J. Ecophysiol. Occup. Hlth. 15(1 & 2), 2015, 9–17

DOI : 10.15512/joeoh/2015/v15i1&2/91182

Ichthyofaunal Diversity of Sarda Sagar Reservoir in Tarai Region

Prem Kumar*, K. K. Saxena[1], B. C. Tyagi, K. D. Joshi[2], N. N. Pandey, A. K. Singh

ICAR- Directorate of Coldwater Fisheries Research, Bhimtal, Nainital, Uttarakhand, India - 263136
[1]Department of Zoology, Bareilly College, Bareilly, U.P., India - 243005
[2]Reverine Division, Central Inland Fisheries Institute, Pannalaal Road, Allahabad, U.P., India - 211002

Abstract : *Studies conducted for Sarda Sagar reservoir in Uttarakhand state and found 42 fish species belonging to 33 genera, 15 families and 6 orders with disappearance of some earlier reported important species. The available data of fish landing for the period 1997 to 2007 showed dominance (58.86 %) of small sized weed/trace fishes followed by minor carps (16.9%), while the commercially important species like Indian major carps, Common carps and mahseer contributed least share (6.99%), among them only Common carp formed sizeable catch (53%). In general, Gudusia chapra and Labeo gonius of the minor carps group are the dominant species in the catch. The estimated production was recorded 60 Kg/ha. A declining trend was observed in the production during 1997-2007 due to over exploitation and habitat destruction. Rational stocking and harvesting especially ranching with fingerlings of Indian major carps are desirable for stock enhancement.*

Keywords: Sarda sagar reservoir, Ichthyofaunal diversity, Fisheries, Fingerlings, Indian major carps.

Introduction

The Uttarakhand Himalaya is a typical example of maximum utilization of rivers under Hydro-electric projects and in relation to this power production, the state is also now known as the energy Pradesh. In the state, there are many small (<1000 ha) and medium sized (1000-5000 ha) reservoirs like Sarda Sagar, Nanak Sagar, Tumaria, Baigul, Dhaura, Haripura, Tehri, Dhauliganga and Kalagarh etc. with total area of 20075 ha. (Sugunan, 1995). The river systems and associated water bodies, reservoirs support valuable piscine diversity. Reservoirs hold tremendous potential for inland fisheries development in India has long been recognized. Besides satisfying numerous developmental needs, reservoirs play an important role in fish production and contribute significantly to the livelihood of people. At present, the most of the rivers and associated water bodies in the country are under the threat of environmental degradation and over exploitation. Water and fishery resources of reservoirs are highly exploited by the stakeholders. As a result the principal fishery in many reservoirs is under different phases of transformation. Gobind Sagar reservoir in Himachal Pradesh is an example of the phenomenon. The inadvertent entry and emergence of exotic silver carp in the Gobind Sagar radically changed the catch structure and established dominance over all other species (Kumar, 1988; Sugunan, 1995). Though there is sufficient information available on ecology and fishery aspects of a number of reservoirs in the country (Sreenivasan, 1970; Ganapati, 1970; Natarajan, 1976; Khan *et al*., 1996, Bhaumik *et al.,* 2003), but still there is dearth of systematic information on status of fish diversity, fishery and conservation aspects. The ecology and fishery aspects of the reservoirs of Uttarakhand have been reported by Motwani and Saigal (1974), Singh *et al.* (1990), Rawat (1991), Salim and Ahmad (1985), Bhaumik *et al.* (2009) and Mishra *et al.* (2010). Bhaumik *et al.* (2009) studied ecology, fish fauna, production potential and assessed the impact of ranching in the Dhaura reservoir. Motwani and Saigal (1974) studied the fish fauna of Sarda Sagar

*Email: prem_nrc@rediffmail.com

and listed 61 species of fish. The mighty river, Sarda feeds the reservoir, which known to be a turbulent type of river. Geographically, the river is natural border in-between India and Nepal. Sarda Sagar was created in 1962 by constructing 22.2 km. Long earth dam. The reservoir has a catchments area 121.0 sq.km. This study deals with present status of fish diversity catch composition and production trend during last ten years and recommendations for fishery management in Sarda Sagar reservoir, a medium sized reservoir, located in Tarai region of Uttarakhand and Uttar Pradesh.

