Chapter one

1.0 Introduction

Nepal is a small landlocked country lying in between Tibetan and Gangetic plain and has heavy rainfall due to the southwest monsoon governed by the topography of the Himalayas. It comprises a total area of 147,181 sq km and has an altitude ranging from 70 - 8848 m above the sea level. Nepal is rich in fresh water resources; approximately 5% of the total area is occupied by different fresh water aquatic habitats. The water bodies are found in the form of snow fed rivers, torrential hill streams, lakes, ponds, swamps, seasonal water logged areas etc. There are more than 6000 rivers in Nepal. The Nepal Himalayas are well known for fast flowing running water carrying heavy sediment loads during floods. However, some 217 indigenous fish species are reported to thrive in the different water bodies of Nepal (Shrestha, 2008).

Agriculture plays a vital role in the livelihood of Nepalese economy. Fish farming is an alternative means of agriculture as good source of income generation and has solved the problem of malnutrition and hunger to some extent. Fish, both fresh and dried, is a good source of easily digestible protein. Although the contribution of fish as animal protein food is very low in Nepal, fish as a protein rich diet is acceptable to every segment of the population. Fish farming is not only carried in productive water bodies but in all available water resources such as marsh, bogs and pits etc. also for profitably productive use. Fisheries also remove biodegradable organic, inorganic and toxic materials from water flowing across them through intra system of cycling and chemical exchange. Fish culture has helped integrated rural development by generating job opportunities for unemployed and underemployed people of rural areas. Many rural communities living around wetlands subsist on a combination of fishing and agriculture activities.

Table1. Protein Content of Various Food items

S.N	Food	Proteins grams per 100 grams	
		Fresh	Dried
1.0	Fish		
1.1	Fatty	17	46
1.2	Non fatty	16	84
2.0	Meat	20	67
3.0	Milk	3.4	26
4.0	Egg	12	46
5.0	Rice	8	37
6.0	Soybean	33	24
7.0	Cabbage	2.3	9
8.0	Potatoes	2.1	

Source: NARC, 1989

Note: These are the approximate values. The exact amount of protein in a food item varies according to its age, size, and quality and how it is cooked and stored.

1.1 Water Resources

Nepal is the second richest country in water resource in the world. These water bodies have been carrying about 174 billion cubic meters of water runoff annually. These rivers are grouped into different basins- Sapta Koshi river basin, Gandaki river basin, Karnali river basin, southern river basin of the Mahabharat range and border river basins. All the major river basins except those of the southern river originate in the Himalayas of entire Tibetan plateau. The inland water resources of Nepal occupied 817,000 hectare areas comprising about 3% of land area (DOFD,2007).

Table 2: Estimated Water Surface Area in Nepal

S. N.	Resource	Estimated area (ha)	Coverage (%)	Potential area (ha)
1.0	Natural water	401,500	49.14	
1.1	Rivers	395,000	48.34	
1.2	Lakes	5,000	0.61	
2.0	Reservoirs	1,500	0.18	78,000
3.0	Village ponds	6,500	0.80	14,000
4.0	Seasonal water			
4.1	Marginal swamps	11,100	1.36	
4.2	Irrigated paddy fields	398,000	48.71	
	Total	817,100	100	92,000

Source: Directorate of Fisheries Development, 2007

1.2 Lakes of Nepal

Lakes of Nepal hold nearly 2-3 percent of water. There are several types of lakes here which are of different origins like glacial lake, tectonic lake and oxbow lake. Lakes are called by different names in Nepal such as pokhari, raha, daha or kunda. Lakes above 4,000 metres in the north are mostly of glacial origin; tectonic lakes are found in mid land and oxbow lakes in southern terai plain.

i. Glacial Lake

These Lakes are formed by the melting of snow at high altitude. Lake Rara is located in the Humla of far-western Nepal is a glacial Lake. Similarly the lakes of Pokhara valley such as Phewa Lake, Begnas Lake and Rupa Lake are also glacial lakes. Besides these lakes such as Khaste, Maidi, Dipang and other lakes are originated from feeding tributaries and rivers. These Lakes are biologically productive. Some other glacial Lakes of Nepal are Ghat khola lake, Tilicho lake, Phoksondo lake, Dudh Pokhari, Panch Pokhari, Jageshwor Kunda etc.

ii. Tectonic Lake:

These Lakes are formed by the collection of water in the low land. Many tectonic Lakes are known to occur in mid land of Nepal. The important Lakes are found in Kathmandu valley, Panchakhal Banepa, Tansen, Dang and Surkhet valleys. The famous Maipokhari in Ilam and Rajapokhari in Churia hill are also famous tectonic Lakes.

iii. Oxbow Lakes:

These Lakes are formed due to the change in water course. In Nepal, oxbow lakes are found in large numbers. These lakes are located in southern terai zone where rivers meandering are associated with major lakes. In terai region, lakes are partly used for irrigation purpose.

1.3 Reservoirs

In Nepal, reservoirs cover nearly about 0.2% of total water area, that is, 1,500 ha. These reservoirs are constructed mainly for hydropower and irrigation purposes. The existing reservoirs in Nepal are Indrasarobar reservoir, Kulekhani reservoir, Trisuli, Marsyangdi, Panauti, Sunkoshi reservoirs, Kaligandaki reservoir etc.

1.4 Fish Resources

1.4.1. Status of Fish and Fisheries

According to recent taxonomic revision, there are 217 native fish species reported in different water sources of Nepal (Shrestha, 2008). They belong to 98 Genera, 35 families and 11 Orders. Besides native fishes, 15 fish species are exotic. The study showed two species like *Tor tor* and *Tor putitora* endangered but they are not listed in IUCN and CITES list.

Table 3: Accounts for Fish Species of Nepal.

S.N.	Categories	Designated	No. of fish species
1	Common	C	71
2	Uncommon or Lower risk/ least common	UN	53
3	Conservation dependent and rare	CDR	27
4	Data deficient, pristine, rare and ornamental	PRO	32
5	Critically endangered	CE	0
6	Endangered	EN	2
7	Extinct	EX	0
8	Vulnerable	VU	9
9	Rare or near threatened	R	23
	Total native species		217
10	Exotic		15
	Total fish species		232

Source: Shrestha, 2008.

15 exotic fish species including fresh water prawn were introduced by the public and private sector in the country (Shrestha, 2008). Out of these *Salmo gairdaera, Salmo trutta,* and *Onchorhynchus rhodurus* do not exist anymore. The exotic species like *Cyprinus carpio, Ctenopharyngodon idella, Hypothalmicthys molitrix, Aristichthys nobilis, and Onchorhynchus mykiss* are cultured in Nepal.

1.4.2 Captured Fisheries

Captured fisheries in Nepal are widely scattered and unorganized. Very few records are available on captured fisheries in Nepal. In Nepal, captured fisheries play a very important role to provide nutritional food to poor people. Capture fishery contributes more than 50% of the total harvest of the country.

Table 4. Estimated fish production from fisheries in year 2006/2007.

S.N.	Aquatic Resources	Total Fish (mt)	Productivity (Kg/ha)	Contribution (%)
	Total fish production	46,779		100.00
1.0	Total production from aquaculture	26,679		57.00
2.0	Total fish from captured fisheries	20,100		43.00
2.1	Rivers	7,031	17.8	15.0
2.2	Lakes	805	161.0	1.7
2.3	Reservoirs	364	242.7	0.8
2.4	Marginal swamps/Ghols	4,987	449.3	10.7
2.5	Irrigated rice fields	6,913	17.4	14.8

Source: Directorate of Fisheries Development, 2007.

1.4.3 Aquaculture

It involves all activities with complete or partial control upon fish and non-fish production. In Aquaculture systems adopted in Nepal are carp polyculture in ponds, lakes and enclosures, cage culture of herbivorous carps and common carp in paddy-cum fish culture. Different exotic fish spp. such as common carp and Chinese carps were introduced in the various water resources of Pokhara valley such as Phewa Lake, Begnas Lake, and Rupa Lake and in Kathmandu such as Godawari and Balaju. In aquaculture, a total 87,000 active members are involved and the number of direct beneficiaries reaches upto 182,000. Although information on shares of indigenous fish species in aquaculture production is lacking/unavailable, increased preferences of growers and consumers towards these high valued indigenous fish species would have substantially contributed to the livelihood of rural people.

1.5 Jalari community in Phewa Lake

The Jalari community is also called 'Pode' and they are traditional fisher community living in Pokhara valley. They are involved in catching and selling fishes from very beginning and still continuing in the present day. The total number of family involved in cage fish culture in Phewa Lake is about 90 households. At the beginning, only source of income of Jalari's community was capture fishery from Phewa Lake and nearby seasonal streams. Fisheries Development Centre, now Fishery Research Station established in Pokhara assisted poor fisher community through cage culture and open water fisheries. Different types of fishes such as grass carp, silver carp, big head carp and common carps are cultured in the cages. The cost of one cage for fish culture is above Rs. 10,000. Due to extreme poverty, some members have no access to cage culture. With the efforts of fisheries Research Centre and active Jalari community members, they were organized to work in social organizations - One organization is 'Machhapuchhre Aama Samuha' with female Jalari community and another is 'Phewa Fishery Business Organization' with male Jalari community. They control the illegal fishing, pollution in the Phewa Lake and involved in the removal of water hyacinth or jalkumbhi.

1.5.1 Socio-economic status of women

Society is a web of human relationship. The different factors such as social, economic, health, educational and other factors determine the status of society. Nepali society is made up of so many cultures but it is a Hindu culture so it is most influential with regards to defining the role of women. The position occupied by women in the social structure of society in regards to power, prestige, rights and duties is called women status. Women group is not in minority in number, but it is obvious that women constitute slightly more than half of the population of our nation (50.04%). By limiting women's participation in any development process, society deprives themselves of the full talent of almost half of members. In spite of almost of equal population, they have low position and status in the society in comparison to the male. The literacy rate of women is 42.8% while that of male is 65.08% in respect to total 54.1% literacy rate of our country (CBS, 2004).

Women's equal participation is not only desirable but also essential to increase speed of the development process. The slogan of the development process remains in papers unless women do not participate equally to share the fruits of development. In the past and even today, women are considered as second class citizen in most of the developing countries and Nepal as well. Nepali women are recognized as daughter, wife and mother but are not recognized as individual with their own identity. Women are usually confined to their houses for their household works. In the rural/village area, women work in the field, take care of the cattle and also have to look after their children. The load of work is more in women than in men. Their position is quite helpless in many ways because the female child is deprived of education. They usually drop out or are compelled to drop out of school before they become adolescent. The common attitude of Nepali society is that education for women is wastage of time and money. Women are not in position to do any decision for themselves due to the lack of education/awareness. These days some women are involved in many economic activities and played an important role to improve the household/economic condition. Government, NGO, INGO are lunching different kinds of income generating activities for them. The high status of women is important to influence socio-economic development of country.

1.5.2 Participation of women in fisheries and aquaculture

In Nepal, women have a major role in fisheries and aquaculture. Mostly women from lower ethnic group like Mushar, Dhangar, Dom, Paswar, Malah, Danuwar, Majhi and Tharu are involved in aquaculture and capture fisheries also. Females belonging to better economic condition are not involved in fishery with the feeling of violation of reputation. Poor women are involved in making gears, crafts, net weaving etc. Fish collection and selling in market had raised their socio-economic status and has removed dependency upon male members for their wants/needs.

