller (1951) recovered *Sobolevicanthus gracilis* from all groups of green winged teal, found it in the mallard, black duck, *Anas rubripes*, and lesser scaup, *Aythya affinis*, collected in Michigan, Ohio and Wisconsin.

Buscher (1965) Wilkinson et al. (1977) and Broderson et al. (1977) reported that *Notocotylus attenuatus* occurred more frequently in ducks collected in the fall.


Crichton and Welch (1972) found *Amidostomum anseris* in adult and Juvenile mallards and pintails collected in Manitoba and reported high prevalence of 53%, particularly among Juveniles (62%).

Turner and Threlfall (1975) reported *Notocotylus* species in 31% of *Anas crecca* collected in eastern Canada with juvenile teal exhibiting a range of infection from 1-636.
McLaughlin and Burt (1979) reported it from the black duck, blue winged teal, wood duck, *Aix sponsa*, and American widgeon all collected in New Bruns Wick, Canada.

Shaw and Alan (1980) reported various helminth fauna of waterfowl in Oklahoma. The parasites recovered were viz., *Echinostoma revolutum, Echinuria uncinata, Epomidiostomum uncinatum, Amidostomum* species and *Hymenolepis* species.

Seegar (1981) furnished an account on circum polar infection in swans by heartworm, *Sarconema eurycera*. The larvae of *S. eurycera* were found to be nocturnal, concentrating in blood between 01.00 and 04.00h.

Roscoe and Huffman (1981) studied the trematode (*Sphaeridiotrema globulus*) induced ulcerative haemorrhagic enteritis in wild mute swans, causing a huge number of deaths in the hosts.

Petrov and Davidov (1981) made some observations on the use of drug, benacil in *Amidostomum* infections in geese. It was studied that intensity of *Amidostomum* infections in gostlings was reduced following doses of 0.2 and 0.3 g/kg body-weight of benacil.

Saez *et al*. (1981) reported parasites in 5 species of swans which died in zoological gardens in Paris and were infected with *Echinuria, Aspergillus, Hymenolepis, Capillaria, Ascaridia* and *Eimeria*.

Takla and Thiel (1983) while working on parasitic infections in two black swans, *Echinuria uncinata* was reported in the proventriculus of the emaciated swans.

Kobulej (1983) emphasized an account on pathology and epidemiology of *Amidostomum anseris* infection in geese.
Kononenko and Khaizade (1983) worked on the helminth fauna of Charadriiformes and Anseriformes. The prevalence of cestode, nematode, trematode and acanthocephalan infections was 50.0, 45.0, 13.3 and 1.6% respectively.

Aguirre et al. (1984) reported different Mallophagan ischnoceran lice of domestic birds of Spain. Ornithobius bucephalus was collected on 6 of 18 mute swans, Cygnus olor.

Lauzo et al. (1985) observed the efficacy of faecal examination for the diagnosis of helminthiasis in domestic chicks.

Stenko and Bakova (1986) while studying the helminthes of Cygnus olor revealed the prevalence of 92.9% of Amidostomum cygni. The blood nematode, Sarconema eurycera (35.7%) was investigated and L3 of the filarid were found in Trinoton anserinum.

Johal and Bala (1986) have studied comparative incidence of parasites in two common varieties of Gallus domesticus. It was revealed that white Leghorns were parasitized only by Ascaridia galli whereas the desi variety was parasitized by the lice, nematodes and cestodes.

Fried et al. (1987) furnished an account on SEM observations of papillae of Echinostoma revolutum. It was revealed that most abundant papillae were unciliate and arranged on the body and tail of cercaria.

Tendeiro (1989) discussed chewing lice in family Menoponidae, species studied were Trinoton gambensis, T. alopochen, T. aculeatum, T. straeleni and T. madagascariense. The effect of biting louse Menacanthus stramineus on reducing the egg production of poultry was studied by Pavlovic et al. (1989).

