Nepal Journal of Science and Technology 8 (2007) 63-68

Fish and Benthic Fauna in Kulekhani Reservoir, Makwanpur

Tej Bahadur Saund[1] and Jiwan Shrestha[2]

[1]Central Department of Environmental Science
Tribhuvan University, Kirtipur, Kathmandu
[2]Central Department of Zoology
Tribhuvan University, Kirtipur, Kathmandu
E-mail: saudtej@gmail.com

Abstract

Physico-chemical parameters of Kulekhani reservoir at surface were in satisfactory level for cage fish culture. This paper has reported only two indigenous fish species in the reservoir namely Katle (*Neolissocheilus hexagonolepis*) and Karange (*Nazirator chelynoides*) comprising only 2.4% and 1.36% respectively whereas other exotic fish species mainly carps i.e. Bighead carp (*Aristichthys nobilis*) and Silver carp (*Hypophthalmichthys molitrix*) were dominant group of fish fauna in the reservoir comprising 96.24% at study sites. Average fish production of cage culture in Kulekhani reservoir was 3.8kg/m^3/year. This has study also reported only two groups of benthic fauna at the study sites namely Oligochaeta and Chironomidae comprising 95.52% and 4.47 % respectively in their abundance.

Key words: benthic fauna, cage culture, fish fauna, physico-chemical parameters, reservoir

Introduction

One of the land locked countries, Nepal, is situated on the southern slope of Himalayas by covering an area of 147,181 km^2 (from 26° 22' to 30°27' N and from 80°4' to 88°12' E) with an elevation ranges from about 70m to 8848m from sea level. The Informal Wetland Group in Nepal at the first meeting on wetland management in Nepal (Shrestha & Bhandari 1992) attempted to define wetlands as follows: "Wetlands represent landmass saturated with water due to high water table through ground water, atmospheric precipitation or inundation. It may be natural or artificial, permanent or temporary, static or flowing and fresh water or brackish water." DOFD (2002) has reported various types of wetlands of Nepal, which occupy 816,954ha. area. One of the wetlands, reservoir, is created by damming the river system for various purposes such as hydroelectric power, irrigation, flood control and drinking water etc. In addition, FDD (1998) did the survey and reported the major reservoirs of Nepal as follows: Jagadishpur (175ha), Trishuli (16ha), Marshyandi (62ha), Kulekhani (220ha) and Kali Gandaki (500ha).

Rai (1990) studied the Kulekhani reservoir and reported that the surface water of the reservoir was always saturated with oxygen while carbon dioxide (CO_2) exhibited trace amount at surface. During feasibility study in 1979, Nippon Koei Co., Japan reported that nitrogen and phosphorous inflow in various forms in Kulekhani reservoir from surrounding watershed was 48459kg/yr and 2907kg/yr respectively i.e. nitrogen accumulates more than 90%.

KC. (1988) reported the following benthic fauna in the feeding streams of Kulekhani reservoir: Ephemeroptera, Odonata, Placoptera, Megaleptera and Tricoptera. Yadav (1989) reported Tricladida, Tubificidae, Hydracarina, Gastropoda, Naididae, *Erpobdella* spp., Placoptera, Chironomidae, Coleoptera, Tricoptera, Hemiptera, Ephemeroptera, Odonata, Enchytraeidae and Lumbriculidae before impoundment for 1980, while he has reported only Tubificidae, *Branchiura* spp., *Limnodrilus* spp. and Naididae after impoundment for 1986/1988 in Kulekhani reservoir. After Yadav (1989), there is a long gap in the study on benthic fauna of Kulekhani reservoir.

Pradhan (1987) studied the fish fauna of Kulekhani reservoir and reported that construction of a dam on the Kulekhani river has introduced substantial changes in the composition of fish population. For example, Gadela (*Nemacheilus* spp.), Kafre (*Glyptothorax* spp.) and Buduna (*Garra* spp.); which were available before the impoundment are now non-existent in the reservoir. Swar (1992) reported that *Garra lamta, Puntius ticto, Puntius* spp., *Nemacheilus* spp., *Channa gachua, Glyptosternum* spp. *and Coraglanis* spp. disappeared from Kulekhani reservoir after impoundment. He studied the population ecology of Katle (*Neolissocheilus hexagonolepis*) in Nepalese reservoirs and river and reported that population of Katle in Kulekhani reservoir underwent heavy mortality due to heavy monsoon floods, siltation from soil erosion and drawdown in the reservoir.