1.6 Cage culture in Nepal

In Nepal, fish culture in cages started in 1972 A.D. at Phewa Lake, Pokhara valley (Swar et. al. 1983) to hold the broods of common carp (*Cyprinus carpio*) as government fish pond near Phewa Lake suffered from water shortage. This was carried out for several years to rear fish. Later in 1975 A.D., a feasibility study of cage culture was carried by Government Fish Farm. At the beginning of 1978 A.D., cage culture was practiced in Phewa, Begnas and Rupa Lake where Rupa Lake was found to be highly productive and suitable for intensive cage culture. Two crops of fish could be harvested from Rupa Lake in a year.

1.6.1 Construction and design of cages: Although the first cage used in Lake Phewa was made from nylon net. Several cages were constructed from local material during 1976- 1978 A.D.

i**. Bamboo cage:** It was constructed entirely from bamboos and anchored with heavy stone. It lasted about two years and did not function well. Because it was inconvenient in handling and harvesting, this type of cage was not popular among the fish grower of the Pokhara valley.

ii. **Wooden cage:** Although wooden cage was very durable, but it was affected by water fluctuation. It was not popular because of its heavy weight, bulk and handling problem.

iii. **Iron angled nylon cages:** It consisted of iron angles in nylon mesh. Generally four empty oil drums were mounted at four sides of the cage to keep floating at 2m depth. The cage volume was about 32 m^3 with a cover on the top. Iron angle of 1.3 or 1.9 cm were welded together to form frame of 4.0× 4.0×2.5 $m^{3.}$

iv.**Nylon cages:** Nylon net cage was most popular among the fish growers in the Pokhara valley with the size of 50m^3 (5×5×2m^3); as it was easy to handle and maintain. However, few large cages of 150m^3 or 98m^3 were also in operation in the Government sector. Generally the cage was mounted on bamboo frames, which also served as float, or it was also mounted on a wooden or galvanized iron using stones at four corners. Here, fish was harvested with the help of bamboo log.

v. **Norwegian cage:** Norwegian cage was made from 15 mm knotless mesh. It had a size of 100m^3 (5×5×4m^3). The cage was supported by metal horizontal bars which in turn were fixed to vertical bars arising out of plastic buoyant. Norwegian cage was highly durable requiring little cleaning. As they are made up of anti fouling chemicals, growth of fresh water sponges and algae was not at all any problem.

vi.**Japanese cage:** The dimension of cage was variable. Two types of cages of varying size were imported with the size of 73.5m^3 (7×7×1.5m^3) size and 52.5 m^3 (7×5×1.5$m^{3)}$.

vii.**Nursing cages:** The size of nursing cages varied and ideal nursing cage was 1.5m in depth
and nylon mesh size of 0.5 cm.

In 1975 A.D., Government Fish Section initiated integrated fish culture development project first in Lake Phewa and Begnas on experimental basis. The experiment proved it to be successful and the work was transferred to the public at large in the Pokhara valley. Cages were made from materials locally available, but the cages were found to be least durable. Later, imported nylon cages were used on trial basis including common carp (*Cyprinus carpio*), silver carp (*Hypothalmicthys molitrix*), grass carp (*Ctenopharyngdon idella*) and big head carp (*Aristicthys nobilis*) on floating cages without supplementary feedings.

1.7 Limitations of Study

The limitations of the present study are given below

i. Due to limited time and resources, separate cage was not installed for present study.
ii. Only one third of the households were selected for sample study.
iii. For socio-economic study, only Jalari community residing in the Phewa watershed area was selected for the study; so, the results obtained from this work might not be applicable to the fisher communities of other parts of Nepal.

1.8 Justification of study

Phewa Lake is rich in fish diversity including a large number of indigenous fish species. Besides it, it has socio-cultural and economic importance. The scientific research works on indigenous fishes and socio-economic condition of local fisher community are very scanty in Phewa Lake. Hence the present research was undertaken.

1.9 Aims and objectives

The aims and objectives of the present study are-

i. To study the distribution, frequency and diversity of fish in Phewa Lake.
ii To study the physicochemical parameters of water
iii To study the socio-economic condition of the local fisher community.
iv To study different fishing implements used in Phewa Lake.

CHAPTER TWO

2.0 Literature review

Nepal is rich in fascinating fresh water fish fauna, which is attracting many researchers for the study on this field since 18th century. Colonel Kirkpatrick was the first person who gave first historical account on fish fauna of Nepal in the year 1793 A.D. He described the fishing methods in Rapti River of Makawanpur District, southwestern Nepal. Francis Buchanan (1822) was the second person during the beginning of 19th century. He gave the first authentic information about the fishes of Nepal in his book entitled "An account of the fishes found in the River Ganges and its tributaries". This provided the description of 269 species of fish of the Ganges and its tributaries. From the days of Colonel Kirkpatrick (1793) to the present day many research works on fish and fishery of Nepal have been performed and published.

Mc Clelland (1839), Beaven (1877) and Day (1878-81) also reported on the fish fauna of Nepal. Day(1886) mentioned the distribution of some freshwater fishes of Nepal in his historical work "Fishes of India, Burma and Ceylon". Boulenger and Regan (1907) reported a small collection of fishes from Nepal. Hora (1920-1952) gave an outstanding contribution to his field. He obtained a collection of fishes from Nepal through Bailey that included 158 specimens of 22 species from Nepal belonging to 15 different genera. Hora (1940) reported the Nepalese 'Katle' (*Neolissocheilus hexagonolepsis*). Menon (1949) collected 11 families of fish comprising 26 genera and 52 species from Koshi River and also prepared a checklist of fishes of Koshi River. He also provided informative description of Zoogeography of the fishes of Nepal. Taft (1955) submitted a report on his survey 'Fishes of Nepal' and collected 94 species of fishes from Kathmandu and adjoining area. Further, De witt (1960) elaborated Taft's checklist by adding some new species. His list included 102 species representing 21 families contributing to the ichthyology of Nepal.

Some ichthyologists have performed other important works in the field of taxonomy of fishes. They are Das (1955-1967), Misra (1959), Shaw and Shebbeare (1937) and Shrivastava (1968) who described some of the fishes of Nepal. Along with taxonomic study of fishes, parallel studies on the field of fishery resources, fish ecology and behavior are conducted in different parts of Nepal. Thapa and Rajbanshi (1968) studied the ecology of hill stream fishes of Nepal. Dibbs (1965) reported various aspects on the development of fisheries in Nepal. Majupuria and Shrestha (1968) published a paper on fresh water fishes and fisheries of Nepal. Bhatta and Shrestha (1973) have studied the fish fauna of Suklaphanta and listed 27 species of fishes. The other researchers are Fellow and Swar (1978) who made survey on biological and limnological condition of lakes and natural waters in Pokhara valley with reference to the existing fish population with their feeding habits and biology. Shrestha (1979) studied the resource biology and aquatic ecology of freshwater of Kathmandu valley with particular reference to fish production, marketing management and conservation. Shrestha and Pradhan (1979) did combined study about the aquatic ecology and

fishery potential of Bagmati river. Shrestha (1979) studied the life-history of hill stream trout *Schizothorax plagiostomus*.

A milestone work in the field of taxonomic study of fish fauna in Nepal was done by Shrestha (1970-1986). She published her findings in various journals and published a very popular work entitled "Fishes of Nepal" in 1981. This book covered the description of scientific details of 120 species. Terashima (1984) had reported three endemic species of genus *Schizothorax* from Lake Rara, North-western Nepal. Edds (1985) added a list of 8 new records of fish previously not reported in Nepal. Edds (1989) studied the fishes of Kali Gandaki/Narayani river and Chitwan National Park reporting 111 and 107 fish species respectively. He also highlighted the needs and opportunities of conservation there. Jha and Shrestha (1989) had collected 57 species of fish from the Karnali River in western Nepal.

Ferro and Swar (1978) surveyed the biological and limnological conditions of the Lakes and natural waters in Pokhara valley. Badgami (1980) studied the commercially important species of fishes of Pokhara valley. Pokhrel (1998) studied the fish diversity and feeding habits of major lakes of Pokhara valley. Shrestha (1991) reported 59 species of cold water fishes from the natural water bodies of mountains and Himalayan region of Nepal. Shrestha (1995) made enumerations of 185 indigenous fish species but again in 2001, she revised her work with a total of 182 species belonging to 93 genera, 31 families and 11 orders. Shrestha (2001) reported fresh water fishes of 11 orders, 31 families and 92 genera. Shrestha (2008) reported 232 species of fishes of which 217 species are indigenous fish species.

2.1 Limnological Study in Nepal

Limnology is the branch of science, which deals with the study of fresh water ecosystem of all kind of lakes, ponds, streams and reservoirs. Forbes (1887) described lakes as a "microcosm" a little world itself. Forel (1892), the father of limnology had worked on Swiss lake and published a book 'Lemon' in three volumes. Published research papers indicated that prior to 1960, very limited limnological works had been conducted in the fresh water environment of Nepal. After 1960, the limnological study on the lotic and lentic freshwater environment of Nepal had been carried out by several scholars. Brehm (1953) was the first limnologist who studied some aquatic fauna from Kalipohari, Eastern-Nepal. Hirono (1955) published few papers concerning the Nepalese algae. Loffler (1969) did some limnological investigation on the high altitude lakes of Everest region.

Hickel (1973) did some works on the lakes of Pokhara valley during research scheme of Nepal Himalaya. Shrestha et al. (1979) studied some limnological aspects of the Bagmati and Trisuli rivers. Swar (1980) described the status of limnological studies and research in Nepal. The physico-chemical parameters of lakes situated in Mid-hill had been studied by other limnologists such as Ferrow (1978), Kato and Hayashi

(1980). Ferrow (1980-1981) studied the limnology of lakes of Pokhara valley and its implication and fishery potential of Indra sarober at Kulehani, Nepal. Nakanishi et al. (1988) obtained limnological data for the late monsoon and dry season of main lakes in Pokhara valley. They categorized Begnas and Rupa lakes as eutrophic. Talling and Lamoalle (1998) also reported much information about tropical and temperate lakes of Nepal. Jones et al. (1989) also studied the lakes in Pokhara valley on the basis of mineral contents.

Some of the researchers worked on the socio-economic condition of fisher communities. Out of 103 ethnic groups, 20 of these groups largely live on the bank of water resources and are heavily dependent on the wet land products and services (IUCN,2004). The prominent groups are Pode or Jalari, Suneha, Mallah, Bote or Majhi, Mushahar, Mukhiya, Danuwars, Darai, Kumal and Tharu. Swar (1980) estimated that there were about 80,000 fishers. Gyawali (1997) studied about socio-economic aspect of Botes.

The fishing implements and methods were described by some of the researchers. Shrestha (1946) describes the 5 basic conventional methods used for fishing in different water bodies in Nepal. They are nets, basket implements, rod and line, spearing and manual method of killing. Various nets with indigenous names such as Tunnay jal, Chatti jal, Chanki jal, Sohat, Lapa, different types of traps, Baskets, rod and lines are used in Koshi river basin.

CHAPTER THREE

3.0 Materials and Methods

3.1Study period and study area

For the present study, field study work was carried out for one 11 months from September 2009 to July 2010. The sampling sites were visited two times every month for the collection of fishes and information about socio-economics of fisher community. Phewa Lake is the study site of present study. It is situated at the south western part of Kaski district in between 25º7' and 28º10' North latitude and 83º50' and 84 º 50' East longitudes at 884 m above the sea level and 200 km. west from Katmandu valley. Pokhara valley is famous for many lakes; of which Phewa is the most important one. The lake is fed by several tributaries like Harpan Khola, Hani Khola, Khahare Khola, Sedi Khola and numerous seasonal streams. The total surface area of the lake is about 443 hector and total watershed area of 110 km^2. It has a maximum depth 23 m (Lamichhane, 2000) and minimum depth of 7.5m. The lake has only one main outlet. The reported surface water temperature of lake ranged from 15.5 – 27.0^{0}C. Pokhara is an area of heavy monsoon with mean annual rainfall of 3,710mm. Maximum rainfall occurs in July and from November winter rainfall starts continues upto April. Water of Phewa Lake mixes with Frushe Khola lying in the southern part of Pokhara valley. Several native carps were reported in the Phewa Lake.

