Indian J. Fish., 36 (1) : 19 - 27 (1989)

OBSERVATIONS ON SOME LIMNOLOGICAL ASPECTS OF FOUR IMPORTANT LAKES OF KUMAON HILLS OF U.P. AND SUGGESTIONS FOR THEIR PROPER EXPLOITATION

V.K. JOHRI, S.K. AWASTHI, S.R. SHARMA, N.K. TANDON
Directorate of Fisheries, 7-Faizabad Road,Lucknow - 226 007
AND L.M. JOSHI
Department of Fisheries, Bhital, Nainital, India

ABSTRACT

The paper, broadly aiming at eco-conservation, attempts to communicate certain limnological observations in respect of four sprawling lakes viz. Nainital, Sattal, Bhimtal and Naukuchiatal of Kumaon hills of U.P. on the basis of studies conducted during the year 1988. Values of relevant parameters exhibiting the various physico-chemical properties of water of the aforesaid lakes have been incorporated and discussed. An account of planktonic population and occurrence of benthic organisms in the collected samples have also been depicted. Control of Nainital lake is exercised by Nagar Palika, Nainital, whereas fishery of Bhimtal, Naukuchiatal and Sattal is managed by the fisheries department of U.P. The average per hectare productivity of fish in respect of latter three lakes, taking five years catches into consideration, is low. The resource potential is not less and the productivity can be reasonably enhanced provided better management practices are undertaken and appropriate technologies are applied. Original fish fauna of commercial importance in these upland waters is basically constituted by mahseer and schizothoracids, but the introduction of common carp, Indian major carps, silver carp and grass carp has shown encouraging results. Nainital lake shows a pollutional status and remedial measures are to be adopted to prevent the recurrent mortality of fish during winter because of oxygen deficiency. All the four lakes that add to the scenic glory of the area in a specific way, are required to be developed from fisheries angle in order to ensure availability of nutritious food to the local people and also to provide a wider range of attraction, especially for angling-tourism.

INTRODUCTION

The Kumaon Himalayan lakes of U.P. which occupy a significant position owing to their geographical situation, evolve an integral component of the natural beauty and have been investigated for various limnological parameters by several authors in the recent past (Pant and Sharma, 1978; Bisht and Das, 1979; Das and Upadhyaya, 1979; Pathani and Das, 1979 and Sharma and Pant, 1984, 1985). The studies conducted so far indicate a degrading ecological trend which has ultimately tended to make these lakes unsuitable for the well-being of fish (Sehgal *et al.*, 1988). This is the most unfortunate part that our hills which have been a source of inspriation for sages, philosophers, writers, scientists and many others for generations, have witnessed a state of deterioration of valuable water potential mainly due to human activities, and there is an urgent need to safeguard the interest of the coldwater fishery resources. The present investigations have been taken up to secure the latest know-how of bio-ecological characteristics of Nainital, Sattal, Bhimtal and Naukuchiatal lakes of district Nainital in Kumaon hills of Uttar Pradesh (India) and to make use of available techno-

logical advancements with regard to effective utilization of these lakes.

Materials and Methods

Monthly sampling of sub-surface water in each lake was done at specific spots from January to December, 1988 for the estimation of parameters like temperature (air and water), water transparency, pH, dissolved oxygen, free carbon dioxide, carbonates, bicarbonates, chlorides, total hardness, phosphates, silica and total dissolved solids. Recording of temperature and transparency and determination of pH, dissolved oxygen, free carbon-dioxide and total alkalinity was done on the spot. However, toluene fixed water was brought to laboratory for further analysis. Standard methods (APHA, 1985 and Golterman, 1978) were followed for examination of the water quality.

Samples for plankton analysis were collected by filtering 100 1 of sub-surface water through a ring net of 30 cm diameter made up of organdie cloth. Qualitative estimation of phyto and zooplankton was carried out using Sedegwick-rafter plankton counting cell under a binocular and consulting Needham and Needham (1972) and Edmondson (1959). Occurrence of benthic organisms encountered in the samples collected with the help of Ekman dredge is also summarized. To ascertain the percentage composition of available fish fauna in Bhimtal, Naukuchiatal and Sattal lakes, catch data from 1983-'84 to 1987-'88 through departmental efforts have been taken into account.