Materials and Methods

Study area

Present study was conducted for Sarda Sagar, a medium sized reservoir situated in the Tarai region in the border of Uttarakhand and Uttar Pradesh states between 28° 40' to 28° 53' N latitude and 80° 2' to 80° 12' E longitude (Fig.1). Terai region is the transitional area between hills in the northern Himalayas and Indo-Gangetic plains towards south. The Terai region is characterized for low ground water and rich soil fertility. The average reservoir area was estimated by Kumar (2009) for the period 2006-2007 using IRS LISS III data as 4139 ha at different elevation from 183.704 meter at nearly dead reservoir level (DRL) to 190.504 meter nearly full reservoir level (FRL). For the present investigation three sites were selected in the reservoir - lotic, transitional and lentic zones for sample collection.

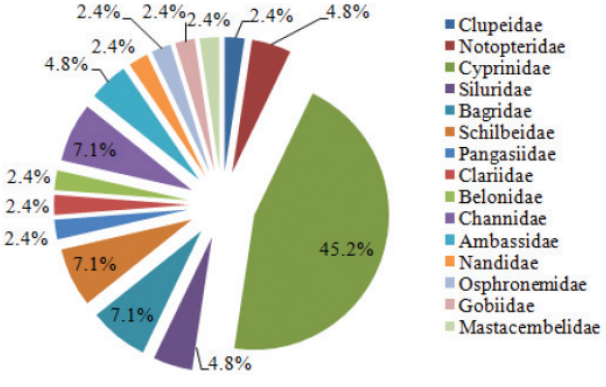

Fig. 1 Percentage occurrence of fish families of Sarda reservoir, India.

Fish sampling, identification and analysis

The sampling was conducted in 4 different seasons (December, March, June and September) on quarterly basis for 3 different landing sites represents the lotic, transitional and lentic zones. Catches from 5 fishermen from each zone of which 100 fish were randomly selected for sampling. Each sample was segregated in 5 different groups as classified by Uttar Pradesh Fisheries Development Corporation (UPFDC), Lucknow based on market value and consumers preferences. The pooled data of the samples of the whole year (4 seasons) were analyzed the species composition. Landing record of the year was used to assess the annual production. Landing records (group wise) of the last 9 years was procured from Uttar Pradesh Fisheries Development Corporation (UPFDC), Lucknow. Fish samples were identified following Talwar and Jhingran (1991) and valid names of genera given by Eschmeyer (1998, 2012) were adopted.

Results and Discussion

The reservoir is located in vast and varied catchments spread in foot-hill region consisting forest, agricultural fields and human settlements. Owing to specific locations, the substratum of the reservoir is erratic and undulating consisting boulders, stones, pebbles, sand, silt and clay. The reservoir is impounded by damming surface run-off from the river Sarda primarily for irrigation and electric generation. Fishery is considered as a secondary activity. Water loss in reservoirs is due to seepage, evaporation and releasing for irrigation and due to sedimentation. There is drastic variation in water level as much water is released during lean period.

Fishing crafts and gears

Sarda Sagar is situated in Pilibhit and Udhamsingh Nagar Districts of Uttar Pradesh

and Uttarakhand respectively. The fishing crafts used is small, non-mechanized, flat bottomed canoes made of GI sheets, ranging from 3.9 to 4.9 m in length overall. The gears used are seines (*mahajal*), portable lift net (*chhattijal*), falling gear (*ghagariajal*), gill nets (*phasiajal*), traps, drift longlines, pole and line and wounding gear (*barcha*). The use of non-selective fishing gears constructed using very small mesh netting such as seines and lift nets and small meshed gillnets are prevalent in the reservoir.