3.2 Flora and Fauna in and around Phewa Lake

In the watershed area of Phewa Lake, 50% of the total land is estimated to remain under agriculture and 25% under forest. The vegetation is dominated by broad leaf forest (98%). The major vegetation found in the area are: *Shorea robusta* (Sal), *Schima castanopsis* (Katus), *Cidrella* sp. (Tooni), *Bombax* sp. (Simal), *Quercus* sp. (Oak), *Rhododendron* sp. (Lali Gurash), *Lyonia* sp. (Angari) etc. In the Lake, 21 fish species are reported and common fishes are *Barilius, Puntius, Channa* etc. Besides fishes, 6 species of amphibians, 14 species of reptiles, 104 species of birds and 34 species of mammals are reported in Phewa and watershed.

3.3 Selection of sampling sites

The study of distribution patterns of fishes was confined within the Phewa Lake. The study also made on socio-economics of local fisher community residing around the lake. Three sampling sites were selected on the basis of the settlement of local fisher community.

Station I: The first station site was selected near the Sedi where few settlements of local fishermen existed and is 500m away from Talbarahi Temple. They have their own cage for fish farming.

Station II: The second site was selected near Fauri which is about 500m far from I station. Here, the settlement of fisher community is denser than Station I.

Station III: The third station was selected at Khapaudi which is about 800m away from Fauri. In this station, the number of cages is high and the population of fisher community is also large.

During the study, 30 people residing around the Phewa Lake in Sedi, Baidam, Fauri and Khapaudi were chosen as respondents. The socio-economic condition of fisher community was studied on the basis of information given by respondents and direct observation.

PLATE-1

Station I

Station II

Station III

3.4 Physicochemical parameters

The main prerequisite for fish culture is the quality of water suitable for survival and growth of fishes. All the vital functions of fishes such as feeding, digestion, assimilation, growth, respond to the various stimuli in water and reproduction is very much dependent on physicochemical parameters of water. The principal physicochemical parameters of water are analyzed by given methods below.

3.4.1 Physical Parameters

Depth, temperature, turbidity and light are important physical parameters on which the productivity of a pond depends.

3.4.1.1 Temperature

The temperature of the tank was measured by dipping the bulb of mercury thermometer. And the temperatures of the four allocated sampling points were observed within 20 minutes to obtain the accurate temperature and the average water temperature was obtained.

3.4.1.2 Transparency

The transparency of water was measured by using Secchi Disc, a metallic device. For it, the Secchi Disc was lowered in the water till it is invisible and the depth of water was noted. Next time Secchi Disc was totally merged in the water till it totally disappears and the disc was gradually pulled up and the depth of water when the disc reappears is noted. Then the transparency was calculated by applying the following formula:

Transparency (cm) = (A+B)/2

Where, A = Depth at which Secchi Disc disappears.

B = Depth at which Secchi Disc reappears.

3.4.2 Chemical Parameters

3.4.2.1 pH

The pH indicates the extent of acidity or alkalinity. The pH of water was determined by using automatic digital pH meter (HANNA) by dipping the pH meter in water for 2 minutes. Before taking the readings, pH meter was calibrated with distilled water (pH 7).

3.4.2.2 Dissolved Oxygen (DO)

The DO was determined by the standard Wrinkle's method. The sample water was filled in the BOD bottle (glass stopper bottle) of 300 ml volume avoiding bubbling and trapping of air bubbles in the bottle after placing the stopper. In this sample water 2 ml of each $MnSO_4$ and Alkaline KI solution were poured and formed the precipitation. Now placing the stopper, the BOD bottle was shaken so that the contents would invert the bottle repeatedly. The bottle was kept for sometimes to settle down the precipitate and then 2 ml of conc. H_2SO_4 was added to dissolve the precipitate by shaking the content well. Now, 50 ml of content of BOD bottle was titrated with standard Sodium Thiosulphate (0.025 N) using starch as an indicator. At the end point, initial dark blue colour changes to colourless. The DO can be estimated by using the formula,

$$DO\ (mg/l) = \frac{(ml \times N)\ of\ titrant \times 8 \times 1000}{V_2 \times \left(\frac{V_1 - V}{V_1}\right)}$$

Where, N = Normality (strength of Sodium Thiosulphate)
V_2= Volume of content titrate
V_1 = Volume of sample bottle (BOD) bottle
V = Volume of $MnSO_4$ and KI added

3.5 Nature and Sources of Data:

The methodology has been followed by primary and secondary data collection. Primary information has been collected through direct observation, participated

method where as secondary information was collected from different published sources.

Data Collection Tools and Techniques:

In the present study different techniques were used to gather information about the distribution pattern of fishes and socio-economic condition of local fisher community.

3.5.1 Direct Observation:

The study area Phewa Lake was visited frequently and the data was collected with the help of observation. During the observation period the local fishermen who had through knowledge were selected for the gathering of information.

3.5.2 Questionnaire:

Before conducting research, pilot survey was conducted. After this questionnaire was prepared in such a way that it provide the information.

3.6 Fish Sampling:

Different fish species were collected in Phewa Lake from September 2009 to July 2010 in each sampling sites. The fishes were collected with the help of local fishermen. Different fishing implements such as hook and line fishing, gill net, fine meshed net etc. were used at the time of fish collection. The collected fishes were preserved at 8% formalin. The fishes were identified after Shrestha (1991, 1994 and 2001) and Shrestha (2008).

3.7 Case Study:

During the present investigation 30 fishermen were chosen in order to gather required informations. This method is the way of exploring and analyzing the economic status of the respondents and gathering data on their fishe and fishery activities Form this study one gets to know about their responses towards the society and the surrounding biological resources. Positive attitude of the surrounding people towards the aquatic resources in general and fish resources in particular is important in conservation of these resourses. It is also easier to document the fishing community's indigenous knowledge regarding the fish ecology and biology from this investigation. Such a body of age old traditional knowledge could be incorporated into modern scientific knowledge while formulating fish conservation policies.

3.8 Statistical Analysis:

The distribution pattern of fish species in Phewa Lake was calculated by using Mean, Standard deviation, Variance and Variance Mean ratio. The formulae to calculate these statistical tools are given as follows:-

1. **Mean:** It can be defined as the sum of observations divided by the number of observations.

   Mean ($\bar{X}$) = $\frac{Total\ no.of\ fish\ collected\ in\ different\ station}{No.of\ station}$

2. **Standard deviation:** It can be defined as the square root of arithmetic mean of square deviation taken from arithmetic mean.

   Standard deviation (σ) = $\sqrt{\frac{\Sigma(x-\bar{x})^2}{N}}$

3. **Variance:** It is the square of standard deviation.

   Variance (V) = Square of the standard deviation.

4. **Variance Mean ratio:** It is the ratio of variance to mean. Jackson, 1968, If $\frac{V}{M}$ = 1 (distribution is random)

   If $\frac{V}{M}$ < 1 (distribution is uniformed)

   If $\frac{V}{M}$ > 1 (distribution is clumped)

CHAPTER FOUR

4.0 Observations and result

4.1 Water Quality Analysis

During present study, water temperature, transparency, pH and dissolved oxygen (DO) were analyzed and data obtained as follows (Table 5):

Water temperature: The surface water temperature in Phewa Lake ranged from 15.5-27^{0}C. The highest peak of the temperature (27^{0}C) was recorded in the month of July at I and II stations and the lowest temperature was in January at III station (Fig 1)**.**

Transparency: The water of the Phewa Lake was almost clear throughout the year except in rainy season. The transparency ranged from 30 cm to 76 cm. The highest transparency 76 cm was recorded in the month of January from station II and the lowest transparency were recorded from station I in the month of July which was 30 cm.

pH: The pH of water of Phewa Lake ranged from 6.7 to 7.6 with an average value of 6.9. The maximum pH of 7.6 was recorded in the month of July from station III while minimum value of 6.7 was recorded in September in station I. There was not much more fluctuation in pH in all three stations (Fig 2).

Dissolved Oxygen: The dissolved Oxygen in the water of Phewa Lake ranged from 6.0 to 9.5 mg/lit with an average value of 8.1 mg/lit. The maximum dissolved oxygen was recorded in the month of July from station III (9.5 mg/lit) while minimum value of 6.0 mg/lit was recorded in the month of January from station II (Fig 3).

Table 5. Water quality analysis in Phewa Lake.

S. N	Parameters	Station I			Station II			Station III			Max	Min	Average
		Sep.	Jan.	Jul	Sep	Jan	Jul	Sep	Jan	Jul			
1	Water temperature (˚C)	25	16	27	24.5	17	27	24	15.5	26.5	27	15.5	22.5
2	Transparency (cm)	50	70	30	55	76	35	51	75	40	76	30	53.5
3	pH	6.7	6.7	7.0	6.9	7.3	7.1	6.7	6.9	7.6	7.6	6.7	6.9
4	Dissolved Oxygen (D.O.)	8.8	8.2	9.1	8.5	6.0	9.0	7.3	6.5	9.5	9.5	6.0	8.1

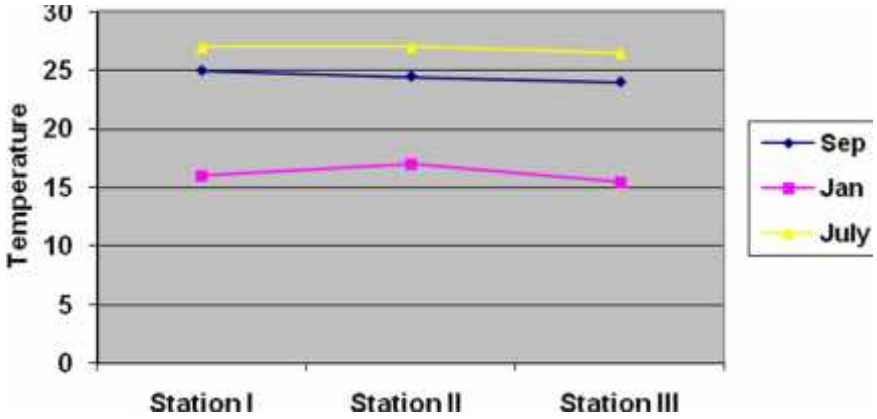


Fig 1. Variation of temperature at three different stations.

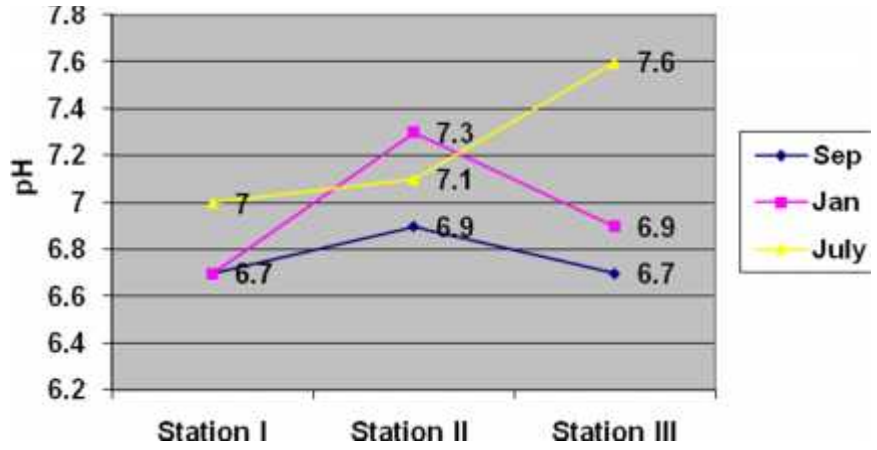


Fig 2. Variation of pH at three different stations.