Cohen (1989) furnished an account on the role of the vector, Trinoton anserinum for the heart worm, Sarconema eurycera of swans.
Cohen et al. (1991) studied the biting lice, *Trinoton anserinum* of swans as intermediate host of *Sarconema eurycera* and it was observed that mandibles in the lice were robust and asymmetric, and the maxillae had a serrated inter cutting surface.

Mucha *et al.* (1990) while working on mallard ducklings experimentally infected with *Echinostoma trivolvis*, revealed that mallard ducklings were less susceptible to *Echinostoma* infections than golden hamsters to *E. trivolvis*.

Spakulova *et al.* (1991) made some observations on seasonal changes in the species composition of nematodes and acanthocephalans of *Anas platyrhynchos*. The results revealed that the majority of helminth species found in wild ducks also parasitized domestic ducks.


Papazahariadou *et al.* (1994) reported the parasites of digestive tract of *Cygnus olor*, *Amidostomum anseris*, *Nematoparataenia southweli*, *Hymenolepis* and *Capillaria*. While working on the helminth community structure and pattern in *Anas platyrhynchos*, Fedynich and Pence (1994) reported that mallards had higher mean abundance of helminths in summer than winter.


Pechenik and Fried (1995) while studying the effects of temperature on survival and infectivity of *Echinostoma trivolvis* cercariae observed that
average carcaria survived more than 2.5 times longer at 18°C than at 32°C. This explained energy limitation hypothesis.

Zuchowska (1997) investigated helminth fauna of anseriformes with a prevalence of trematodes (1.16%), cestodes (13.05%) and nematodes (20.28%).

Pennycott (1998) observed lead poisoning and parasitism in a flock of mute swans and the parasites recovered were Amidostomum, Trinoton, Wardoides and Echinoparyphium.

Simpkins and Fried, (1999) while working on effects of a diet deficient in vitamin A, D and E on infectivity and development of E. trivolvis in chicks, observed that avian hosts lacking fat soluble vitamins showed poor development of E. trivolvis.

Sobhan et al. (2000) investigated the occurrence of avian nematodes viz., Acuaria hamulosa and Acuaria Spiralis, in fowls of Bangladesh. The Pyknotic nuclei in the epithelial lining of the proventricular mucosa indicated necrosis of the organ.

Betlejewska and Kalisnska (2001) observed that significantly more worm cysts of Echinuria uncinata were found in young mallards (33.3%) than in older ones (13.3%).

Gokcen et al. (2002) gave an account on prevalence of nematodes in geese in the province of Konya and it was revealed that the nematode, Amidostomum anseris was detected at the rate of 15.09%.

Tenora et al. (2002) while analyzing the heavy metal concentrations in gravid tapeworm species parasitizing aquatic birds, it was revealed that the effects of heavy metals on tapeworm morphological and anatomical features, were used as indicators of the environmental conditions.
Bwangamoi et al. (2003) in a study in gesorontestinal helminthes of *Leptoptilos crumeniferus*, reported the nemotodes viz., *Acuaria spiralis*, *cheilospirura*, *Echinuria leptopti* and *Amidostomum*.

Evans et al. (2004) studied on high performance thin layer chromatography (HPTLC) and it was observed that the snails infected with *Echinostoma* showed no significant differences in the concentrations of lutein and β-carotene compared to the uninfected cohorts.

Kulisc et al. (2004) reported that the most widespread species of trematodes in *Fulica atra* L. were *E. sarcinum* and *N. pacifera*, identified in 44.92% and 33.05% of the birds, respectively, followed by *Notocotylus attenuatus* (22.88%) *Bilharziella polonica* (15.25%) and *Cotylurus hebraicus* (12.71). The prevalence of infection with the other species of trematodes was at a much lower level.

Morley et al. (2004) furnished an account on the utilization of a single species molluscan community of *Lymnaea peregra* by metacerearia of *Echinoparaphium recurvatum*.