Results

Hydrological features

Figs. 1 and 2 exhibit seasonal fluctuations in water temperature, dissolved oxygen, free carbon dioxide, pH, chloride and total alkalinity in all the four lakes. The various ranges of relevant parameters are incorporated in Table 1.

Plankton

Table 2 gives the monthwise data relating to percentage composition of phyto and zooplankton in all the lakes. Phytoplankters, as a general trend, showed predominance and were mainly represented by green and blue-green algae, diatoms and desmids; whereas protozoa, cladocera, copepoda and rotifera constituted the zooplankton. A list of genera belonging to different groups is presented in Table 3.

Benthic fauna

Principal constituents of bottom-biota in all the four lakes were nymphs, larvae and adults of insects. Nymphs of mayfly, stonefly, dragonfly and damselfly were commonly observed in the collected samples. Nainital lake, in particular, had the presence of *Chironomus* and *Tubifex* to a greater extent. Adult forms of aquatic insects were mainly represented by water bugs in all the lakes. Other specimens like *Eubranchipus* among the crustacenas, leeches among the annelids and *Campeloma, Gyraulus* and *Physa* constituting the molluscs have also been recorded in qualitative analysis of the benthic life.

Fish catches

Data pertaining to departmental fish catches from 1983-'84 to 1987-'88 regarding Bhimtal, Naukuchiatal and Sattal are presented in Table 4. Since Nainital lake is not managed by the Department of Fisheries, data of fish catch are not available.

Discussion

Annual variations in certain physico-chemical parameters regarding Nainital and Bhimtal lakes of Kumaon hills have been studied by Sharma and Pant (1984).

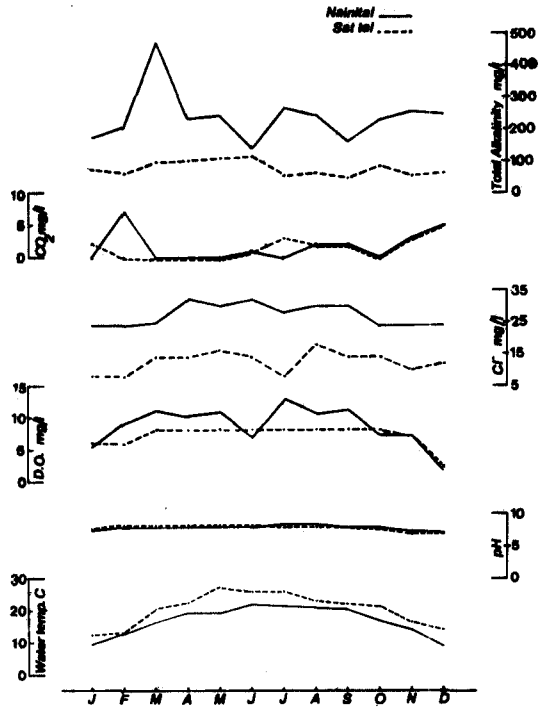

Figure 1– Seasonal variations in physico-chemical properties of Nainital and Sat tal lakes