Piscine diversity

The piscine diversity of a reservoir basically represents the diversity of the parent river system (Vannote *et al.,* 1980). As the reservoir studied under present communication has been constructed on the river Sarda, hence the reservoir also holds the fishes of the parent river. On the basis of the pooled data of the 60 samplings in 4 different season from 3 different landing sites and of 5 fishermen of the each landing site, a total of 42 fish species classified under 33 genera, 15 families and 6 orders have been collected from the reservoir during the present study (Table 1). But, Motwani and Saigal (1974) recorded 61 species of fish belonging to 13 families from the same reservoir of which *Garra, Glyptothorax, Labeo, Nemacheilus, Tor* and *Crossocheilus* were most dominant genera in the catches. Sinha and Sharma (2003) also reported 55 species of fishes from Sarda River, the main feeder river of Sarda Sagar. The present study indicates loss of fish biodiversity with disappearance of some important species like *Glyptothorax* spp*., Nemacheilus* spp*., Tor tor*, *Crossocheilus* spp*., Labeo calbasu, Botia* spp and *Bagarius bagarius.*

The disappearance of native species could be attributed to habitat alterations and over exploitation. Job *et al.* (1955) surveyed the fisheries resources of Mahanadi river system during embankment of the Hirakud Dam and they found 103 species of which 24 were important commercially. But Khan *et al.* (1992) described only 43 species of fish in Hirakud reservoir. Petts (1984) reported that the flow modifications affect water quality, water depth and velocity, substrate composition, food production and transport, stimuli for migration and spawning, survival of eggs, spatial requirements and eventually fish species composition. Habitat alterations in Himalayan waters have affected distribution and abundance of native fishes in the mountain streams of India and Nepal (Shrestha *et al.*, 1990; Sehgal, 1994). Power dams and reservoirs have dramatically changed fish habitats and local fish communities. The migration routes of important native fishes like mahseers *(Tor putitora* and *T. tor)* and snow trouts (*Schizothorax richardsonii* and *S. plagiostomus*) have been blocked (Sehgal, 1994; Shrestha, 1997). The upland fast moving habitat has been lost to reservoirs which are unfavorable for rheophytic species (Maitland, 1993; Dhanze and Dhanze, 1994) on the Beas river system has shown a decline in the native populations of *Tor putitora* and *Schizothorax richardsonii* and abundance of the bottom inhabiting predatory catfishes *(Mystus seenghala* and allied species) due to impoundment of the river at Talwara in the form of a big reservoir covering an area of 24,000 hectares (Dhanze and Dhanze, 1998). Unfortunately, the consequences of sedimentation are proving to be more serious than previously contemplated. Siltation from the catchment areas, besides changing the ecology due to construction of dams, has destructed the feeding and breeding grounds of many fishes (Sehgal, 1994).

Catch composition

The fishes caught from the reservoir was categorized under 5 different groups based on market value and consumers preferences as classified by Uttar Pradesh Fisheries Development Corporation (UPFDC), Lucknow (Table 2). The group-1 is comprised by *Labeo rohita, Cirrhinus mrigala* and *Catla catla,* along with exotic carp, *Cyprinus carpio* (Communis) and a single species of mahseer, *Tor putitora*. This group represents the fish species of