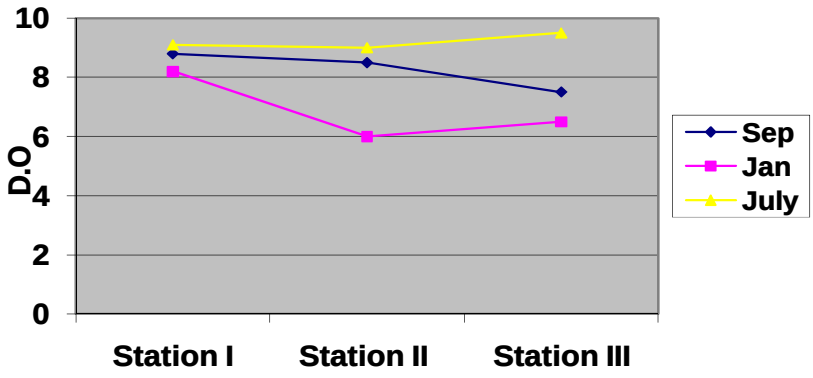


Fig 3. Variation of dissolved oxygen at three different stations.

4.2 Fish Diversity in Phewa Lake

During the present study, a total of 21 native species belonging to 5 orders, six families and 16 genera were recorded (Table 6). The most common species distributed in Phewa Lake was *Puntius* sp. followed by *Barilius* sp., *Garra annandalei* and *Channa gachua*. *Neolissocheilus hexagonalepsis, Changunius changunia, Tor putitora and Schizothorax richardsonii* were found occasionally during the study period. *Tor putitora* and *Neolissocheilus hexagonalepsis* were caught only during the month of July and August. Besides indigenous fishes, five exotic fish species were recorded in present study from Phewa Lake. They were *Clarias gariepinus, Aristicthys nobilis, Hypothalmicthys molitrix, Ctenopharyngodon idella* and *Tilapia mossambica.*

Table 6. List of fishes found in Phewa Lake.

S.N.	Genus	Species	Local name
1	***Channa***	***gachua***	Bhoti
2	***Clarias***	***batrachus***	Magur
3	***Heteropneustes***	***fossilis***	Singhe
4	***Barilius***	***barna***	Bagefageta
5	***Barilius***	***vagra***	Lamfageta
6	***Barilius***	***bendelensis***	Chiplefageta
7	***Neolissocheilus***	***hexagonalepsis***	Katle
8	***Tor***	***putitora***	Sahar
9	***Chagunius***	***changunia***	Rewa
10	***Schizothorax***	***richardsonii***	Asala
11	***Xenentodon***	***cancilla***	Dhungebam
12	***Mastacembalus***	***armatus***	Chuchebam
13	***Danio***	***devario***	Sera
14	***Danio***	***dangila***	Deutamachha
15	***Puntius***	***sarana***	Bhitte
16	***Puntius***	***conchonius***	Bhitte
17	***Puntius***	***sophore***	Bhitte
18	***Esomus***	***dandricus***	Junge
19	***Brachaydanio***	***rerio***	Zebra fish
20	***Acanthocobatis***	***botia***	Gadela
21	***Garra***	***annandalei***	Buduna

4.3 Systematic Positions of Icthyofauna of Phewa Lake

The classification and systematic positions of Icthyofauna (Table 7. and Fig 4) reported from Phewa Lake are as follows:

I. Order: Cypriniformes

Family: Cyprididae

Sub-family: Cyprininae

1. ***Neolissocheilus hexagonalepsis*** **(Mc Clelland) 1839**
2. ***Tor putitora*** **(Hamilton- Buchanan) 1822**
3. ***Changunius changunia*** **(Hamilton- Buchanan) 1822**
4. ***Puntius sophore*** **(Hamilton- Buchanan) 1822**
5. ***Puntius conchonius*** **(Hamilton- Buchanan) 1822**
6. ***Puntius sarana*** **(Hamilton- Buchanan) 1822**
7. ***Esomus dandricus*** **(Hamilton- Buchanan) 1822**

Sub-family: Rasborinae

8. ***Barilius vagra*** **(Hamilton- Buchanan) 1822**
9. ***Barilius barna*** **(Hamilton- Buchanan) 1822**
10. ***Barilius bendelensis*** **(Hamilton- Buchanan) 1822**
11. ***Danio devario*** **(Hamilton- Buchanan) 1822**
12. ***Danio dangila*** **(Hamilton- Buchanan) 1822**
13. ***Brachiyodanio rerio*** **(Hamilton- Buchanan) 1822**

Sub-family: Garrinae

14. ***Garra annandalei*** **(Hora) 1921**

Sub-family: Noemacheilinae

15. ***Acanthocobatis botia*** **(Hamilton- Buchanan) 1822**

Sub-family: Schizothoracinae

16. ***Schizothorax richardsonii*** **(Gray) 1832**

II. Order: Siluriformes

Family: Claridae

17. ***Clarias batrachus*** **(Linnaeus) 1758**

Family: Heteropneustidae

18. ***Heteropneustes fossilis*** **(Bloch) 1785**

III. Order: Perciformes

Sub- order: Channiodei

Family: Channidae

19. ***Channa gachua*** **(Hamilton) 1822**

IV. Order: Beloniformes

Sub-order: Belonoidei

Family: Belonidae

20. ***Xenentodon cancilla*** **(Hamilton- Buchanan) 1822**

V. Order: Synbranchiformes

Sub-order: Mastacembeloidei

Family: Mastacembeloidae

Sub-family: Mastacembelinae

21. ***Mastacembalus armatus*** **(Hamilton- Buchanan) 1822**

Table 7. Fishes of Phewa Lake with their systematic positions

Order	Sub order	Family	Sub Family	Genus	Species
Cypriniformes		**Cyprinidae**	**Cyprininae**	***Neolissocheilus***	***hexagonalepsis***
				Tor	***putitora***
				Changunius	***changunio***
				Puntius	***sophore***
				Puntius	***conchonius***
				Puntius	***sarana***
				Esomus	***dendricus***
			Rasborinae	***Barilius***	***vagra***
				Barilius	***barna***
				Barilius	***bendelensis***
				Danio	***devario***
				Danio	***dangila***
				Brachiyodanio	***rerio***
			Garrinae	***Garra***	***annandalei***
			Noemacheilinae	***Acanthocobatis***	***botis***
			Schizothoracinae	***Schizothorax***	***richardsonii***
Siluriformes		**Claridae**		***Clarias***	***batrachus***
		Heteropneustidae		***Heteropneustes***	***fossilis***
Perciformes	**Channiodei**	**Channidae**		***Channa***	***gachua***
Beloniformes	**Belonoidei**	**Belonidae**	-	***Xenentodon***	***cancilla***
Synbranchiformes	**Mastacembeloidei**	**Mastacembeloidae**	**Mastacembelinae**	***Mastacembalus***	***armatus***

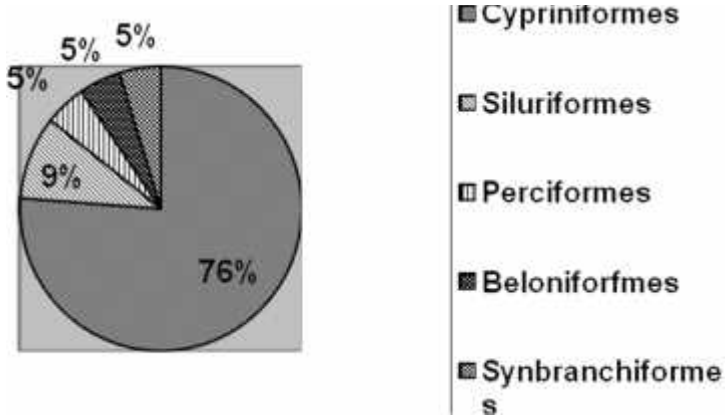
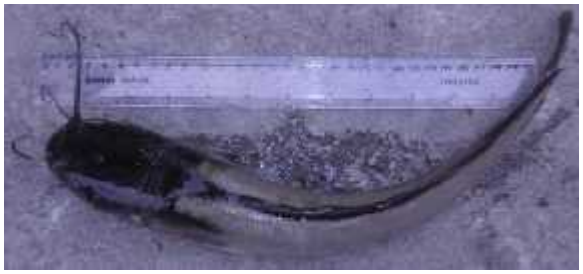


Fig 4. Pie Chart showing fish composition order-wise in Phewa Lake.