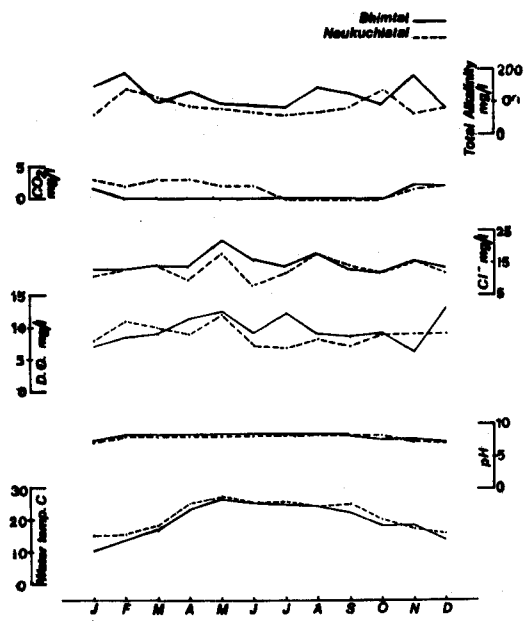

Figure 2– Seasonal variations in physico-chemical properties of BHIMTAL & NAUKUCHIATAL lakes

TABLE 1. *Physico-chemical parameters of Nainital, Sattal, Bhimtal and Naukuchiatal lakes*

Parameters	Nainital	Sattal	Bhimtal	Naukuchiatal
Air temperature (°C)	7-24	10.5-28	14-29	15-31
Water temperature (°C)	9-22	12.5-27	10.5-26.5	15-27
Secchi disc reading (cm)	30-243	140-526	210-370	256-468
pH	7.2-8.4	7.2-8.3	7.2-8.3	7.3-8.2
Dissolved oxygen (mg/1)	1.7-12.8	5.6-10	6.2-12.6	6.8-12
Free carbon dioxide (mg/1)	nil-7	nil -5.1	nil -2.1	nil-3
Carbonates (mg/1)	nil-160	nil-20	nil-32	nil-30
Bicarbonates (mg/1)	136-250	46-110	80-182	60-142
Total alkalinity (mg/1)	140-470	46-124	80-182	60-142
Chlorides (mg/1)	24-32	8-18	13-22	8-18
Total hardness (mg/1)	220-376	48-112	64-140	60-128
Phosphates (mg/1)	nil-0.45	nil-0.25	nil-0.05	nil-0.05
Silica (mg/1)	1-8	2-10	4-15	4-15
Total dissolved solids (mg/1)	330-550	50-250	80-200	100-250

TABLE 2. *Percentage composition of phyto and zooplankton in Nainital, Sattal, Bhimtal and Naukuchiatal lakes*

Month	Place	Phytoplankton				Zooplankton			
		Green algae	Blue-greenalgae	Diatoms	Desmids	Protozoa	Clado-cera	Cope-poda	Rotifera
1	2	3	4	5	6	7	8	9	10
January	A	-	-	57.14	-	42.86	-	-	-
	B	100.00	-	-	-	-	-	-	-
	C	52.94	-	41.17	-	5.88	-	-	-
	D	40.00	-	60.00	-	-	-	-	-
February	A	60.00	-	40.00	-	-	-	-	-
	B	-	33.33	-	-	16.66	16.67	33.33	-
	C	10.98	5.98	61.12	0.99	15.96	3.98	0.99	-
	D	33.33	33.33	-	-	-	-	33.33	-
March	A	-	-	38.46	-	-	-	-	61.54
	B	31.58	-	2.63	-	2.63	5.26	57.89	-
	C	33.33	-	11.11	11.11	11.11	11.11	11.11	11.11
	D	50.00	-	25.00	-	-	-	25.00	-
April	A	11.11	11.11	-	-	-	-	33.33	44.44
	B	-	-	28.57	-	-	14.28	42.86	14.28
	C	16.66	8.33	-	-	41.68	-	25.00	8.33
	D	7.15	57.14	-	-	21.42	-	14.28	-
May	A	1.40	0.70	6.64	-	90.79	-	0.23	0.23
	B	41.68	4.16	8.33	4.16	8.33	-	12.50	20.83
	C	17.74	22.58	4.84	-	48.39	-	4.83	1.61
	D	-	4.16	62.50	-	12.50	8.33	12.50	-
June	A	11.11	8.33	8.33	-	25.00	-	41.66	5.56
	B	-	-	6.26	84.37	-	-	6.24	3.12
	C	-	6.34	17.48	-	9.52	19.04	47.61	-
	D	37.50	-	25.00	-	25.00	-	12.50	-
July	A	-	97.23	-	-	0.31	0.61	-	1.84
	B	2.20	-	-	97.80	-	-	-	-
	C	33.33	2.22	28.89	2.22	20.00	8.89	2.22	2.22
	D	20.00	-	25.00	25.00	5.00	20.00	5.00	-

TABLE 2 Contd.