FDC (2001) mentioned that the indigenous fish species of Kulekhani reservoir comprised very of few percentage of fish catch composition: Katle (7.88%), Karange (0.03%) and Asla (2.01%) while introduced fish species comprised of the rest high percentage. From the taxonomic revision, there are 184 fish species (Shrestha 2003) belonging to 93 genera, 31 families and 11 orders existing in natural water bodies of Nepal whereas Rajbansi (2005) listed 186 fish species from Nepal. Recently Ng and Edds (2004, 2005 a b), Ng (2006) and Edds and Ng (2007) have listed 6 new species and 11 new records from Nepal which further increased the total number of fish species of Nepal. According to them, *Batasio macronotus, Pseudechenis serracula, P. crassicauda, P. eddsi, Erethistoides ascita* and *E. cavatura* are new fish species from Nepal and *Puntius terio, Psilorhynchus gracilis, Lepidocephalichthys menomi, Neoeucirrhichthys maydelli, Batasio tengana, Glyptothorax alaknandi, G. botius, G. garhwali, Nangra assamensis, Sisor rheophilus* and *Anabas coboijus* are newly recorded species from Nepal. Therefore 184 species of Nepal increased to a total number of 199 species as earlier identified two species (*Batasio batasio* and *Pseudechenis sulcatus*) have been abolished from the list of Shrestha (2003).

In Kulekhani reservoir, cage culture was started in 1987/88 in private sector. Volume of private cage in the reservoir was 30128.0m^3 at the study period. Similarly, the volume occupied by government cage in the reservoir was 3245.0m^3.

Hence, to identify the present status of physico-chemical parameters, fish fauna, cage culture and benthic fauna of Kulekhani reservoir were the main objectives of this study.

Study area

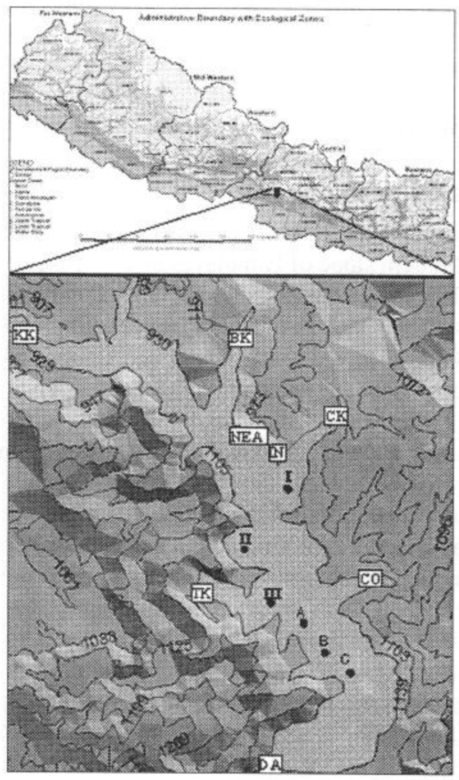
Kulekhani watershed is sub-watershed of Bagmati basin that occupies approximately 126km^2. Altitude of whole watershed ranges from 1534m to 2621m.

Kulekhani reservoir (Fig. 1) is located at about 35 km southwest of Kathmandu valley and politically it lies in Makawanpur district. The 114m elevated dam was constructed in June 1981 to regulate the water of Kulekhani river running along with deep valley. The length of the reservoir is about 7km with an average width of about 318m. Generally, depth of Kulekhani reservoir ranges from 53m to 80m. Water surface area of the reservoir also varies with seasons. Kulekhani reservoir is classified as deep storage because of thermal stratification. Palung, Chakhel, Thado, Chalkhu and Chitlang streams are the tributaries of Kulekhani river that feed the reservoir throughout the year. Due to high variation in altitude, the climate of Kulekhani watershed varies from subtropical at low land to temperate at higher elevation. The average annual precipitation recorded by Daman Station from 2000 to 2003 was 1920.7mm.