Table 1 Piscine diversity of Sarda Sagar reservoir

Order	Faimily	Scientific Name	Local Name
Clupeiformes	Clupeidae	*Gudusia chapra* (Ham.)	Suia
	Notopteridae	*Notopterus notopterus* (Pallas)	Patra
		Chitala chitala (Ham.)	Moy
Cypriniformes	Cyprinidae	*Securicula gora* (Ham.)	Chelwa
		Salmophasia bacaila (Ham.)	Chelwa
		Devario devario (Ham.)	Dendua
		Rasbora daniconius (Ham.)	Dendua
		Osteobrama cotio (Ham.)	Cotio
		Chagunius chagunio (Ham.)	Puthia
		Puntius sarana (Ham.)	Puthia
		Puntius sophore (Ham.)	Puthia
		Puntius ticto (Ham.)	Puthia
		Catla catla (Ham.)	Bhakur, Katla
		Cirrhinus mrigala (Ham.)	Nain
		Cirrhinus reba (Ham.)	Raiya
		Garra gotyla (Gray)	Gara
		Labeo rohita (Ham)	Rohu
		Labeo dero (Ham)	Dero
		Labeo bata (Ham)	Kharad
		Labeo gonius (Ham)	Khursa
		Tor putitora (Ham.)	Mahseer
		Cyprinus carpio communis Lin.	Common
Siluriformes	Siluridae	*Ompok pabda* (Ham.)	Laachi
		Wallgo attu (Bl. & Schn.)	Kursa
	Bagridae	*Sperata aor* (Ham.)	Tengra
		Sperata seenghala (Sykes)	Seenghala
		Mystus tengara (Ham.)	Tengra
	Schilbeidae	*Clupisoma garua* (Ham)	Badam
		Eutropiichthys vacha (Ham.)	Bachha
		Silonia silondia (Ham.)	Silonia
	Pangasiidae	*Pangasius pangasius* (Ham.)	Pangaas
	Clariidae	*Clarias magur* (Ham.)	Maagur
Beloniformes	Belonidae	*Xenentodon cancila* (Ham.)	Nunwa
Perciformes	Channidae	*Channa gachua* (Ham.)	Kamar
		Channa punctatus (Bloch)	Girai
		Channa marulius (Ham.)	Saur
	Ambassidae	*Chanda nama* Ham.	Chanda
		Pseudambassis ranga (Ham.)	Chanda
	Nandidae	*Nandus nandus* (Ham.)	Godhi
	Osphronemidae	*Trichogaster fasciata* (Bl. & Schn.)	Bhedal
	Gobiidae	*Glossogobius giuris* (Ham.)	Baila

Table 2 Composition of fish species under different groups

Fish Groups	Characteristics	Fish species
1	High local market demand and consumer liking	*Catla catla, Labeo rohita, Cirrhinus mrigala, Tor putitora, Cyprinus carpio communis* (Major carps and Mahseer)
2	Very Good local market demand and price but moderate consumer liking.	*Ompok pabda, Sperata seenghala, Sperata aor, Channa marulius, Channa punctatus, Mastacembelus armatus* (Catfish/carnivorous fish)
3	Good local market demand and consumer liking	*Notopterus notopterus* and *Chitala chitala* (feather back)
4	Good market demand and consumer liking, but due to the smaller size fetches low price	*Cirrhinus reba, Labeo bata, Labeo gonius* (Indigenous minor carps)
5	Low local market demand due to small size and less consumer liking.	*Gudusia chapra, Chagunius chagunio, Puntius sarana, Puntius sophore, Puntius ticto, Chanda nama, Parambasis ranga, Salmophasia bacaila* (Weed/ Trash fish)

commercial value having good market demand, consumer liking and high sale price (Rs.120-150/- kg). Though, this group is important for the commercial fishery of the reservoir, it contributes only 6.99% in the total catch. Among this group, Common Carp constituted highest 53% of the catches followed by *C. mrigala* (20%), *L. rohita* (19%), *C. catla* (7.5%) and *T. putitora* (0.15%). Adult *T. putitora* was available only in the spring (March-April) sampling, while yearlings were also seen in the catch of winter. Mahseer is known as a migratory fish moving upstream for spawning during August to October and fingerlings drifted downstream to feedings area during winter (Shrestha, 2010).

Catfishes, carnivorous fishes were represented by *Ompok pabda, Sperata seenghala, S. aor, Channa marulius, C. punctatus* and *Mastacembelus armatus* under the group-2. This is the second important group of the fish after major carps and mahseer having good market price but moderate consumer liking it. Among the catfishes, carnivorous fishes, *Mystus* spp. contributed maximum catch (40.5%) followed by murrels (29%), *O. pabda* (20%) and *Mastacembelus* spp. (21.2%). The fish of this group were obtained in all catch months having highest catch during the month of June (55.05 quintals) with 10.12% share in the total catch of the year.