1	2	3	4	5	6	7	8	9	10
August	A	33.33	-	33.33	4.17	4.16	-	25.00	-
	B	7.69	-	12.82	71.79	-	2.56	5.13	-
	C	6.93	11.09	12.48	31.19	25.12	-	12.49	0.69
	D	2.22	22.22	35.55	20.00	6.68	2.22	6.66	4.44
September	A	-	43.18	-	-	3.41	-	44.31	9.09
	B	68.75	-	8.33	20.83	-	-	2.08	-
	C	8.88	15.56	37.78	13.33	8.89	-	14.44	1.11
	D	41.86	-	4.65	18.60	23.26	2.32	9.31	-
October	A	-	80.00	-	-	-	2.85	8.57	8.57
	B	84.61	1.92	-	-	1.92	3.84	7.70	-
	C	29.33	34.66	-	2.67	28.00	-	5.33	-
	D	17.14	42.86	5.71	-	2.86	5.71	25.71	-
November	A	-	63.63	1.82	1.82	-	-	20.00	12.72
	B	-	33.33	-	-	33.33	-	33.33	-
	C	38.86	37.04	4.16	-	17.09	0.52	2.33	-
	D	15.38	-	15.38	-	15.38	-	53.85	-
December	A	-	13.33	20.00	-	-	-	40.00	26.66
	B	-	50.00	-	-	-	-	50.00	-
	C	2.50	1.25	1.87	-	81.87	4.38	8.12	-
	D	32.14	-	42.85	-	-	-	25.00	-

Abbreviations : A= Nainital; B =Sattal; C= Bhimtal and D=Naukuchiatal.

TABLE 3. *List of plankton present in Nainital, Sattal, Bhimtal and Naukuchiatal lakes*

Phytoplankton
Green Algae
Ankrishtrodemus
Chaetophora
Chlorococcum
Draparnaldia
Germinella
Hydrodictyon
Microspora
Oedogonium
Pediastrum
Polvedriopsis
Protococcus
Selenastrum
Sphaercystis
Spirogyra
Tetraspora
Ulothrix

Blue-green alge
Anabena
Aphanizomenon
Coelosphaerium
Oscillatoria
Rivularia
Spirulina

Diatoms
Eunotia
Fragilaria
Frustulia
Melosira
Navicula
Nitzchia
Pinnularia
Synedra
Tabellaria

Desmids
Closterium
Desmidium
Gonatozygon
Mesotaenium
Micrasterias
Staurastrum

Zooplankton
Protozoa
Astramoeba
Ceratium
Eudorina
Paramecium
Vorticella
Clodacera
Acroperus
Alonella
Bosmina
Chydorus
Daphinia
Diaphanosoma
Copepoda
Canthocamptus
Cyclops
Diaptomus
Nauplii
Rotifera
Asplanchna
Brachionus
Chromogaster
Euchlanis
Filinia
Keratella
Kellicottia
Notholca
Polyarthra
Rotaria
Testudinella
Trichocerca