Materials and Methods

Sampling sites and time schedule of study

Sites A, B and C for limnological parameters by focusing their impacts on primary productivity of water and cage culture were selected near watch house around which cages were fixed. According to ease of access, another three sites (I, II and III) were selected for fish catch composition (Fig. 1). Fieldwork was started in February 2006 and completed in October 2006.



Legends

N

KK – Kulekhani Khola
BK – Bhisinkhel Khola
CK – Chitlang Khola
NEA – NEA Guest House
IN – Inland Fisheries Office

W E S

SCALE
1 km

SCALE:

TK – Thado Khola DA – Dam CO – Chakhel Outlet
I – Site I II – Site II III – Site III
A – Site A B – Site B C – Site C

Fig. 1. Map of Kulekhani reservoir with the location of study sites

Methods for physico-chemical parameters

The parameters like temperature, pH, transparency, dissolved oxygen and free carbon dioxide were measured immediately at study sites at the time of sampling and the parameters like alkalinity, hardness and primary productivity were measured within few hours after collection of samples. For other parameters such as nitrogen-nitrate and orthophosphate, samples were preserved in refrigerator and then determined in the laboratory of Central Department of Environmental Science (CDES), T.U. by following the standard methods given by APHA, AWWA, WEF (1998).

Sampling method for benthic fauna

Three grab samples at all three predetermined sites of the reservoir were taken every month of study period. Each grab sample after its collection immediately emptied into a plastic bucket: the contents of the bucket were sieved in a brass sieve of 0.4mm mesh. Collected and sieved samples were then sorted out and brought to the laboratory of CDES.

Abundance of benthic fauna was calculated as number per square meter and mean values of three sites were calculated and analysed by following standard method after Hrabacek et al. (1972) and Yadav (1989).

Sampling method for fish

Fishes were sampled at sites I, II and III using multipannel gillnets of 25–50mm mesh size with the help of local fishermen. Then fish specimens collected from the sampling sites were brought to the laboratory of CDES and identified by using standard method of taxonomy after Sherstha (1981, 2003) and Jayaram (1999).

Survey method for cage culture

Five fishermen of different groups (i.e. Kalidevi, Ghaneshwar, Laligurans, Sateshwar and Sayapatri) who have engaged with cage culture in Kulekhani reservoir were randomly selected to complete the questionnaire that was developed to study the productivity of cage culture.

Statistical analysis

Microsoft Excel (2000) software programme was used for statistical analysis.

Results and Discussion

Depth of the reservoir depends on the inflowing water from the watershed and feeding streams and outflow of water from the reservoir to generate electricity. The transparency of the reservoir water changes with season, which is the result of various factors, viz. growth of planktons, materials derived from the shore by wave action, erosion, wind turbulence and settling rate of the suspended matter. The surface water temperature followed air temperature pattern throughout the study period. Kannan and Job (1980) observed similar situation. Surface water temperature of the reservoir showed positive relation with gross primary productivity of water.

Temperature and dissolved oxygen at bottom were recorded less than surface throughout the investigation period (Table 2) so that some of the fish and benthic fauna, which cannot tolerate such new types of temperature regime and low oxygen level, were eliminated from the altered habitat (river system to reservoir).

The surface water of the reservoir was saturated with oxygen throughout the investigation period (Table 1). Yadav (1989) and Rai (1990) also observed similar situation in Kulekhani reservoir. The oxygen content of surface water of the reservoir was found to be in quite satisfactory level for fisheries point of view throughout the investigation period. The dissolved oxygen at surface and bottom of the reservoir also depends on the stratification (during summer) and break down of stratification (during winter). The low level of dissolved oxygen and presence of pollution tolerant benthic fauna at bottom indicated high pollution that was due to heavy accumulation of organic matter.