PLATE: 2

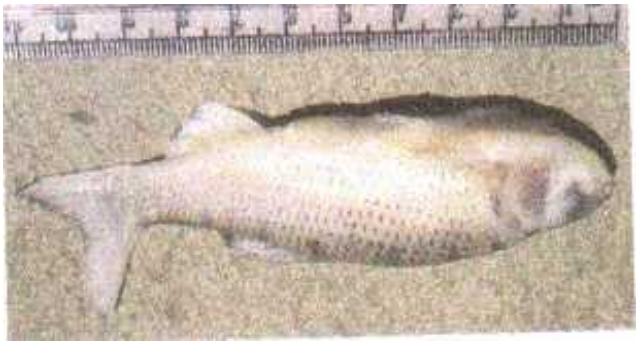
Channa gachua



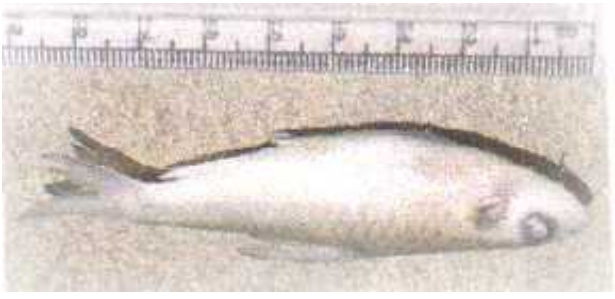
Clarias batrachus

Barilius barna

Barilius vagra



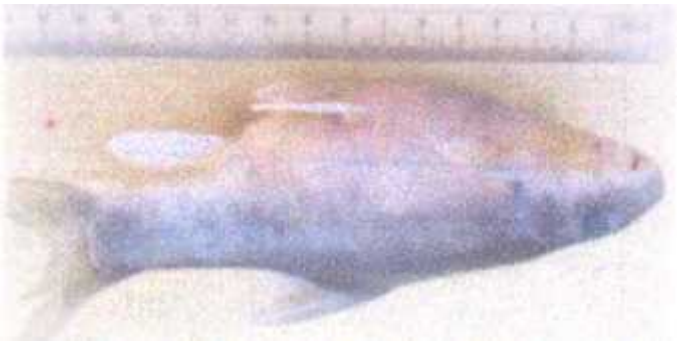
Barilius bendelisis



Neolissocheilus hexagonalepsis

Chagunius changunia

PLATE: 3



Schizothorax richardsonii

Xenentodon cancilla

Mastacembalus armatus

Danio devario

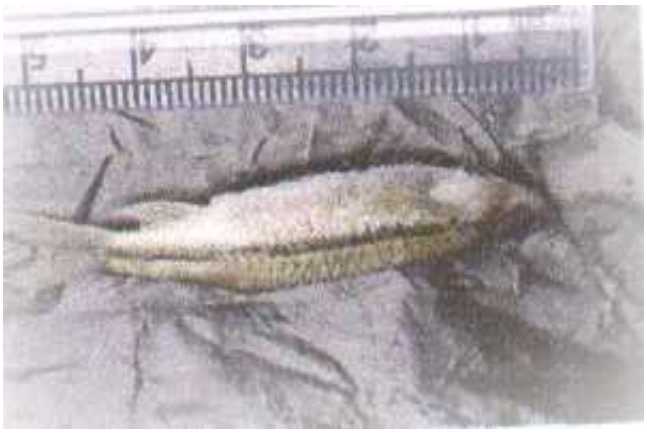
Danio dangila

Puntius sarana

Puntius conchonius

Puntius sophore

PLATE: 4

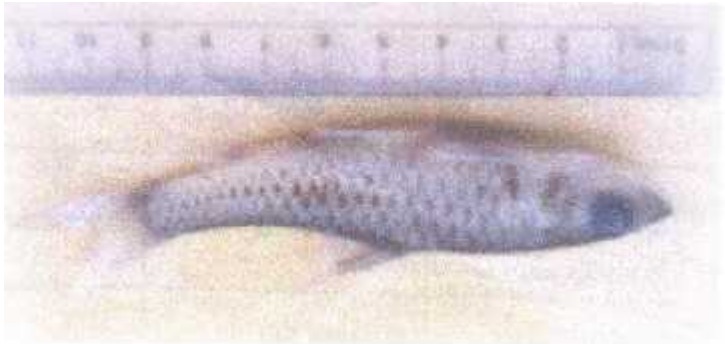


Esomus dandricus

Brachaydanio rerio

Acanthocobatis botia

Garra annandalei



Tor putitora

4.4 Fish Diversity in Phewa Lake stationwise

The species like *Barilius barna, Barilius bendelensis, Puntius* sp., *Danio* sp., *Channa gachua* etc were found in all the three stations. The fish species like *Tor putitora, Esomus dandricus, Brachaydanio rerio*, and *Heteropneustes fossilis* were not recorded in station III only. The fishes like *Barilius vagra* and *Schizothorax richardsonii* were not found in station II while the fishes like *Neolissocheilus hexagonalepsis, Acanthocobatis botia* and *Garra annandalei* were not caught in station I in present study(Table 7 and Fig 6).

Table 7. Number of fishes in Phewa Lake stationwise.

S.N.	Genus	Number	Sampling sites		
			I	II	III
1	*Channa gachua*	37	+	+	+
2	*Clarias batrachus*	14	+	+	+
3	*Heteropneustes fossilis*	18	+	+	-
4	*Barilius barna*	38	+	+	+
5	*Barilius vagra*	36	+	-	+
6	*Barilius bendelensis*	40	+	+	+
7	*Neolissocheilus hexagonalepsis*	8	-	+	+
8	*Tor putitora*	7	+	+	-
9	*Chagunius changunia*	8	+	+	+
10	*Schizothorax richardsonii*	5	+	-	+
11	*Xenentodon cancilla*	16	+	+	+
12	*Mastacembalus armatus*	12	+	+	+
13	*Danio devario*	10	+	+	+
14	*Danio dangila*	13	+	+	+
15	*Puntius sarana*	58	+	+	+
16	*Puntius conchonius*	55	+	+	+
17	*Puntius sophore*	60	+	+	+
18	*Esomus dandricus*	13	+	+	-
19	*Brachaydanio rerio*	12	+	+	-
20	*Acanthocobatis botia*	14	-	+	+
21	*Garra annandalei*	39	-	+	+
	Total	513			

Full Page Figure:

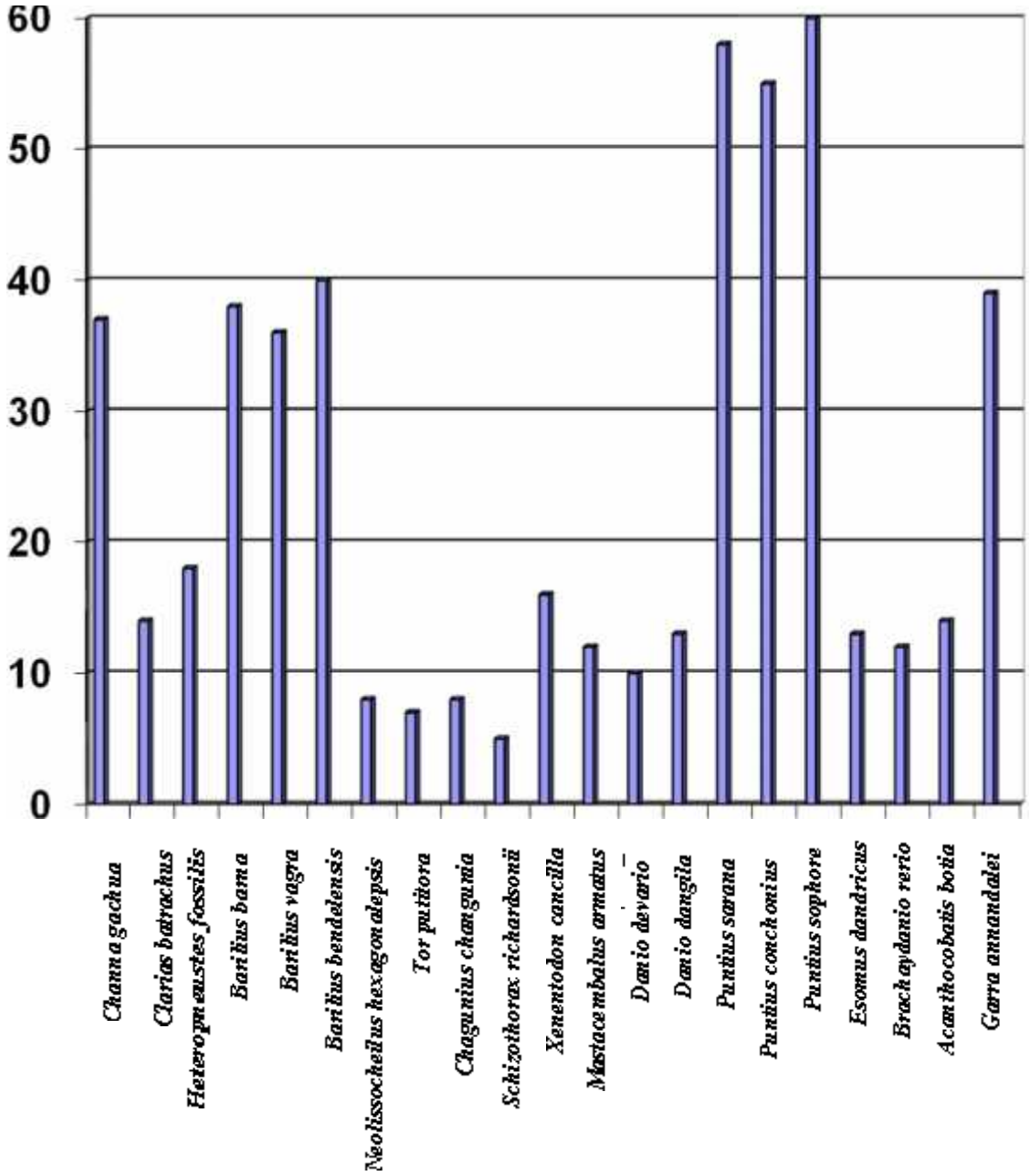


Fig 6. Bar diagram showing number of each species collected in Phewa Lake

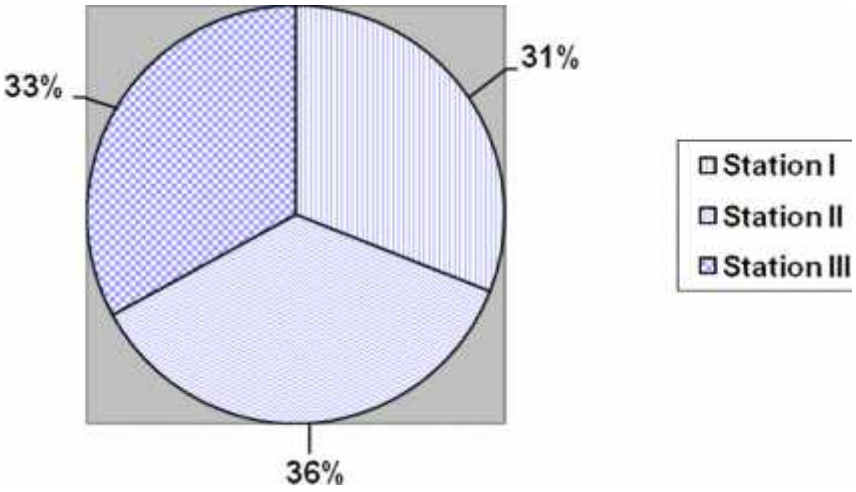


Fig 7. Pie chart showing fish catch composition in different stations of Phewa Lake

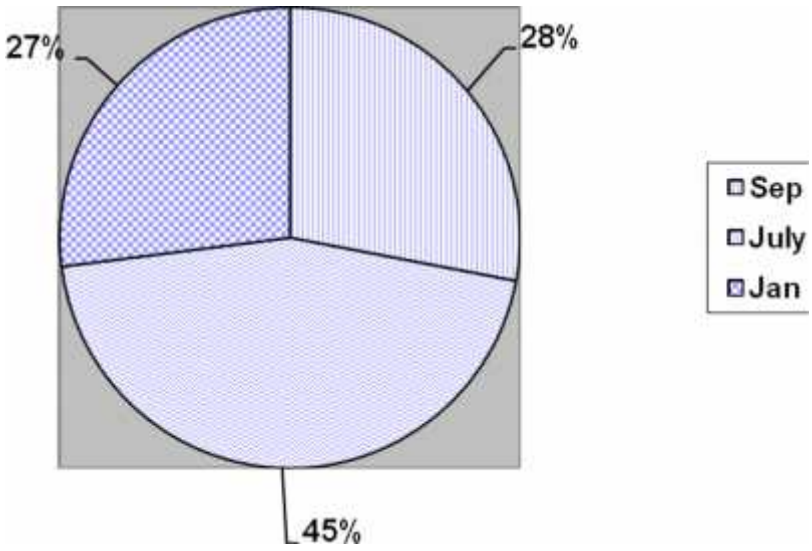


Fig 8. Pie chart showing monthly catch composition of fishes in Phewa Lake.

4.5 Distributional pattern and frequency occurrence of fishes in Phewa Lake

During the present study, a total of 513 fishes were collected. The maximum number was 60 of *Puntius sophore* and the minimum number was 5 of *Schizothorax richardsonii***.** Similarly, the highest frequency occurrence was highest for *Puntius sophore* **(**11.69%) and lowest for *Schizothorax richardsonii* **(**0.97%). The distribution pattern of fishes in Phewa Lake was found to be clumped and uniform in distribution (Table 8).

Table 8. Frequency occurrence of fishes in Phewa Lake.