Toledo et al. (2004) while working on the effect of age of adult worms of *Echinostoma freidi* on the infectivity of miracidia, suggested that adult worms producing viable eggs required additional maturation to be able to yield eggs containing infective miracidia.


Schneck et al. (2004) studied on thin layer chromatographic analysis, revealed that free fatty acids composition of faeces or infected *Biomphalaria glabrata*, was significantly lower than that of uninfected samples.
Fish Haematology

Fishes are the most abundant and yet least known class of vertebrates. Fishes have been used as protein rich diet for human consumption. Economically, the interest in and the importance of fish is considerable, but the fish industry is suffering a lot owing to parasitic infestations which leads to ill health of the fish resulting in anaemia and death. Much of the work has been done on the hematology and health of the fish and the review that follows gives the overall picture of the work done on the hematology of fish.

Summer felt (1967) in the assessment of the blood parameters of gold fish *Carassius auratus*, observed that males consistently had significantly higher haematocrit values than the females and suggested the need to separate blood component data on the basis of sex to avoid attributing sex differences to other factors.

Gelineo (1969) studied concentration of haemoglobin in 53 species of fresh water and marine fish and observed an average of 8.6% haemoglobin. He reported that fresh water, active and male fish have a higher concentration of haemoglobin than marine inactive and female fish related to them.

Ivasik and Virepo (1969) studied the effect of sanguinicolosis in carp during winter. They reported that due to this infection haemoglobin was reduced by 20% in mild cases and 61% in serious cases.

Ashman and Barber (1970) prepared a dual diluter for hematology which was accurate, simple to use, reliable and saved a considerable amount of time.

Einszpom-orecka (1970) observed that the copepod parasites of the fish cause damage to the respiratory epithelia of the gill filaments in the fish, mainly with their swimming appendages, parts of their mouth and their second antenna. The damage caused by movements, feeding and attachment of the parasites results in the appearance of necrotic alterations.
Smirnova (1971), while studying *Cyprinus carpio* infested by haemogregarines found various phases of destruction of erythrocytes in the blood of the outer lying tissues of the infected fish on certain occasions in infected fish it occurs that a high percentage of erythrocytes are destroyed by haemogregarines, so the capacity of the blood to carry out its respiratory functions falls off considerably, which could be associated with the periodic deaths of Carp. Becker (1970) and Kirmse (1980) believed that part of the life cycle of haemogregarines occurs in the leucocytes.

Andreev and Markov (1971) studied the effect of some helminths on the sturgeons. The level of haemoglobin, number of erythrocytes, copper, cobalt, manganese and to some extent zinc contents and the index of colloidal stability of serum protein were affected.

Haider (1972) made haematological observation on rainbow trout, *Salmo gairdneri* Rich and formulated an erythrocytic distribution curve. He suggested measuring of RBC’s as a differential diagnostic feature in fish pathology. The size distribution of the RBC’s showed a bell shaped “guass”. Blaxhall (1972) reviewed some selected literature regarding the use of haematological techniques for assessing the health of fresh water fish. He compared the technique already widely used in human pathology for the assessment of health and for aid in diagnosis of various diseases and condition in fresh water fish. He also considered the use of haematological values in assessing sub-lethal concentrations of environmental pollutants and the possibility of chromosomal changes.

Blaxhall and Daisley (1973) tried all human hematology methods successfully on fish blood. They described routine haematological methods for examining fish blood which included haemoglobin estimation, PCV, erythrocyte counts, ESR, TLC and DLCs and cyto-chemical staining. They gave description of stained blood cells as well as the range and mean value for these tests on
brown trout *Salmo trutta* (L). These methods were suggested as possible means of assessing the fish health.

Evans (1974) studied growth, mortality and haematology of cut throat trout *Salmo clarki* experimentally infected with the blood fluke, *Sanguinicola Kiamathensis* Wales, (1958). He observed that packed cell volume and haemoglobin values were reduced significantly in experimental fish as compared to the controls.