The concentration of CO_2 in water depends mainly on temperature and it controls the concentration of hydrogen ion, bicarbonate and $CaCO_3$. The calcium hardness moves directly with total hardness too (Ruttner 1953). The finding of present investigation also supports this statement. The concentration of free CO_2 showed negative relation with the dissolved oxygen and pH levels. For example, CO_2 was recorded in trace amount or virtually absent at surface whereas surface water was always saturated with oxygen and showed higher pH values during the investigation period (Table 1). Free CO_2 in water forms carbonic acid (H_2CO_3) which dissociates into H^+ and HCO_3^- ions. This brings a change in pH of water. As hydrogen ions are set free, HCO_3^- reacts with calcium to form calcium bicarbonate that is soluble in water. The total hardness content in the reservoir water correlates with total alkalinity and both of these inversely with pH. Zafer (1967) observed similar situation. Total hardness of reservoir water up to 3m depth ranged from 36mg/L to 65mg/L, which was in satisfactory level for fisheries according to Boyd (1982).

The main source of phosphorous is rock and soil for the Kulekhani reservoir. There are two types of origin of orthophosphate in the aquatic system: inorganic origin (rock and soil) and organic origin (bacterial decomposing process). The level oforthophosphate correlated with temperature. This may be because of higher temperature enhances the bacterial activities which convert the organic phosphate to inorganic phosphate. At surface, the level of this nutrient was recorded maximum during June which may be because of the large influx of this nutrient occurs through the floodwater. Similarly, high value of nitrate at surface was recorded particularly in May and June, which may be due to large influx through surface run-off whereas high value of this nutrient in September and October may be due to the rise in temperature of surface water. Low value of nitrate particularly in July seems to be associated with the heavy utilization of this nutrient by phytoplankton production.

Primary productivity of surface water correlates with nutrients and temperature. Although the high rate of phytoplankton production remove these nutrients from water, high level of nutrients during monsoon accompanied high primary productivity of reservoir water (Table 1). Rai (1990) suggested similar type of seasonal fluctuation of carbon production in Kulekhani reservoir.

Karl Pearson Correlation (r) of primary productivity with phisico-chemical parameters of surface water was calculated. From which it can be asserted that productivity of water showed strong negative relation with transparency (r = -0.93), carbondioxide (r = -0.53) and Total hardness (r = -0.73) whereas temperature (r = +0.70) and orthophosphate (r = +0.63) showed strong positive relation with it.

Table 1. Physico-chemical parameters of reservoir water at surface

Parameters→ Month↓	Transparency (cm)	T (°C)	pH	DO (mg/L)	CO_2 (mg/L)	TA (mg/L)	TH (mg/L)	N (µg/L)	P (µg/L)	GPP (mg/m^3/Day)
February	240.4	13.4	8.2	8.2	0.8	74	62	39	125	521.33
March	243.5	14.5	8.7	9.5	0.4	79	65	10	145	411.66
May	245.1	22	9	9.6	0.1	81	49	80	160	422
June	75.2	24.2	9.3	8.1	0.1	85	42	70	243	1525
July	80.2	22.5	8.2	7.4	0.15	59	36	40	150	1450
August	90.5	24.5	9.4	10.8	0.01	38	48	55	190	1051.66
September	80.5	24.4	9.1	9.8	0.05	42	49	70	230	1126.33
October	220.5	21	8.5	6.2	0.2	58	39	75	120	781

Table 2. Physico-chemical parameters of reservoir water at bottom

Parameters→ Month↓	Average Depth (m)	T (°C)	pH	DO (mg/L)	CO_2 (mg/L)	TA (mg/L)	TH (mg/L)	N (µg/L)	P (µg/L)
February	33	9.3	7.8	7.2	1.4	79	59	112	205
March	23.5	9.5	7.6	5.1	1.8	83	65	11	200
May	16.3	13.1	7.6	1.5	2.41	89	52	79	260
June	15.8	14.9	7.9	1.1	2.41	95	41	92	160
July	20.2	14.9	7.55	0.7	2.46	80	57	75	95
August	41.6	18.8	7.5	4.1	0.8	52	37	125	163
September	44.4	18.1	8	4.3	2.2	62	38	100	105
October	46.7	19.2	7.6	2.9	3.5	77	49	68	100

Bishop (1979) and Yadav (1989) reported the disappearance of many stream benthic fauna species (caddis, mayfly and stoneflies) after construction of the dam. Presence of only two groups of benthic fauna during present investigation period exhibited the disappearance of many fresh water benthic fauna, which were reported earlier by Yadav (1989) before impoundment for 1981 from Kulekhani reservoir.