Feather backs namely *Notopterus notopterus* and C*hitala chitala* are important fishes of the Sarda Sagar categorized under group-3. Market demand and consumer liking for this group is lesser in comparison to major carps, cat fishes and minor carps groups. Feather back contributed 281.19 quintals in total catch of 1894.13 quintals with 14.84% share in total catch. *N. notopterus* species has contributed 91.2% in the total catch of feather back group and the remaining catch (8.8%) has been contributed by *C. chitala.* Maximum catch of these species was recorded during the month of June with fish size ranging between 45-350 g body-weight.

Minor carps were represented by *Labeo gonius*, *L. bata* and *Cirrhinus reba*, under the group-4. Small sized fishes like *Gudusia chapra, Puntius spp., Securicula gora, Salmophasia bacaila, Xenentodon cancila, Chanda spp., Trichogaster fasciata* and *Glossogobius giuris* constitute the bulk of reservoir catches are in the group-5. The group of minor carps, contributed 16.9% (Total- 319.85 quintals) in total catch of the year with highest share of

Labeo gonius (61.8% of total catch of minor carps). The body weight of the captured fish of this species was in the range of 190-540g. *Cirrhinus reba* is the next species of commercial importance among the minor carps with a fair share of 24.6% within the group. The market demand of this group is similar to the major carps group, but due to smaller in size, sale prices (Rs.80-100/-kg) remain lower than the major carps.

Weed Trash fish contributed maximum share (58.86%) of the total catch of the year with most prominent occurrence of *Gudusia chapra* (body weight in the range of 80-210 g). This species contributed alone 88.5% share within the group and 43.48% in total catch of the reservoir. Data of the catch composition revealed that *Gudusia chapra* is a most prominent species of the catch of Sarda Sagar especially during the winter months. Rest share of this group was contributed by *Puntius* spp., *Osteobrama cotio, Securicula gor, Salmophasia bacaila, Rasbora daniconius, Xenentodon cancila, Chanda* spp*., Trichogaster fasciata* and *Glossogobius giuris.* Market value of the fish (Rs. 40-60/kg) of this group remains always lowest due the small size and less consumer liking.

In general, *Gudusia chapra, Labeo gonius, Notopterus notopterus, Mystus* spp. and Common carp are the dominant fish species in the catch of the reservoir. The catch size of the reservoir is declining with dominance of the weed and trash fish, might be due to the over exploitation and habitat alterations. Declining population of carnivorous mahseer and other cat fishes may be a cause of the dominance of weed and trash fish. Among the carps, common carp contributes maximum due the self-recruitment by pond breeding habit, but its contribution in the whole catch was moderate. A seasonal variation in the occurrence was observed with the dominance of weed trash fish, carps and mahseer, catfish and feather back and minor carps during winter, spring, summer and autumn season respectively.

Fish production trend

An average annual catch of 1894.13 quintal was recorded from the Sarda Sagar reservoir during 1997-98 to 2006-07 (Table 3). The maximum catch was recorded during the month of May and June, 2007 due to minimum water area with maximum fishing. The catch of the reservoir was dominated by smaller fishes especially *Gudusia chapra* and *Labeo gonius* of the minor carps group. The fish catch data revealed that the present production is an average of 60 Kg/ha, which is considerably higher than the national average production from medium reservoirs i.e. 12.30 Kg/ha (Sugunan, 1995). Bhaumik *et al.* (2009) reported the 32 kg/ha production in Dhaura reservoir prior to ranching programme. A declining trend was observed in the production of the reservoir during the last ten years, might be due the over exploitation. Remarkable low catch during the year 2001-02 was observed due the over exploitation during the previous (2000-2001) year with 3684.05 quintals catch.