Hussein *et al.* (1974) made a haematological study of healthy *Anguilla vulgaris* and *Mugil cephalus*. They studied the seasonal variations of the cellular blood constituents, erythrocyte counts, size of the erythrocytes and the erythrocyte nuclei, the number of leukocyte and DLC, haematocrit values, haemoglobin content, ESR and specific gravity. They found that the average RBC counts, haematocrit values and haemoglobin content for the mullet, *M. cephalus* were always higher than those of the eel – *A. vulgaris* throughout the whole experimental period. They observed no clear seasonal variations for both species in ESR and specific gravity whereas erythrocyte count, haematocrit values and haemoglobin content were found to be higher in summer and lower in winter.

Voznyi *et al.* (1975) worked out immunophysiological reactivity of carp and carp hybrids with parasite infection. They compared the blood formula and serum proteins of the common pond-breed carp, *Cyprinus carpio* and its hybrids with mild carp infected with *Dactylogyrus extensus*, *Khawia sinensis* and *Bothriocephalus gowkingensis* with an infected controls. In infected fish, particularly those in which *D. extensus* and the sporozoan *Sphaerospora carasli* were present together, the haemoglobin, erythrocyte numbers and total proteins were lower than in controls. The ESR and phagocytic activity of leucocytes and their number were increased and the polymorphonuclear and neutrophil cells were above normal. The lymphocyte number was reported to be down.
Golovina (1976) reported changes in white blood composition of the carp during infection with *Dactylogyrus extensus* in the light of a new classification of formed elements. He presented a new data on the effect of *D. extensus* on the blood of carp as per which a characteristic feature of dactylogyrosis is eosinophilia, anisocytosis and polychromatophilic anaemia.

Golovina *et al.* (1977) studied the effect of certain diseases on haematological indices of carp. They studied carp blood disease of infections, mycotic and invasive origin and observed that each disease evokes definite deviations in the carp, which could be used for diagnosis of these diseases.

Lucky (1977) conducted haematological investigation of fish for diagnostic purpose. Skvortosva (1977) worked on haemalotogical indicators of carp infected with *Dilepis unilateralis* larvae. He observed that in heavily infected fish the haemoglobin level was significantly reduced and the percentage of neutrophils, monocytes and polymorphonuclear agranulocytes were increased. These changes were not subject to age variations.

Natrajan and Balakrishnan (1977) worked out certain effects of parasitic infestations by *Lernaeenicus hemirhamphi* kirtisinghe on *Hemirhamphus xanthopterus* val. and *H. far* forsk. In both species higher haemoglobin content was evident in fish with immature parasites. They, however, noticed that this rise was soon lost when fishes were infected with mature parasites. Also a reduced erythrocyte count in infected host fishes was noted.

Kapustina (1978) examined the host parasite relationships in the system *Khawia sinensis* – carp in low intensity infection. He observed no increase in basophil numbers, no eosinophilia, no specific humoural or tissue reactions, however, the number of pseudophils in infected fish was doubled.

Kawatsu (1978) made studies on the hypodermic microcytic anaemia of crucion carp caused by infestation with a trematode, *Diplozoon nipponicum*. 
The haemoglobin levels of host fish decreased with increasing number of parasites and the relationship between them appeared approximately linear. He observed that in anaemic fish all haematological indices decreased. A high percentage of immature erythrocytes were found.

Denisov (1979) worked out the pathogenic effect of *Posthodiplostomum cuticola* infection of silver carp. He noted that during infection haemoglobin reduced by 2.7%, erythrocyte number by 25% and the serum protein content was halved. However the ESR increased 2 to 4 fold and leukocyte numbers rose by 44%.

Baturo (1980) studied pathological changes in cyprinid fry infected by *Bucephalus polymorphus* and *Rhipidocotyle illensis* metacercaria. They were mostly mechanical injuries. Hyperemia, hemorrhage, edema of organs and tissues, extensive blood extravasations, necrobiotic and necrotic changes were the most frequent histopathological findings.