KC. (1988) reported the following benthic fauna in the feeding streams of Kulekhani reservoir: Ephemeroptera, Odonata, Placoptera, Megaleptera and Tricoptera. Similarly, Yadav (1989) reported Tubificidae, Naididae and Chironomidae in the bottom of Kulekhani reservoir during 1986-1988. However, during present investigation period, only two groups of benthic fauna were recorded: Oligochaeta and Chironomidae in the reservoir. Between these two groups of benthos, Oligochaeta was dominant in number comprising 95.52% and Chironomidae was inferior and comprised only 4.47% (Fig. 2). Oligochaeta worms were abundant due to sediment everywhere in fresh water (Moss 1998). The dominancy of the Oligochaeta during present investigation supports this statement.

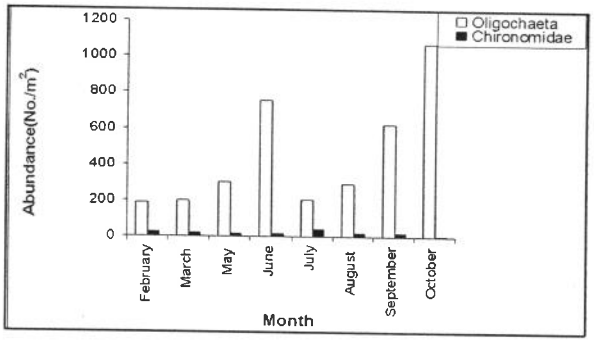


Fig. 2. Abundance (no./m^2) of benthic fauna

Abundance of total benthic fauna showed strong positive correlation with carbon dioxide and temperature of bottom water ($r = +0.50$) and ($r = +0.63$) respectively and it showed negative relation with orthophosphate of bottom water ($r = -0.51$). Finally, it can be concluded that presence of hemoglobin containing macro-invertebrate or pollution tolerant organisms (Oligochaeta and Chironomidae) in Kulekhani reservoir is the consequence of various factors. For example,

- Changes in physico-chemical parameters of bottom water,
- Habitat alteration from stony to muddy,
- Change in water regime (running to still) and
- Depth and frequent water level fluctuation.

Swar (1992) reported that *Garra lamta, Puntius ticto, Puntius* spp., *Nemacheilus* spp., *Channa gachua, Glyptosternum* spp. *and Coraglanis* spp. disappeared from the reservoir while present investigation showed that *Schizothorax richardsoni,* reported earlier by FDC (2001) also disappeared from the reservoir. During present sampling period, Katle (*Neolissocheilus hexagonolepis*) and Karange (*Nazirator chelynoides*) were dwindling species comprising only 2.4% and 1.36% respectively while other introduced exotic carp species (mainly *Aristichthys nobilis* and *Hypophthalmichthys molitrix)* were dominant in the reservoir comprising of 96.24% at sampling sites (Figure 3).

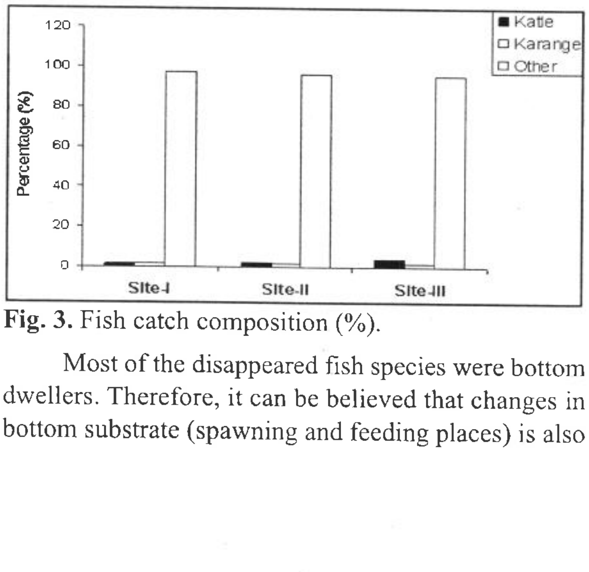


Fig. 3. Fish catch composition (%).