Suggested management measures

Fish production enhancement of capture fisheries and aquaculture in lakes and reservoirs are two important strategies for meeting the increasing demand of fish in the country. However, open water bodies need to be used judiciously to preserve the fish diversity also, and to remain an attraction as well as source of food for tourists and nationals. Community ownership and participation in the management of water bodies will assist in developing and maintaining sustainable fisheries in reservoirs.

The Sarda Sagar reservoir is holding considerable fish diversity and some valuable commercially important species too. Besides Indian major carps the reservoir holds a number of sizeable large fishes of the categories: catfishes- *Sperata seenghala, S. aor, Ompok pabda*; murrels- *Channa marulius, C. punctatus* and some other minor carps- *Labeo bata, L. gonius* etc. Therefore, there is

Table 3 Trend of fish production from Sada Sagar reservoir during 1997-98 to 2006-07

Fishery groups	Year wise Production (Quintals)										Total	Average (Q/ Year)	% group wise
	97-98	**98-99**	**99-2000**	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**	**2006-07**			
1	260.86	161.91	270.19	243.61	22.17	83.14	152.57	85.37	63.17	152.66	1495.65	149.57	**6.99**
2	184.01	341.14	431.32	281.18	29.85	151.79	175.1	185.16	95.05	172.38	2046.98	204.70	**9.57**
3	137.78	205.5	438.78	409.98	28.3	127.12	325.05	262.22	96.6	274.35	2305.68	230.57	**10.78**
4	289.85	373.62	589.15	382.95	31.18	190.4	305.07	332.5	142.82	314.55	2952.09	295.21	**13.80**
5	2222.83	2007.81	1500	2366.33	8.2	1670.72	525.5	1038.8	369.95	878.24	12588.38	1258.84	**58.86**
Total	3095.33	3089.98	3229.44	3684.05	119.7	2223.17	1483.29	1904.05	767.59	1792.18	21388.78	2138.88	**100**
Year wise %	**14.47**	**14.45**	**15.10**	**17.22**	**0.56**	**10.39**	**6.93**	**8.90**	**3.59**	**8.38**	**100**		

(Source: UPFDC, Lucknow)

need to develop the reservoir on sustainable basis. Though, the need of the hour is to enhance the fish production and conservation of fish diversity simultaneously. Keeping the view, the reservoir should be brought under maximum utilization by means of sustainable culture based practices i.e. rational stocking and harvesting, cage and pen culture based on autochthonous productivity of the water body. Cage and pen culture was adopted in Phewa, Begnas, Rupa lake and in Indrasarobar reservoir in Nepal for keeping good fish stock in these water bodies (Pradhan and Shrestha, 1997). Ranching would be helpful for increasing percent composition of high valued Indian major carp and ultimately the revenue of the reservoir. Further, the stocked seed must be of fingerling size to enhance the chances of survival of stocked seed. Bhaumik *et al.* (2009) reported fish production 106.6 kg ha^{-1} against pre adoption production of 32 kg ha^{-1} after ranching of carps @ 413 ha^{-1} in Dhaura reservoir of Uttarakhand. On the other hand, enforcement of fishing regulations such as mesh size, closed season is also necessary to conserve the important diversity of minor carps and trash fishes of the reservoir. Further, ranching programme for the well-known sport fish, Golden mahseer would be helpful for conservation of this threatened species and for development of the Fishery based eco-tourism. The catches in glut especially during winter season difficult to fetch the commendable price in the local market. The fishermen are forced to sale their catches at low prices. If the ice plant facility is available near the site, the catches could be send to far off market to get the reasonable price. Maine *et al.* (1996) suggested that the environmental assessment should be based on participatory methods that support scientific and consultative approaches, accommodate the uncertainties and complexities of environmental issues, and include non-expert participants. According to Kamal (2002) restocking of fish into small reservoirs has proved to be a useful tool for developing fisheries potential of such small

aquatic systems. Kumar *et al.* (2002) identified some issues those which are very important for biodiversity conservation of Hirakud reservoir at Mahanadi River.