Mohabey and Agarwal (1981) estimated qualitatively as well as quantitatively the amino acids of uninfected and infected fishes, *Clarias batrachus* parasitized by caryophyllaeids.

Jara and Szerow (1981) carried out electrophoretic examination of the serum of carp *Cyprinus carpio* infected with the cestode *Caryophyllaeus* species. They found that this infection in carp produced a statistically significant reduction in the albumin fraction and consequently in the total protein level.

Elarifi (1982) studied the histopathology of larval anisakid nematode infections in the liver of whiting *Merlangius marlangus* (L) Examination of blood smears revealed presence of thrombocytes, lymphocytes, monocytes and neutrophils.

Radujkovic, *et al.* (1983) produced preliminary results of studies on the effect of some parasitoses (Acanthocephala and nematoda) on erythrocytic constants
of host fish, *Chelon labrosus*. They detected a macrocytic anaemia in fish infected with Acanthocephala. Nematoda did not affect the blood composition of the host. These workers explained that the intestinal inflammation caused by Acanthocephala could cause vitamin B and folic acid deficiency and could explain the macrocytic anemia.

Mille et al. (1983) established normal ranges for diagnostically important haematological and blood chemistry characteristics of rainbow trout, *Salmo gairdneri*. Munkittrick and Leatherland (1983) measured haematocrit values in feral gold fish *Carassius auratus* as indicators of the health of the population. They found that haematocrit in male were larger than in females in all collection of the feral fish except spring caught.

Radhakrishnan et al. (1984) studied the nature of infection by *Scolex pleuronectis* (cestode) in *Trichiurus lepturus*. Significant hematological changes suggestive of the occurrence of anemia and noticeable depletion in the basic energy reserve of the fish occurred as a result of the infection.

Nikulina (1985) worked on the treatment of valipora in carp and some haematological indices of the fish. He observed no significant differences in haemoglobin levels, erythrocytic numbers or in the leukocyte formula of infected, treated and uninfected fish.

Kurovskaya and Kititsyna (1986) studied the physiological and biochemical characteristics of the while amur *Ctenopharyngodon idella* infected with helminths, *Ligula intestinalis* and *Bothriocephalus acheilognathi*. The presence of *L. intestinalis* reduced host’s oxygen uptake by half. The indices for *B. acheilognathi* infected specimens were not considerably different from those of control group. The total serum protein content of helminth infected fish was considerably higher than the control. Kurovskaya (1987) studied changes in the biochemical and morphological parameters in the grass carp yearlings invaded by helminths, changes were observed in the total protein
content in the blood serum of *Ctenopharyngodon idela* invaded by *Bothriocephalus acheilognathi*. The invasion with *Ligula intestinalis* did not produce such changes.

Natarajan and Felix (1987) observed in *Mystus gulio* contaminated by various parasites, including *Ergasilus* specie, a drastic reduction of Er, Hb and Ht, with an elevation in MCV, MCH and MCHC as compared to the non infested fish. However in the beginning of the infestation, there was an increase in the values of the blood parameters.

Heming (1989); Campbell and Murru (1990) held stress, as one of the factors responsible for haematological changes in fish caused by handling, transport and captivity conditions such as water temperature and pH.

Agarwal et al. (1989) conducted studies on haematology of trematode infested fresh water fish, *Rita rita*. It was observed that haemoglobin, TEC and PCV values were reduced but ESR increased in infected fish. In healthy ones these values were higher but ESR was lower in males.

Engelherdt et al. (1989) made haematological studies in rainbow trout affected by *Proteocephalus neglectus*. The findings were recorded in 1987 from infected rainbow trout in cages in a flooded abandoned open cast mining pits while tape worm infestation had no detectable effects on several parameters such as haemoglobin, erythrocyte count, leucocyte count, MCV, MCH and MCHC, PCV was reduced with statistical significance right at the parasitic infection.