S.N.	Genus	Number	Frequency (%)	Sampling sites		
				I	II	III
1	*Channa gachua*	37	7.21	+	+	+
2	*Clarias batrachus*	14	2.72	+	+	+
3	*Heteropneustes fossilis*	18	3.50	+	+	-
4	*Barilius barna*	38	7.40	+	+	+
5	*Barilius vagra*	36	7.01	+	-	+
6	*Barilius bendelensis*	40	7.79	+	+	+
7	*Neolissocheilus hexagonalepsis*	8	1.55	-	+	+
8	*Tor putitora*	7	1.36	+	+	-
9	*Chagunius changunia*	8	1.55	+	+	+
10	*Schizothorax richardsonii*	5	0.97	+	-	+
11	*Xenentodon cancilla*	16	3.11	+	+	+
12	*Mastacembalus armatus*	12	2.33	+	+	+
13	*Danio devario*	10	1.94	+	+	+
14	*Danio dangila*	13	2.53	+	+	+
15	*Puntius sarana*	58	11.30	+	+	+
16	*Puntius conchonius*	55	10.72	+	+	+
17	*Puntius sophore*	60	11.69	+	+	+
18	*Esomus dandricus*	13	2.53	+	+	-
19	*Brachaydanio rerio*	12	2.33	+	+	-
20	*Acanthocobatis botia*	14	2.72	-	+	+
21	*Garra annandalei*	39	7.60	-	+	+
	Total	513	100			

4.5.1 Frequency occurrence of fishes in Phewa Lake during different seasons and year.

During September 2009, a total of 144 fishes were collected. The maximum number was 22 of *Puntius sophore* and the minimum number was 2 of *Schizothorax richardsonii*, *Neolissocheilus hexagonalepsis*, *Tor putitora* and *Chagunius changunia* with the highest frequency occurrence for *Puntius sophore* **(**15.27%) and lowest of 1.38 for all of them (Table 9)**.** During study, *Barilius* spp and *Channa gachua* were also recorded dominant after *Puntius sophore.*

Table 9. Fish catch composition in Phewa Lake in September, 2009.

S.N.	Genus	Total catch	Frequency (%)	Sampling sites		
				I	II	III
1	*Channa gachua*	11	7.63	5	2	4
2	*Clarias batrachus*	6	4.16	2	-	4
3	*Heteropneustes fossilis*	5	3.47	4	1	-
4	*Barilius barna*	12	8.33	3	6	3
5	*Barilius vagra*	10	6.94	4	-	6
6	*Barilius bendelensis*	20	13.88	2	10	8
7	*Neolissocheilus hexagonalepsis*	2	1.38	-	1	1
8	*Tor putitora*	2	1.38	1	1	-
9	*Chagunius changunia*	2	1.38	-	1	1
10	*Schizothorax richardsonii*	2	1.38	1	-	1
11	*Xenentodon cancilla*	4	2.77	1	2	1
12	*Mastacembalus armatus*	3	2.08	1	1	1
13	*Danio devario*	3	2.08	1	1	1
14	*Danio dangila*	4	2.77	1	2	1
15	*Puntius sarana*	13	9.02	4	3	6
16	*Puntius conchonius*	6	4.16	2	1	3
17	*Puntius sophore*	22	15.27	5	8	9
18	*Esomus dandricus*	4	2.77	2	2	-
19	*Brachaydanio rerio*	4	2.77	1	3	-
20	*Acanthocobatis botia*	3	2.08	-	2	1
21	*Garra annandalei*	6	4.16	-	2	4
	Total	144	100	40	49	55

During January 2010, a total of 140 fishes were collected. The maximum number was 19 of *Puntius conchonius* and the minimum number was 2 of *Schizothorax richardsonii, Neolissocheilus hexagonalepsis* and *Tor putitora* with the highest frequency occurrence for *Puntius conchonius* **(**13.57%) and lowest of 1.42 for all of them (Table 10)**.** During study, *Barilius* spp, *Puntius sarana* and *Channa gachua* were also recorded dominant after *Puntius conchonius.*

Table 10. Fish catch composition in Phewa Lake in January, 2010.

S.N.	Genus	Total catch	Frequency (%)	Sampling sites		
				I	II	III
1	*Channa gachua*	13	9.28	6	2	5
2	*Clarias batrachus*	5	3.57	-	3	2
3	*Heteropneustes fossilis*	5	3.57	2	3	-
4	*Barilius barna*	11	7.85	4	3	4
5	*Barilius vagra*	11	7.85	3	-	8
6	*Barilius bendelensis*	13	9.28	3	9	1
7	*Neolissocheilus hexagonalepsis*	2	1.42	-	1	1
8	*Tor putitora*	2	1.42	1	1	-
9	*Chagunius changunia*	3	2.14	2	1	-
10	*Schizothorax richardsonii*	2	1.42	1	-	1
11	*Xenentodon cancilla*	4	2.85	1	2	1
12	*Mastacembalus armatus*	4	2.85	1	2	1
13	*Danio devario*	3	2.14	1	1	1
14	*Danio dangila*	4	2.85	2	1	1
15	*Puntius sarana*	12	8.57	3	6	3
16	*Puntius conchonius*	19	13.57	6	8	5
17	*Puntius sophore*	7	5.0	2	3	2
18	*Esomus dandricus*	4	2.85	3	1	-
19	*Brachaydanio rerio*	3	2.14	2	1	-
20	*Acanthocobatis botia*	4	2.85	-	3	1
21	*Garra annandalei*	9	6.42	-	3	6
	Total	140	100	43	54	43

During July 2010, a total of 229 fishes were collected and the catch was highest record in present study. The maximum number was 33 of *Puntius sarana* and the minimum number was 1 of *Schizothorax richardsonii* with the highest frequency occurrence for *Puntius sarana* **(**14.41%) and lowest of 0.43 for *Schizothorax richardsonii* (Table 11)**.** During study, *Puntius sophore, Puntius conchonius* and *Garra annandalei* were also recorded dominant after *P. sarana.*

Table 11. Fish catch composition in Phewa Lake in July, 2010.

S.N.	Genus	Total catch	Frequency (%)	Sampling sites		
				I	II	III
1	*Channa gachua*	13	5.67	8	4	1
2	*Clarias batrachus*	3	1.31	1	2	-
3	*Heteropneustes fossilis*	8	3.49	3	5	-
4	*Barilius barna*	15	6.55	5	7	3
5	*Barilius vagra*	15	6.55	6	-	9
6	*Barilius bendelensis*	7	3.05	1	2	4
7	*Neolissocheilus hexagonalepsis*	4	1.74	-	2	2
8	*Tor putitora*	3	1.31	2	1	-
9	*Chagunius changunia*	3	1.31	2	1	-
10	*Schizothorax richardsonii*	1	0.43	1	-	-
11	*Xenentodon cancilla*	8	3.49	1	3	4
12	*Mastacembalus armatus*	5	2.18	2	1	2
13	*Danio devario*	4	1.74	1	2	1
14	*Danio dangila*	5	2.18	2	1	2
15	*Puntius sarana*	33	14.41	15	8	10
16	*Puntius conchonius*	30	13.10	10	11	9
17	*Puntius sophore*	31	13.53	12	10	9
18	*Esomus dandricus*	5	2.18	3	2	-
19	*Brachaydanio rerio*	5	2.18	2	3	-
20	*Acanthocobatis botia*	7	3.05	-	5	2
21	*Garra annandalei*	24	10.48	-	12	12
	Total	229	100	77	82	70

4.5.2 Distributional pattern of fish species in Phewa Lake

Distribution pattern of most of the fishes were uniform except *Channa gachua, Barilius bendelensis*, *Puntius sophore*, *Puntius sarana, Puntius conchonius* and *Garra annandalei*. These fishes had showed clumped type of distribution (Table 12).

Table 12. Distributional pattern of fish species in Phewa Lake.

S. N.	Name of species	Mean ($\bar{X}$)	Standard deviation (σ)	Variance (V)	Variance mean ratio ($\frac{V}{M}$)	Distribution pattern
1	*Channa gachua*	4.11	2.07	4.31	1.04	Clumped
2	*Clarias batrachus*	2.33	0.94	0.88	0.37	Uniformed
3	*Heteropneustes fossilis*	3.0	1.22	1.5	0.5	Uniformed
4	*Barilius barna*	4.22	1.39	1.94	0.46	Uniformed
5	*Barilius vagra*	6.0	2.08	4.33	0.72	Uniformed
6	*Barilius bendelensis*	4.44	3.36	11.35	2.55	Clumped
7	*Neolissocheilus hexagonalepsis*	1.33	0.45	0.21	0.15	Uniformed
8	*Tor putitora*	1.16	0.13	0.017	0.01	Uniformed
9	*Chagunius changunia*	1.33	0.45	0.21	0.16	Uniformed
10	*Schizothorax richardsonii*	1.0	-	-	-	-
11	*Xenentodon cancilla*	1.77	1.02	1.05	0.59	Uniformed
12	*Mastacembalus armatus*	1.33	0.44	0.2	0.15	Uniformed
13	*Danio devario*	1.11	0.3	0.09	0.08	Uniformed
14	*Danio dangila*	1.44	0.48	0.24	0.16	Uniformed
15	*Puntius sarana*	6.44	3.80	14.46	2.24	Clumped
16	*Puntius conchonius*	6.11	3.41	11.65	1.90	Clumped
17	*Puntius sophore*	6.66	3.52	12.43	1.86	Clumped
18	*Esomus dandricus*	2.16	0.67	0.46	0.21	Uniformed
19	*Brachaydanio rerio*	2.0	0.81	0.66	0.33	Uniformed
20	*Acanthocobatis botia*	2.33	1.37	1.88	0.80	Uniformed
21	*Garra annandalei*	6.5	4.07	16.58	2.55	Clumped

4.6 Ecology and behavior of some important fishes

During the study period, the totals of 26 fish species were reported from Phewa Lake. Among them, 21 species were indigenous species and rest five species are exotic. Some of the economically important fish species are described concerning their morphology, ecological behavior and fin formula.

***Neolissocheilus hexagonolepsis* (Mc Clelland)**

Neolissocheilus hexagonolepsis is commonly known as 'Katle' in Nepali. It is well known colorful game fish of Nepal. It is olive green dorsally and with splashes of golden on sides**.** There is a yellow band just above the lateral line. Fins are slate grey, faint towards the margin. The fish breeds in April through July to September. It is an omnivorous fish. This fish feeds on aquatic plants and known to control them. Males attain fish maturity at 9-12 cm and female at 23 cm. It is distributed all over torrential rivers of Nepal from 300-1,500 m. Spawning ecology and behavior has been worked out by in detail by Shrestha (1989).

Diagnostic character: D 12 (3/9); P 17; V 9; A 7 (2/5); C 19; L.l 28-31; L.tr. $4\frac{1}{2}4\frac{1}{2}$; TL = 60cm.

***Puntius sophore* (Hamilton- Buchanan)**

Puntius sophore is commonly known as 'Bhitte' or 'Pothi' in Nepali. It is deep bodied fish having distinct orange golden spot below the eye and a distinct black blotch on caudal peduncle and dorsal fin base. Coloration varies with seasons; back is mostly olive green, side silvery with reddish flush and silvery on the belly. The opercles are golden red and tip of the fins reddish. There is a faint black bent on the lateral line. Barbels absent. Lateral line system is complete. The fish breeds from May to July. It lives in lakes and over grown low land rivers in which the water flows vary slowly.

Diagnostic character: D 11 (3/8); P 15-16; V 9; A 8 (3/5); C 19; L.l 22-26; L.tr. $5-5\frac{1}{2}/5-5\frac{1}{2}$ TL = 8cm.

***Barilius bendelensis* (Hamilton- Buchanan)**

This fish is commonly known as 'Chiple-fageta' in Nepali. It is a medium sized hill stream fish having fine pores on the snout. The body is crossed with 8-12 lateral bands and dashed with bluish green silvery tinge. The fish has black spots at the base of each scale. Generally the paired fins are whitish, tinged with orange. Barbels are two pairs. The fish breeds in April to August. Spawning of fish takes place in small stream with gravel bed where water is clear and oxygenated. It is fairly common fish of rivers lakes and ponds where the flow is moderate. This fish is found in the altitudinal range 100-2,000m.

Diagnostic character:

D 9 (2/7); P 15; V 9; A 11 (3/8); C 19; L.l 40-43; L.tr. $7-8/5$;TL = 15cm.