Acknowledgements

The authors express sincere gratitude to Uttar Pradesh Fisheries Development Corporation (UPFDC), Lucknow for the permission rendered for sampling in Sarda reservoir.

References

Bhaumik, U., Mandloi, A.K., Sehgal, H.S., Singh, U.P. and Patra, T. (2003) Ecology of three reservoirs and its impact on enhancing fish production. *J. In. Fish. Soc. Ind.,* **35**, 86–92.

Bhaumik, U., Singh, U.P. and Paria, T. (2009) Ecology and management of the Dhaura reservoir, Uttaranchal for enhancing fish production. *Ind. J. Fish.,* **56**, 189–193.

Dhanze, J.R. and Dhanze, R. (1994) An appraisal of depleting fish genetic resources of Himachal Pradesh. In: Dehadrai, P., Das, P.Y. and Verma, S.R. (Eds.). Threatened Fishes of India. Nature Conservators, Muzaffarnagar, pp. 97.

Dhanze, J.R. and Dhanze, R. (1998) Impact of habitat shrinkage on indigenous fish genetic resources of Beas drainage system. In: Ponniah, A.G., Das, P. and Verma, S.R. (Eds.). Fish Genetics and Biodiversity Conservation. Nature Conservators, Muzaffarnagar, pp. 500.

Eschmeyer, W.N. (1998) Catalog of Fishes. California Academy of Sciences, San Francisco.

Eschmeyer, W.N. (2012) Catalog of Fishes electronic version (Online: Updated on 15 March 2012). Available online: http://research.calacademy.org/ichthyology/catalog/fishcatmain.asp.

Ganapati, S.V. (1970) Energy available relationship in natural aquatic biosystems in India. *Ecol*., **11,** 49–68.

Job, T.J., David, A. and Das, K.M. (1955) Fish and Fisheries of Mahanadi in relation to Hirakud Dam. *Ind. J. Fish.,* **2**, 1–36.

Kamal, M.Y. (2002) Effect of Impoundment on the Indigenous Fish Population and their Management. In: Boopendranath, M.R., Meenakumari, B., Joseph, J., Sankar, T.V., Pravin, P. and Edwin, L. (Eds.). Riverine and Reservoir Fisheries of India. Soc. Fisheries Tech. (Ind.) (SOFTI), CIFT, Cochin, 1–5.

Khan, A.A., Dawson, P., Rao, J.S.R. and Varghese, M.D. (1992) Fishing in Impounded Waters, a Case Study of Hirakud Reservoir-Orrisa. Bull. CIFT Publication.

Khan, M.A., Singh, H.P., Dwivedi, R.K., Singh, D.N. and Tyagi R.K. (1996) Ecology and fish yield from Baghla reservoir- a small impoundment in Ganga Basin. *J. In. Fish. Soc. Ind.,* **28**, 91–100.

Kumar, K. (1988) GovindSagar Reservoir - A Case Study on the Use of Carp Stocking for Fisheries Enhancement. FAO Fish. Rep. No. **405** (Supp1.), FAO, Rome.

Kumar, P., Meenakumari, B. and Bandyopadhyay, J.K. (2002) Biodiversity Conservation of Hirakud Reservoir. *Natcon*, **14**, 147–150.

Kumar, P. (2009) Spatial Database on Fish and Fisheries Resources of Sarda Sagar Reservoir, Tarai Region of Uttaranchal and U.P., India. Ph.D. Thesis, MJP Rohilkhand University, Bareilly.

Maine, R.A., Cam, B. and Davis-Case, D. (1996) Participatory analysis, monitoring and evaluation for fishing communities: a manual. FAO Fish. Tech. Paper No. **364**, Rome, FAO. pp. 142.

Maitland, P.S. (1993) Conservation of freshwater fish in India. In: Singh, B.R. (Eds). Advances in Fish Research, Narendra Publishing House, New Delhi. pp. 349.