Boon et al. (1990) studied the effect of different infection levels with infective larvae of *Anguillicola crassus* on haemological parameters of European eel *Anguilla anguilla*. They inoculated three groups of nematode free yellow eel with three levels of infective larvae of *A. crassus* respectively. Infestation were carried out weakly for five weeks and haematological parameter were
determined for seven weeks after inoculation. They concluded that infestations with the parasite can decrease the haematocrit and the quantity of plasma proteins.

Kititsyna and Kurovskaya (1991) worked out physiological and biochemical changes caused by ectoparasite invasion in carp. They studied age related changes in the morphophysiological, biochemical and hematological indices of carps to investigate the pathogenic role of various levels of *Ichthyophtherius multifilis* (Ciliata) and *Dactylogyrus extensus* (trematoda) invasion in the carp-ectoparasite system. They found direct correlation between the level of the invasion on one hand and haemoglobin concentration and erythrocyte count on the other hand. Also protein content in the blood serum increased as the level of invasion increased.

Hoglund *et al.* (1992) studied haematological variations in a population of *Anguilla anguilla* naturally infected with *Anguillicola crassus* off the Swedish Baltic coast in an area receiving heated cooling water from a nuclear power station. The erythrocyte count, haematocrit, leukocrit, haemoglobin concentration, mean corpuscular volume (MCV), mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration (MCHC), the various cell types in peripheral blood, serum iron concentrations, the amount of total serum protein and serum protein fractions $\alpha_1$, $\beta_1$, $\alpha_2$, $\beta_2$ and $\gamma$ were all measured. Each variable was correlated to the intensity of infection (number of parasites/host) and parasitization index (the weight of parasite/somatic weight of the host). Most variables showed no or only minor reactions to the infection. However a marked increase in the $\gamma$ fractions of serum protein, reduced lymphocyte numbers and increased granulocyte numbers were considered indicative of a humoral and cellular immune response.

Saxena and Chauhan (1993) worked out the effect of parasitic infection on the blood of *Heteropeustes fossilis* (Bloch). They took blood samples from the
heart of *H. fossilis* infected with *Lucknowia indica* and uninfected controls. As compared to controls, infected fish had erythrocyte count reduced by 8.6%, haemoglobin levels reduced by 8.1% and serum cholesterol level reduced by 5.0%. In contrast, the total leucocyte count and blood sugar, blood urea and serum bilirubin levels were increased by 2.77%, 14.0%, 33.33% and 16.66% respectively.

Schweiger (1994) studied the *Anguillicola crassus* infestation of eels in lake Constance and its effect on blood values. He observed that the nematode (average burden 6.8) was present in 68.3% of 957 *Anguilla anguila*, resulting in anaemia, while swim bladder lesions appeared in 11% of eels.

Ogawa *et al.* (1997) made a field observation of *Heterobothrium* infection of cultured tiger puffer, *Takigugu rubripes*. The blood parameters of the host were not severely affected probably because the level of infection was not high in this case. Again the worker in the same year studied experimental infection of *Heterobothrium* in cultured tiger puffer, *Takifuga rubripes*. Infected fish showed anaemia as indicated by the decreased haematocrit value and haemoglobin content with the growth of parasites.

Ranzani-Paiva *et al.* (1997) noted haematological characteristics associated with parasitism in mullets, *Mugil platanis* Gunther from the estuarine regions. Analysis of variance was carried out to evaluate the effects of blood and gill parasitism on measured blood parameters. Significant differences were found for the haematocrit in infected versus non-infected fish. They found no differences with regard to leukocytes.

Yadav (1998) worked out effect of trematodes on blood urea level of the fish *Heteropneustes fossilis*. He observed that in an uninfected fish the mean level of urea was 80.019 ± 2.895mg/100ml blood, whereas in infected fish the mean level of urea was 128.429 ± 3.982 mg/100ml blood.
Sahoo and Mukherjee (1999) worked out normal ranges for diagnostically important hematological parameters of laboratory reared Rohu (*Labeo rohita*) fingerlings. The morphology of cells was also described. There was wide variations in hematocrit and MCV of individual healthy fish.