***Clarias batrachus* (Linnaeus)**

This fish is commonly known as 'Magur' or 'Mungri' in Nepali. A grace black catfish with splashes of yellow brown color with vertical head and laterally compressed tail. The dorsal and anal fins are long. The caudal fin is separated from dorsal and anal fins. Body color is brownish black. It has four pairs of barbels. This fish breeds in monsoon (May to August) in marshes and paddy fields. It constructs nest hole of about 20 cm in diameter usually 2-5cm below the surface of the water. Female produces a about 3,000 greenish sticky eggs.

Diagnostic character: D 65-70; P /8-11; V 6; A 47; C 17; TL = 47cm.

***Xenentodon cancilla* (Hamilton- Buchanan)**

This fish is commonly known as 'Dhunge Bam' in Nepali. It is an elongated fish with beak like jaws. Body is greenish above and whitish below. A series of four or five blotches are found on sides of body between pectoral and anal fins in adults. Dorsal and anal fins have dark edge. The lower jaw is slightly longer than upper. Dorsal and anal fins are closed to tail. Its altitudinal range is 80-800m.

Diagnostic character: D 16-17; P 11; V 6; A 17; C 15; TL = 30-40cm.

***Mastacembalus armatus* (Hamilton- Buchanan)**

This fish is commonly known as 'Chuche Bam' in Nepali. This fish has elongated body having anal and dorsal fins confluent with caudal. It has pointed snout. Generally body color is brownish becoming lighter on belly. There is a row or distinct rounded black spots along base of dorsal fins. The body of fish is covered with small scale. This fish breeds in June and July.

Diagnostic character: D 32-39/74-90; P 23; A 3/75-88; C 14-17; TL = 61cm.

4.7 Cage Fish Culture

Cages were made up of nylon net of wire gauze to culture the fish by keeping them under the water. It was started for the first time in Japan. But now it had become very popular throughout the world. For the first time fish culture in cages in Nepal started in 1972 at lake Phewa, Pokhara valley (Swar. et.al. 1983) as a facility for holding the brood of common carp (*Cyprinus carpio*). Cage culture in Phewa Lake exclusively depended on plankton. In 1975, Integrated Fish Culture Development Project was initiated by Nepal Government. First it was started on an experimental basis in Lakes Phewa and Begnas. The experiment provided demonstrative benefit to the public at large in the Pokhara valley. For making cages different types of materials locally available were used, but cages made from local materials were found less durable. Therefore nylon net cages from different countries were imported. In the cages of Lake Phewa, common carp (*Cyprinus carpio*), silver carp (*Hypothalmicthys molitrix*) and big head carp (*Aristicthys nobilis*) were raised in floating cages. Cages of

approximately 5m×5m×2m were very popular for fish production in Nepal (Swar and Pradhan 1992 and Gurung 2001). Silver carp and bighead carp were reared at the rate of 10 fish per m^3. The farmer stocked 25g fingerlings in 25mm mesh sized cages and harvested at the size of 500- 1,000g after 12-15 months (Rai 2000).

Monetary income from 4-5 cages was adequate to cover all expenses of a typical fisher family comprising five members (Swar and Pradhar 1992). There are about 19 families involved in cage fish culture in Phewa Lake and the total number of cages were about 621. Now some fishers owned as many as 16 cages producing about 3,000-4,000kg/yr of marketable fish. The annual income of these fishers reached to about NRs. 200-300 thousands or $2,850- 4,280 (Gurung and Bista 2003). With the rise of income, fisher groups were able to send their children to private Boarding Schools. Some of the fishermen had motorbikes, television in most families, own land, houses and private toilets.

4.8 Socio-economic Characteristics of Respondents:

In this study, a large percentage of respondents, that is, 54% was involved in both cage culture and capture fishery, 13% of the respondents in capture fishery only and remaining 33% of them in cage culture only (Table 13). The fish species cultured in the cage were silver carp, big head carp and grass carp.

Table 13. Respondents classified according to the type of fishing.

S.N.	Fishing Practice	Number	Percentage
1	Capture fishery	4	13
2	Cage culture	10	33
3	Both	16	54
	Total	30	100

The socio-economic conditions of Jalari community of Phewa Lake were studied from their case studies, direct observations and through a set of questionnaire. The information obtained was analyzed and conclusions were drawn. The socio-economic condition of the Jalari community was studied on the basis of age, marital status, education, economic status and fishing methods. The fisher groups of Phewa Lake was classified into three categories - Full time, Part time and Occasional fishermen. In this study, a large percentage i.e. 53% of the respondents were found to be part time fishermen and 30% of the respondents were full time fishermen and remaining 17% were occasional fishermen. Occasional fisher groups were pastime groups for entertainment carrying fishing activities only in the morning (Table 14).

Table 14. Involvement of Respondents in Fishing Activities.

S.N.	Fishermen	Number	Percentage
1	Full time	9	30
2	Part time	16	53
3	Occasional	5	17
	Total	30	100

4.8.1 Age

To analyze the data, age groups of the individuals were categorized in to three groups: 15-25, 26-35 and > 36 years of age. In this study, the highest age of respondents was from age group above 36 i.e. 47% and the lowest percentage of the respondents i.e 13% was of the age group 15-25 years (Table 15).

Table 15. Respondents classified according to their age.

S.N.	Age (years)	Number	Percentage
1	15-25	4	13
2	26-35	12	40
3	Above 36	14	47
	Total	30	100

4.8.2 Marital status

Marital status was one of the determining factors to study socio-economic condition of the fisher group. In this study, 50% of the respondents got married before the age of 15 years, 43% between the age of 16-25 and 7% of the respondents got married after the age of 26-30 years (Table 16). Illiteracy and poor health was seen in the respondents of early marriage.

Table 16. Marriage age of respondents.

S.N.	Marriage Age (years)	Number	Percentage
1	Below 15	15	50
2	16-20	7	23
3	21-25	6	20
4	26-30	2	7
	Total	30	100

4.8.3 Education

Education plays an important role for the improvement of quality of life. In this study 37% of the respondents were illiterate and among the literate also, 43% were under SLC. Only 20% of the respondents passed SLC (Table 17).

Table 17. Education status of the respondents.

S.N.	Education	Number	Percentage
1	SLC	6	20
2	Literate	13	43
3	Illiterate	11	37
	Total	30	100

4.8.4 Economic Status

In this study the economic status of the respondents has been studied. More than 80% of the respondents earn money by selling the fish. Fisheries Research Centre has been playing an effective role to uplift the economic status of the Jalari community. In this study, 20% of the respondents belong to higher income group where as 30% of then fall under the lowest income bracket Most of the family members do not have a habit of saving money. Both male and female members spend money (Table 18).

Table 18. Income of Respondent's family per year.

S.N.	Family income/yr (Rs)	Number	Percentage
1	30,000-40,000	9	30
2	41,000-60,000	15	50
3	More than 60,000	6	20
	Total	30	100

4.9 Case Studies

Case I (Ramchandra Jalari, 48 yrs. and from Simalchaur)

He has joint family with seven members - wife, two sons, two-daughter in-law and one grandchild. He has two sons and one daughter and all of them are married. His family had migrated from Simalchaur to Khapaudi nearly 40 years ago. He was married at the age of 18 years. He is illiterate but the children are educated up to class 8. Ramchandra Jalari is a full time fisherman. He is engaged in both captured and cultured fishery. He has 16 cages out of which 4 cages are for nursery and remaining 12 cages are for adult fishes. He has three boats only for fishing purpose. The fish cultured in the cages are silver carp, bighead carp and grass carp. His gross family income per year is about Rs. 100,000 to 120,000 which is supposed to be a good income whencompared to the other fishers .

Case II (Seti Maya, 56 yrs.)

She has five family members at home. She got married when she was 14 years old. She has her husband, one son, daughter in-law and one grandson. She is an uneducated woman as she didn't have access to school as the school was very far from home. One of the reasons was also that the daughter was not allowed to go to school at her time. She has been the chairman of the 'Machhapuchhre Aama Samuha' since last two years. She is participating in different social activities also. Seti Maya has 8 cages in which silver carp, big head carp and grass carp are cultured. She is also engaged in captured fishery along with her husband. In the morning, she collects the fishes with the help of boat and sells these in the market. Her yearly income is about Rs. 80,000 to 90,000. As compared to the other fisher men of the community this income is good income.

4.10 Major factors for the depletion of indigenous fish species in Phewa Lake

The Phewa Lake supports about 21 species of biologically diverse icthyofauna with predominance of family cyprinidae. During present study, some problems were noted for the declination of fish population in Phewa Lake.

a. **Environmental factors:**A large number of environmental factors such as deforestation, landslide, soil erosion, flood, silt deposition and chemical pollution due to discharge of industrial wastes have changed the natural environment of Phewa Lake.

b. Other factors:

i. **Pollution:** The municipal sewage and industrial wastes are found directly discharged into the feeder stream and in the dam side area. Another potential hazard for the declination of icthyofauna in Phewa Lake is the mixing of chemicals like Aldrin, Thiodine, BHC and Malathion from surrounding slopes of agricultural lands near the Phewa Lake.

ii. **Land slide and flood:** The villagers have been cutting down the forests located in its southern and western part haphazardly which is responsible for heavy soil

erosion during monsoon season. This has affected lake ecology and fish biology directly by destroying breeding and nursery ground.

iii. **Use of Destructive Fishing Appliances:** In Phewa Lake and in the feeder streams, some of the fishermen are found to be operating destructive fishing methods like electro fishing, explosive, poisoning etc. Such activities affect whole aquatic ecosystem. These types of fishing methods kill all types, sizes of fishes and other aquatic organism along with the destruction of the breeding grounds of fishes.

iv. **Lack of motivation and support to the fishing community.** Because of the lack of motivation and support from government and concerned authorities the fishing community in spite of holding a rich body of ethnoichthyological knowledge has not been able to apply it for the conservation and management of fish and fishery resources. Had this knowledge been properly managed there would not have been a decline of important fish population.

v. **Effect of Dam:** The effect of dam is highly evident in the distribution of fish population in Phewa Lake. The dam has obstructed the migration of local fishes which descend from the lower parts of surrounding hills.

4.11 Fishing implements used in Phewa Lake

Fishing is the primary occupation of Jalari community residing in the Phewa lake watershed. Most of the Jalari people are involved in cage culture for their livelihood besides age old capture fishery. During the present study, varied fishing appliances/methods are recorded being in use in fishing by local fisher community. Fishing practices used in the lake are mainly grouped into two categories:

A. Conventional fishing methods.
B. Non- Conventional fishing methods.

A. Conventional fishing methods: It includes almost all traditional fishing gears like netting, hook and line, fishing with bowl and fishing with hand.

1.0 Nets: A net is basically a piece of webbing, in which the twins are intersected into regular meshes, given a certain form. Usually the nylon thread is used for the preparation of net.

1.1 Gill Net: A net is a webbing of nylon thread in which the twines are intersected into regular meshes. Gill net is commonly known as Tiyari Jaal. The upper & lower rims of the net are supported by stout rope that may be tied to boat or anchor. These nets are set across the lake in the evening and the fishes are collected in the

next morning. The fish gets entangled in the fabric mesh of nylon net.

1.2 Cast Net: It is round in shape and locally known as 'Jal" having mesh size of about 15-25mm. Along the circumference places of iron or lead are attached so as to make the net sinkable in water. Some pouch or pocket like structures are made at the circumference of cast net where fishes are trapped. A long rope is tied to the centre of the net. While throwing the net, the fishermen keep it in the land and throw it with a jerk into water.