Mishra, A., Chakraborty, S.K., Jaiswar, A.K., Sharma, A.P., Deshmukhe, G. and Madan Mohan (2010) Plankton diversity in Dhaura and Baigul reservoirs of Uttarakhand. *Ind. J. Fish.,* **57**, 19–27.

Motwani, M.P and Saigal, B.N. (1974) Fish fauna of Sarda Sagar Reservoir in Pilibhit (U.P.) and some recommendations for development of reservoir fisheries. *Ind. J. Fish.,* **21**, 109–19.

Natarajan, A.V. (1976) Ecology and the state of fishery development in some man-made reservoirs in India. In: IPFC, Symposium on the development and utilization of Inland fishery resources, Colombo, Sri Lanka, 27-29 October.

Petts, G.E. (1984) Impounded Rivers, New York, USA: Wiley.

Pradhan, G.B.N. and Shrestha, S.B. (1997) Status of fisheries and aquaculture development and their potential for expansion in Nepal. In: Swar, D.B., Pradhan, G.B.N. and Lofvall Westlund, L.M. (Eds.). Proceeding of National Symposium on Role of Fisheries and Aquaculture in the Economic Development of Rural Nepal, NEFIS, Kathmandu. 15-16 August. 1996.

Rawat, H. S. (1991) Studies on the limnology and fisheries of Tumaria Reservoir (Nainital). Ph.D. Thesis, Kumaon University, India.

Salim, M. and Ahmed, Z. (1985) Environmental factors and planktonic communities of Baigul and NanakSagar reservoirs, Nainital. *J. Bom. Nat. Hist. Soc.,* **82,** 13–23.

Sehgal, K.L (1994) State-of-art of endangered, vulnerable and rare coldwater fishes of India. In: Dehadrai, P.V., Dasand, P. and Verma, S.R. (Eds.). Threatened Fishes of India, *NATCON*, **4**, 127–135.

Shrestha, B.C., Rai, A.K., Gurung, T.B. and Mori, K. (1990) Successful artificial induced spawning of Himalayan Mahaseer (*Tor putitora*) in Pokhara Valley, Nepal. In: Hirano, R. and Hanyu, I. (Eds.). The Second Asian Fisheries Forum, Asian Fisheries Society, Manila, Philippines.

Shrestha, T.K. (1997) The Mahseer in the Rivers of Nepal Disrupted by Dams and Ranching Strategies. R.K. Printers, Kathmandu, Nepal.

Shrestha, T. K. (2010) Migration of deep bodied Mahseer in Himalayan water of Nepal. In: Mahanta, P.C. and Sarma, D. (Eds.). Coldwater fisheries management, Directorate of Coldwater Fisheries Research (ICAR), Bhimtal. PP. 229–240.

Singh, C.S., Sharma, A.P. and Deorari, B.P. (1990) Analysis of plankton population in relation to fisheries in NanakSagar reservoir, Nainital. In: Proceeding of National seminar on recent advances in hydrobiology, 23-25 Oct., Devi Ahalya University, 21–29.

Sinha, R.K. and Sharma, G. (2003) Faunal Diversity of the river Sarada, Uttar Pradesh, India. *J. Ecophysiol. Occup. Hlth*., **3,** 103–116.

Sreenivasan, A. (1970) Limnology of tropical impoundments- a comparative study of reservoirs in Madura state. *Hydrobio.,* **36**, 443–469.

Sugunan, V.V. (1995) Reservoir fisheries of India. *FAO Fisheries Technical Paper,* 345. FAO Rome, pp. 423.

Talwar, P. K. and Jhingran, A. G. (1991) Inland Fishes of India and adjacent countries (Vol. 1 & 2). Oxford IBH Publishing Co. Pvt Ltd., New Delhi, pp. 1062.

Vannote, R.L., Minshal, G.M., Cummins, K.W., Sedel, J.R. and Cushing, C.E. (1980) The river continuum concept. *Can. J. Fish. Aqua. Sc.*, **37,** 130–137.