TABLE 4 *Data of fish catch from Bhimtal, Naukuchiatal and Sattal lakes*

Lake	Year	Fish production (kg)							
		Mahseer	Schizothoracids	Common carp	Indian major carp	Silver carp*	Grass carp*	Miscelleneous	Total
Bhimtal	1983-'84	537.80	2.50	375.60	9.90	-	-	-	925.80
(86.5 ha)	1984-'85	466.40	6.30	330.90	32.50	-	-	-	836.10
	1985-'86	534.45	14.75	98.60	28.90	1.20	7.75	1.60	687.25
	1986-'87	382.95	5.60	221.55	63.10	1.60	6.30	7.70	688.80
	1987-'88	480.30	0.50	375.75	15.70	-	23.30	0.60	896.15
	Five year's average	480.38	5.93	280.48	30.02	0.56	7.47	1.98	806.82
	% Composition	59.54	0.73	34.76	3.72	0.07	0.93	0.25	
	Average productivity : 9.32 kg/ha/annum								
Naukuchiatal	1983-'84	43.50	-	13.40	1.10	-	-	-	58.00
	1984-'85	22.70	-	15.90	25.20	-	-	-	63.80
(65.0 ha)	1985-'86	16.50	2.00	25.10	15.80	-	-	4.80	64.20
	1986-'87	15.70	0.30	8.80	1.30	-	-	4.10	30.20
	1987-'88	10.10	-	12.70	2.30	-	-	-	25.10
	Five year's average	21.70	0.46	15.18	9.14	-	-	1.78	48.26
	%Composition	44.97	0.95	31.45	18.94	-	-	3.69	
	Average productivity : 0.74 kg/ha/annum								
Sattal									
(24.48 ha)	1983-'84	53.90	-	54.30	226.80	-	-	-	335.00
	1984-'85	14.70	-	94.90	318.00	-	-	-	427.60
	1985-'86	52.10	-	113.30	193.50	-	-	-	358.90
	1986-'87	35.30	-	25.30	199.30	-	-	-	259.90
	1987-'88	56.20	-	87.00	111.80	-	-	-	255.00
	Five year's average	42.44	-	74.96	209.88	-	-	-	327.28
	% Composition	12.97	-	22.90	64.13	-	-	-	
	Average productivity : 13.36 kg/ha/annum								

* Introduced in Bhimtal lake only during 1985-'86.

According to these authors, Nainital lake (height above mean sea level: 1,937 m) depicted air and water temperature to vary between 10-28 and 10-26°C respectively. Water transparency was of the order of 62-164 cm and pH ranged from 6.9-9.1. Dissolved oxygen, total alkalinity and total dissolved solids varied between 3-16.1, 66.1-510.4 and 30-205 mg/l respectively. However, Bhimtal lake (height above mean sea level: 1,331 m) showed air temperature to range from 11.5 to 30 and water temperature from 11 to 28°C. Transparency was recorded to be 123-340 cm and pH was 7-9.1. Dissolved oxygen, total alkalinity and total dissolved solids ranged between 9 and 13.4, 43.5 and 290 and 16 and 81 mg/1 respectively. Both the lakes were characterised as warm with a winter circulation period and a stratification period extending from March to November. Water transparency of Nainital and Bhimtal lakes, showed respective values of 30-243 and 210-370 cm which highlighted the fact that water of Bhimtal lake was more clear than that of Nainital lake. Apart from this, total dissolved solids in Nainital lake and Bhimtal lake were recorded to vary from 330 to 550 mg/1 and 80 to 200 mg/1 respectively. More concentraion of total dissolved solids was found in Nainital lake in comparison to Bhimtal lake, and the present findings correspond to the earlier work. An inverse correlation is confirmed between water transparency and total dissolved solids. Water of all the four lakes, is more or less alkaline in nature (pH was always above 7), although Sharma and Pant (1984) previously reported the lowest pH value in case of Nainital lake as 6.9. The waters of most of the lakes of Kashmir valley, in general, have been found to be alkaline in characteristic (Kant, 1983). Range of total alkalinity (carbonates and bicarbonates) is wide in case of Nainital lake as compared to Bhimtal lake, and a similarity is indicated between the present and past investigations.