Most of the disappeared fish species were bottom dwellers. Therefore, it can be believed that changes in bottom substrate (spawning and feeding places) is also the cause of extinction of local species. In addition, it can be concluded that two types of effects cause the depletion of indigenous fish communities in the reservoir;

1. Immediate impact on the migratory fishes that are highly specialized to running water.
2. Delayed impact of combined effect of various factors. For Example,
   - Water level fluctuation,
   - Oxygen depletion (at bottom),
   - Thermocline,
   - Breakdown of stratification,
   - Interaction with other exotic species and
   - Habitat alteration.

Sharma (1990) reported the average production of cage culture in three lakes of Pokhara Valley was 2.035kg/m^3/yr whereas present finding for Kulekhani reservoir ranged from 2.3kg/m^3/yr to 7.4kg/m^3/yr.

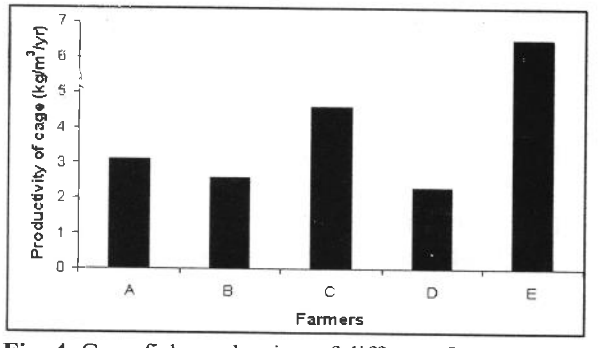


Fig. 4. Cage fish production of different farmers

Karki (2000) suggested the farmers of Kulekhani area that 25-40g sized fingerlings of silver carp *(Hypophthalmichthys molitrix)* and bighead carp *(Aristichthys nobilis)* in 1:1 ratio should be stocked in 10no./m^3 in February/March and should be harvested in November. Most of the farmers, however, were not found following the suggestion properly during the observation period. Nevertheless, the farmers who tried to follow the suggestion of FDC, Kulekhani (for example, Farmer E) could achieve more benefit from cage culture (Fig. 4). Considering the huge water surface area (65-220ha) of Kulekhani reservoir, there is better opportunity of mass production of animal protein by culturing the fast growing fish species.

Acknowledgements

Our sincere thanks go to Prof. Dr. Uma Kant Ray Yadav, Head, Central Department of Environmental Science, Tribhuvan University for providing laboratory facilities. We are very grateful to Mr. Dharani Man Singh, Mr. T.N. Thakur, Mr. B.C. Shrestha, Mr. S.S. Bhat, Mr. B. Shakya, Mr. T.N. Joshi and Mrs. S. KC. for providing necessary supports during this research work.

References

American Public Health Association (APHA), American Water Works Association (AWWA) and Water Environment Federation (WEF). 1998. *Standard methods for examination of water and wastewater.* (20th edition*).* American Public Health Association, 1015 Fifteenth Street, NW, Washington D.C., USA.

Bishop, K.A. 1979. *Fish and aquatic macro-invertebrate communities of a coastal river (Shoalhaven River, New South Wales) during the development of a water diversion scheme.* M. Sc. Thesis. Macquarie University, Sydney, Australia.

Boyd, C.E. 1982. *Water quality in warm water fishpond.* Department of Fisheries and Allied Aqua-cultures, Auburn University, USA. pp.15-20.

DOFD. 2002. *Annual progress report.* Department of Fisheries Development, Balaju, Kathmandu.

Edds, D.R. and H.H. Ng. 2007. Additions to the Ichthyo fauna of Nepal, with a redescription of *Neoeucirrhichthys maydelli* (Teleostei:Cobitidae). *Ichthyol. Explor. Freshwaters* 18 (2): 125-132.

FDD. 1998. *Annual progress report.* Fisheries development division, Lalitpur, Nepal.

FDC. 2001. *Annual progress reports.* Fisheries Development Centre, Kulekhani, Nepal.

Hrabacek, J., P. Blazka, Z. Branal, J. Fott, F. Lellack, L. Prochakova and H.B.N. Hynes. 1972. *The ecology of running waters.* University of Toronto press, Toronto, Canada. 555 pp.