Sinha (2000) after hematological study on *Clarias batrachus* concluded that the helminthic infections produce changes in the haematological manifestations in fish which are quite comparable to those in mammals including man, were particularly in relations to total and differential leucocyte count which may therefore be of diagnostic utility.

Sinha (2000) worked out haematological manifestation in *Clarias batrachus* carrying helminthic infections. He reported that the cat fish *C. batrachus* carrying both *Lycocestus* (Caryophyllid cestode) and *procamallanus* (a Camallanid nematode) infections either singly or mixed showed a significant increase in RBC size (5-7%) indicating macrocytosis, anisocytosis and poikilocytosis. However, concomitant reduction in their count (19-20%) PCV (8-10%) etc as well as surface/volume ratio all confirmed for occurrence of macrocytic (pernicious) anaemia in the infected fish. The infected fish showed restlessness, perhaps reflecting inefficient respiration. Furthermore, highly significant increase in the leucocyte count and well marked higher degree of eosinophilia (715%) and lymphocytosis (>10%) in both male and female fish indicated a diseased state.

Yoshinaga, *et al.* (2000) studied haematology, histopathology and the monogenean. *Neoheterobothrium hirame* infection in anaemic Flounder. Anaemia was haematologically characterized by the appearance of many immature erythrocytes and abnormal staining in the cytoplasm (vacuolation or weak staining of erythrocytes). It was suggested that the anaemia was caused by parasitic haematophagia.
Mushiake et al. (2001) studied epizootiology of anaemia in wild Japanese Flounder. Anaemia of unknown etiology was frequently observed in wild and cultured Japanese Flounder, *paralichthysolivaceus*. They conducted an epizootiological study of the anaemia in wild Flounder (416 fish) captured in 10 different coastal waters from February 1999 to 2000. Anaemia was observed in the fish captured in all coastal waters except for Hokkaido and was characterized by low haemoglobin levels, low erythrocyte numbers and a frequent appearance of immature erythrocytes. In these anaemic Flounder (130), the blood feeding monogenean, *Neoheterobothrium hirame* and or its vestiges were observed at a high prevalence rate (117/130 = 90%) on the buccal cavity wall. There was a negative correlation between the number of adult parasites and haemoglobin levels. These results suggest that the anaemia was caused by the haematophagia of *N. hirame*.

Nakayasu et al. (2002) worked on the haematology of anemia in Japanese Flounder experimentally induced by repeated bleedings. They noted that the haematological characteristics of the anaemia caused by the repeated bleedings was almost identical to the anaemia observed in Japanese founder, supporting the previous conclusion that the blood-feeding activity the monogenean *Neoheterobothrium hirame* is the cause of the anaemia.

Fernandes and Mazon (2003) reported that haematological parameters are closely related to the response of the animal to the environment, an indication that the environment where fish lives could exert some influence on the haematological characteristics (Kori-Siakpere, 1985).

Gabriel et al. (2004) reported that during their study on *Clarias gariepinus* reported that after acclimation, males consistently had higher values of WBC, neutrophilis and monocytes than the females but the reverse was the case with lymphocytes, thus conclude that the males are more responsive to the stress of acclimation than the females.
Malgorzata (2005) while studying haematological and immunological effect of heavy metals on fish blood concluded that short term exposure to high levels of heavy metals induced stress reaction in fish. The changes in RBC system were minor and major in WBC system. The author further emphasized toxic stress may result in considerable increase in susceptibility of fish to infection.

The perusal of the literature indicates that no sufficient work has been done on the limnological aspects of Anchar lake, Kashmir and the subsequent impact on the vertebrate fauna living within and outside the lake. Henceforth, the present study was undertaken to assess the pollution and its subsequent impact on the vertebrate fauna with regard to fish, amphibia and bird fauna of the lake. Furthermore, the impact of pollution and parasitism on the haematological aspect of fish was also monitored.