In the present study low level of oxygen concentration and more carbon dioxide were observed in Nainital lake in December when the fishes, mainly *Puntius* spp., were found dead and floating on the surface. Das (1988) is of the view that in smaller lentic water bodies, where growth of aquatic plants is great, the water may become deficient in oxygen due to accumulation and putrefication of organic matter, and this is especially so in lake Nainital. Oxygen content was found to be congenial for fish life in case of Sattal, Bhimtal and Naukuchiatal lakes. Huge crop of aquatic macrovegetation *(Hydrilla, Potamogeton, Polygonum* etc) and predominance of phytoplankton may be noticed in all the four lakes, but presence of detritus in Nainital lake is more, which consequently gives rise to causative factor for large scale fish kill during winters. Parameters viz. chlorides and total hardness show higher values and contribute to poor water quality in Nainital lake in comparision to other three lakes. Silica content is more in Sattal, Bhimtal and Naukuchiatal as compared to Nainital.

Population of phytoplankton in Kumaon lakes, as revealed in the present observations, exhibits predominance and the same in Nainital, Sattal, Bhimtal and Naukuchiatal is to the tune of 8.74-100, 28.57-100, 5.62-94.11 and 30.76-100% respectively. Its intensity, particularly in Naukuchiatal, appears to be maximum, and this subsequently facilitates the environment to be conducive for culture operations of fish like silver carp *(Hypophthalmichthys molitrix).*

It is obvious from Table 4 that mahseer *(Tor putitora* and *T. tor)* constitutes the major commercial fishery contributing 59.54% in

Bhimtal and 44.97% in Naukuchiatal lakes, while common carp (*Cyprinus carpio* var. *specularis, C. Carpio* var. *communis* and *C. Carpio* var. *nudus)* and Indian major carps in these waters occupy second and third positions respectively. Bhimtal has been observed to afford good environment for catla *(Catla catla)* and rohu*(Labeo rohita)*, but Naukuchiatal lake seems to provide still better ecological conditions for mrigal *(Cirrhinus mrigala).* Catla was not visible in the catches at Naukuchiatal, and perhaps it remained unflourished because of poor availability of zooplankton. Fish catches in Sattal are principally dominated by Indian major carps (64.13%) whereas common carp and mahseer occupy the second and third positions respectively. Introduction of mirror carp *(Cyprinus carpio* var. *specularis)* in the upland lakes of Kumaon hills was attempted as early as 1947 after transporting them from Nilgiri hills (Sarbahi, 1959). Later on, experiment was taken up to introduce Indian major carps in these water bodies which yielded remarkable results and communication of Singh (1983) is authoritative. In the meantime a further experiment was attempted to ascertain the impact of hydrobiological characteristics on the growth pattern of silver carp *(Hypophthalmichthys molitrix)* and grass carp *(Ctenopharyngodon idella)* in Bhimtal lake. Eighty specimens of grass carp and 110 specimens of silver carp were stocked in the year 1985-'86. Besides, 2,000 more fingerlings of silver carp were stocked in the succeeding year in this very lake after assessing its favourable behaviour. Maximum weight attained by catla, rohu, silver carp and grass carp in lake Bhimtal is of the order of 18.0, 10.5, 9.75 and 7.3 kg respectively in the departmental fishing and this shows that intensive culture of these fishes in all such water bodies holds promising prospects.

Per hectare productivity of fish in Bhimtal and Sattal lakes is quite low, and the situation in Naukuchiatal appears to be worst of all. This is mainly due to less fishing efforts, and hence it is proposed to go for regular stocking of mahseer, common carp, Indian major carps, silver carp and grass carp every year ensuring stocking density of atleast 500 fingerlings/ha (silvercarp and grass carp may be nearly 10%) of about 100 mm size on the one hand and maximise the efforts for proper exploitation on the other. Advantages of grass carp for biological control of aquatic weeds cannot be denied and silver carp can afford to consume algae to a greater extent. Therefore, Naukuchiatal and Sattal lakes should no longer remain deprived of these species.

Recently 20,000 fingerlings of silver carp have been stocked in lake Nainital but their behaviour is to be keenly observed. Nagar Palika of Nainital is supposed to take effective measures to check any further organic load owing to the effect of urbanization. Aquatic macrovegetation and detritus accumulated on the marginal sides of the lake may be removed manually as far as possible. Immediate stocking of at least 2,000 fingerlings of grass carp (average size 100 mm) is recommended to minimize the intensity of submerged vegetation, and in this context further regular studies are also proposed.