Moss, B. 1998. *Ecology of fresh water: Man and medium, past to future.* 3rd edition. School of Biology, University of Liverpool, UK. pp. 315- 377.

Ng, H.H. 2006. The identity of *Pseudechenis sulcata* (McClelland) with description of two new species of Rheophitic cat fish (Teleostei:Sissoridae). *Zootaxa* 1254: 45-68.

Ng, H.H. and D.R. Edds. 2004. *Batasio macronotus,* a new species of Bagrid cat fish from Nepal (Teleostei:Bagridae). *Ichthyol. Explor. Freshwaters* 15 (4): 295-307.

Ng, H.H. and D.R. Edds. 2005a. Two new species of Erethistoides (Teleostei:Erethistidae) from Nepal. *Ichthyol. Explor. Freshwaters* 16 (3): 239-248.

Ng, H.H. and D.R. Edds. 2005b. Two new species of *Pseudechensis rheophilic,* cat fish (Teleostei: Sisoridae) from Nepal. *Zootaxa* 1047:1-19.

Jayaram, K.C. 1999. *The fresh fish of Indian reason.* Narendra publishing house, Delhi, India. 551 pp.

Kannan, V. and S.V. Job. 1980. Diurnal depth and seasonal changes of physiochemical factors in Sathiar reservoir. *Hydrobiol.* 70 (1/2): 103-117.

Karki, G.B. 2000. *Technical report.* Fisheries development programme, Markhu, Kulekhani, Nepal. 20 pp.

KC., S. 1988. *Studies on the reproductive biology of Acrossochilus hexagonalapis (Mc. Clelland) a hill stream fish from Kulekhani reservoir, Nepal.* M. Sc. Dissertation. Central. Department. of Zoology., Tribhuvan University, Kirtipur.

Pradhan, B.R. 1987. *Technical report.* Inland Fisheries Project, Indrasarobar, Kulekhani, Nepal. 24 pp.

Rai A.K. 1990. *Technical report.* Inland Fisheries Project, Indrasarobar, Kulekhani. Fisheries Development Division, Lalitpur, Nepal.

Rajbansi, K.G 2005. *Review on current taxonomic status and diversity of fishes in Nepal.* Royal Nepal Academy of Science and Technology. Occasional paper No. 10. 41 pp.

Ruttner, F. 1953. *Fundamentals of limnology.* Toronto University press, Toronto, Canada. 295. pp.

Sharma, B.P. 1990. *Cultural and management practices.* Economics of cage culture of carp in the lakes of Pokhara Valley, Nepal. 24-39 pp.

Shrestha, J. 1981. *Fishes of Nepal.* Curriculum Development Center, Tribhuvan University, Kirtipur Kathmandu. 318 pp.

Shrestha, J. 2003. Taxonomic revision of fishes of Nepal. In: *Cold water fisheries in the trans-himalayan countries.* FAO fisheries technical paper No. 431. 273-288 pp.

Shrestha T.B. and B. Bhandari. 1992. *Proceeding of the first meeting on wetland management in Nepal.* International Union for Conservation of Nature and Natural Resources and Department of National Park and Wildlife Conservation, Kathmandu, Nepal.

Swar, D.B. 1992. Effect of impoundment on the indigenous fish population in Indrasarobar reservoir, Nepal. In: *Proceedings of 2nd Asian reservoir fisheries workshop held in Hangzhou* (15-19 October 1990), *People's Republic of China* (Ed. S. S. DeSilva). Reservoir fishery management in Asia, Ottawa, Canada. pp. 111-118.

Swar, D.B. 1994. *A study on the ecology of Katle, Neolossochilus hexagonolepis (Mc. Clelland), in a Nepalese reservoir and river.* Ph. D. Dissertation. University of Manitoba, Winnipeg, MB, Canada.

Yadav, U.K.R. 1989. *Study on the benthic fauna and their environment in Kulekhani reservoir.* Ph. D. Dissertation. Department of Zoology., Patna University, India.

Zafer, A.R. 1967. On the ecology of algae in certain fishponds of Hyderabad, India. *Hydrobiol.* 30 (1): 96-112.