It is evident that stocking material is the basic input and essential ingredient for scientific development of fisheries of Kuamon lakes, and to achieve this goal, establishment of a modern hatchery complex and sufficient rearing area at Bhimtal is needed to ensure optimum production of mahseer and common carp fingerlings. Breeding operations of schizothoracids, Indian major carps, silver carp and grass carp are required to be undertaken. Fishery of Schizothoracids among

the catches from Bhimtal, Naukuchiatal and Sattal occupies insignificant position, and the same required due upliftment. The overall per hectare productivity of fish in these lakes can be raised to a level of 25-50 kg/annum if efforts are intensified and facilities are provided. Simultaneously the angling-tourism would also receive the desired boost.

REFERENCES

APHA AWWA WPCF 1985. *Standard Methods for the Examination of Water and Waste Water.* 16th ed. American Public Health Association, New York.

BISHT, J.S. AND S.M. DAS 1979. Aquatic entomofauna in relation to coldwater fisheries of Kumaon, India. *2nd All India Seminar on Ichthyology, Nainital* , 37.

DAS, S.M. 1988. In : *Recent Advances in Fish Ecology, Limnology and Eco-conservation.* Surendra Nath (Ed.) Creative Publishers, New Delhi: 5 - 19.

DAS, S.M. AND J.C. UPADHYAYA 1979. Studies on qualitative and quantitative fluctuation of plankton in two Kumaon lakes , Nainital and Bhimtal. *Acta Hydrobiol.,* **21**(1) : 9-17.

EDMONDSON, W.T. (Ed.) 1959. *Freshwater Biology,* 2nd edition, John Willey and sons Inc., New York.

GOLTERMAN, H.L. 1978. *Methods for Physical and Chemical Analysis of Freshwaters.* I.B.P. Handbook No.8, Blackwell Scientific Publications, Oxford, London, Edinburgh and Melbourne.

KANT, S. 1983. *Limnology of the Himalayan lakes : Resource Use and Management.* 165-195. Himalayas Mountains and Men. Print House (India), Lucknow :

NEEDHAM, J.C. AND P.R. NEEDHAM 1972. A *Guide to the Study of Freshwater Biology.* Holden Day, Inc., San Francisco.

PANT, M.C. AND P.C. SHARMA 1978. Observations on some possible casual factors governing the mortality of winter fish in the Nainital lake. *Proc. National Seminar on Resource Development and Environment in the Himalayan Region.,* 248 - 254. New Delhi.

PATHANI, S.S. AND S.M. DAS 1979. Population biology of Mahseer *Tor tor* and *Tor putitora* in Bhimtal of Kumaon hills. *Second All India Seminar on Ichthyology., Nainital* : Abstract 149.

SARBAHI, D.S. 1959. *The Story of Mirror Carp Culture in Uttar Pradesh.* Superintendent, Printing and Stationery, Lucknow (India).

SEHGAL, K.L., S. SUNDER, H.S. RAINA AND B.C. TYAGI 1988. Twenty five years of research on coldwater fisheries in India. *Special Scientific Report No. 1 , National Research Centre on Coldwater Fisheries* (ICAR), Haldwani, Nainital : 13.

SHARMA, P.C. AND M.C. PANT 1984. Abundance and community structure of limnetic zooplankters in Kumaon lakes, India. *Int. Revue qes., Hydrobiol.,* **69** (1) : 91-109.

SHARMA, P.C. AND M.C. PANT 1985. Species composition of zooplankton in two Kumaon Himalayan lakes (U.P. India) *Arch. Hydrobiol.,* **102** (3): 387-403.

SINGH, A.N. 1983. On induced breeding and culture of Indian major carps in coldwater lakes of Nainital district in U.P. *J. Zool. Soc. India,* **35** (1-2) : 115-118.