1.3. Use of Mosquito nets: Mosquito nets are more used by the children. This is the easiest method for fishing.

2.0 Hook and line fishing: In the bamboo rod, nylon thread is tied and the other end of the thread to hook. At the hook, bait is kept to attract fishes. When the fish comes to eat it, the mouth gets entangled in the hook. In this way fishing is done. In Phewa Lake Most of the visitors (foreign as well as Nepali) used modern or imported hook for entertainment.

3.0 Fishing with Bowl: At the side of the lake, fishing with bowl is also popular. It is also known as Depchi thapni. In this method, bowl is covered by cloth from upside and small hole is made in the middle so that the fish can enter the bowl but cannot come out. Only small fishes are caught by this method. Bait inside the bowl is the mixture of wheat, millet, maize etc.

B. Non-conventional fishing methods: Recently developed illegal fishing practices are called non conventional fishing methods like use of explosive, use of chemical poisons and electro-fishing etc. Most of these fishing practices are destructive.

1.0 Use of explosive: It involves fishing by bombing or blasting or dynamiting locally known as golo-hanne. The dynamite is wrapped with thick clothes and thrown into the feeder streams of Phewa Lake. As it explodes, the fishes are killed and floating fishes were collected by hands or scoop net.

2.0 Use of Poisons: Use of fish poisons is a non-conventional fishing practice used in the feeder streams of Phewa Lake. Fish poison is extracted from plant derivatives such as khirro (*Sapium insigress*), sihudi (*Eupherbia royleana*), ketuke (*Agave americana*) etc. The fishes paralyzed by poisons, are collected by hand or with the help of scoop net.

3.0 Electro-fishing: It is done in the feeder stream to kill the targeted and non targeted species including other aquatic organisms also. The fishes injured with electricity, start floating in water and are collected by net.

4.0 Chemical poisons: Beside plant poison, the chemical poison is also found being used in the study area. The chemical was mixed with water and the mixture is sprayed in all sides of pool water areas. The commonly used chemical poisons are DDT (Dichlorodiphenyl trichloroethane), BHC (Benzene hexachloride), Thiodine etc

PLATE-5

Cage fish culture in Phewa Lake

Cage immersed in lake

Fisherman using nets for fishing

Children fishing in the pond near Lake

Fisherman using boat for fishing

Cage used for fish culture in Phewa Lake

PLATE-6

Fish market in open road

Women washing utensils in Lake

Ducks in Lake

CHAPTER FIVE

5.0 DISCUSSIONS

Nepal, a Himalayan kingdom, is rich in biodiversity due to its spectacular topography, geography and water resources. Inspite of its small area, Nepal is endowed with a wide range of renewable water resources providing shelter, nourishment and sustenance for valuable fish stocks. Nepal's main water resources are the numerous rivers and streams running down the mountains. These running water systems are not similar in nature. The running water of any such system has considerable differences in water current, depth, volume and substrates. All these parameters gave to a river system a wide diverse range of habits and ecological niche, invertebrates and other aquatic life. Factors of ecological significance, which exhibit a progressive change of value along the length of rivers are current, velocity, substratum, temperature, transparency, dissolved oxygen and other organisms which are inter-dependent (Whitton, 1975)

The diversity of all aquatic organisms including fish is determined by several factors including physicochemical parameters. The physical factors of the environment appear to be basically more important than the chemical ones in the distribution of fishes (Hynes, 1970). It is well known that all the aquatic organisms including fish have well defined limits of temperature of tolerance. All metabolism and physiological activities and life process such as feeding, reproduction growth rate movement and distribution of aquatic organisms are greatly influenced by water temperature.

In the present study the maximum water temperature recorded was 27^0 C in station I and II at the month of July and the lowest temperature recorded was 15.5^0 C in the month of January in III station. Transparency is another most important physical factor which directly or indirectly determines the productivity through creation of turbidity, blocking the penetration of light hence reduce photosynthetic activities Ansuri (1986) reported low transparency resulting in food scarcity due to checking of light penetration. According to Jhingran (1975) the turbidity of natural water system may be due to the suspended inorganic substances such as silt, clay or due to planktonic organisms. During the present study period the lake water remains highly transparent except in the month of July. The transparency of Phewa Lake ranges from 30cm to 76 cm.

The pH of natural water is an important environment factor, the variation of which is linked with the species composition and life process of animal and plant community inhabiting there (Jhingram, 1991). Under most natural conditions variation of pH value has little effect on fishes, which can tolerate the normal daily pH range (Whitton, 1975). According to Jhingram (1991) fish dies at about pH 11. Acidic water is unsuitable for fish and other aquatic invertebrates as it only reduces the apatite of fish but also their growth and tolerance to toxic substances. During present study of the water quality of Phewa Lake slightly acidic ranging pH of 6:9.

The dissolved oxygen (DO) is of paramount importance to all living organisms. In the present investigation, DO ranged from 6.0 to 9.5 mg/lt. The maximum DO was recorded in the month of July from III station which is 9.5 mg/lt. While minimum value of 6.0 mg/lt. was recorded in the month of January from II station. Physicochemical parameter study shows that water quality of Phewa Lake so far, is still good for the growth and rich fish diversity.

Phewa Lake, the present study area lying in the south western part of Pokhara valley is rich in fish diversity. All the inhabitants of Pokhara valley are either directly or indirectly dependent upon this Lake Phewa for the overall development and for their livelihood., Lake area is the main hub of tourism activities. A number of hotels and restaurants are found in the area. Recreational activities in the lake itself are also note worthy. In this way people of Pokhara valley as a whole either directly or indirectly get benefitted economically from the Phewa lake. The lake on the other hand is dependent upon its feeder streams like Harpan Khola and Khahare Khola. The regular flow of water in the lakes comes from the Harpan Khola which isthe perennial source of water. The migratory species of fishes like sahar and katle of the lake travel upstream from the lake towards the river in breeding season and return to the lake after the end of breeding season.

In the present investigation, the total of 21 species from 16 genera, 6 families and 5 orders were recorded. Among them the family Cyprinidae was found to be the most dominant of the lake which includes 11 genus and 16 species. Among the three sampling sites, the largest number of fish species was found in station II with 19 species. Though rich in fish diversity the published literature in this aspect of Pokhara lakes is scanty in comparison to those on limnology. Ferrow and Bagdgari (1980) studied the commercially important fish species of Pokhara valley. Pokharel (1998) has studied the fish diversity and feeding habits of fishes of major lakes of Pokhara valley and reported 16 species of fishes from Phewa Lake.

Out of total 513 number of fishes collected from three different sampling sites, the largest number of fish catch recorded belonged to the family Cyprinidae with 430 in number. Among three stations largest number of catch was recorded in station III with 229. The highest estimated catch was recorded in July and lowest in January.

Out of total 513 number of fishes collected from three different sampling sites, the maximum number of fish collected is 60 for *Puntius sophore.* Similarly the minimum number of fish collected is *Schizothorax richardsonii* with only 5 in number. The frequency occurrence is highest for *Puntius sophore* i.e 11.69% and lowest for *Schizothorax richardsonii* i.e 0.97% only. The fishes like *Channa gachua, Clarias batrachus, Barilius barna, Barilius bendelensis, Changunius changunia, Xenentodon cancilla, Mastacembalus armatus, Danio devario, Danio dangila, Puntius sarana, Puntius conchonius* and *Puntius sophore* have been recorded from all the three stations during the study period.

In the present investigation it has been found that there are about 90 households of the Jalari community residing near the Phewa Lake. The fishermen in Phewa Lake are also called ‘Pode’ by the local people. It is found in the present study that only 30% of the fisher group take the fishing as their main profession. About 53% of the fisher group is the part time fisher and 17% the occasional fisher. Occasional fishermen do

fishing for recreational purpose. Those involved in full time fishing activities are the Jalaris residing in the Phewa watershed area. Fish and Fishery Resources, Pokhara has been supporting the fisher community by providing financial support to buy cages for the cage culture. Most of the Jalaris are now engaged in cage fish culture. This in turn has uplifted their socioeconomic condition over the years.

During the study period, the socio-economic condition of the fisher community has been studied. Out of 90 households, 30 respondents from different households were chosen to gather the information. The age of the respondents are also noted down to study the involvement of different age group people in fishing. The age groups were classified into 15-25, 26-35 and above 36. It has been found that 40% Jalaris of the age group of 26-35 are involved in fishing activities. The fishermen, in the study site, are not aware about the family planning program. They live in a small house made up of stone, block, mud and cement with galvanized sheet on the roof. In the community the literacy rate is found to be very poor. About 37% of the respondents are illiterate. Among the literate ones 43% are under SLC. Some of the fishermen do send their children to the private boarding school. The market for fish is not a problem as fishermen can directly supply fishes to the hotels, individual customers and to the contractors. They sell the fish at the rate of Rs 120-250 per kg.

Population of fish and richness of fish diversity are reported decreasing gradually. Habitat degradation and use of non conventional fishing appliances are found to be the main reasons for the gradual decrease of population of fish species. The natural fish habitat is being destroyed in the Phewa Lake due to large number of environmental factors such as deforestation, landslides, soil erosion, floods, silt depositions and human activities such as discharge of municipal sewage directly into the lake, washing clothes by using soap and detergent in the lake and the excessive use of chemical fertilizers in the agricultural field by farmers. Fishing appliances and practices used in Phewa Lake are also studied. Fisherman use both conventional and non-conventional fishing methods. Conventional fishing method such as use of nets, rod and line fishing, fishing with bowl etc. are popular. But many fishermen are found to be involved in indiscriminate fishing by the use of improper mesh sized nets which are found to kill both young and adult fishes. Poisoning, electro-fishing and dynamiting are also used. This practice has led to the killing of not only targeted fish species but also non targeted fishes and other aquatic organisms. Poisoning in the feeder streams also kills non targeted species with adverse effects upon the health of people/consumers.

Conclusion and Recommendations:

Conclusion:

Following conclusions can be drawn from the present study:

- Phewa Lake is rich in fish diversity. Altogether 21 species under five orders, 6 families and 16 genera are recorded.
- The distribution pattern of *Channa gachua, Barilius bendelisis, Puntius sarana* and *Garra annandalei* are clumped where as rest of the species are uniform in distribution.
- Economically important fishes found in the lake are *Neolissocheilus hexagonolepsis* (katle), *Puntius sophore* (bhitte), *Barilius bendelisis* (chiple faketa), *Clarias batrachus* (magur), *Xenentodon cancilla* (dhunge bam) and *Mastacembelus armatus* (chuche bam).
- The socio-economic condition of fishermen living in the vicinity of Phewa Lake is found to be poor. More than 53% rarely fulfill their livelihood needs only from fishery activities; so, they adopt other professions like shopkeeping, labor, agriculture etc.
- The literacy rate of the fisher community is low and most of the literates are under SLC level.

Recommendations:

In order to conserve the water quality of Phewa Lake, fish resources and to uplift the socio-economic condition of local fisher community following suggestions are recommended:

- Phewa lake should be set aside as protected area with the implementation of all conservation and management techniques. For this effective conservation policy needs to be formulated.
- During policy formulation, indigenous knowledge of the fishing community regarding the management and conservation of fish resources should be taken into consideration. Research should be conducted regularly for assessing population density and habitat of biologically important fishes in the lake and restocking with the fingerlings of indigenous species should be promoted.

- Release and stocking of the exotic fish species in the lake should be immediately stopped.
- The discharge of municipal sewage in the lake should be strictly prohibited.
- Some of the beautiful fish species such as *Barilius* sp., *Puntius* sp., *Danio rerio, Danio devario, Esomus dandricus, Brachaydanio rerio* could be indigenous aquarium fishes.
- The socio-economic condition of the fisher group should be uplifted by launching development programs from government and other related NGO, INGO.
- Regular training and awareness programs should be conducted in local level for the conservation of lake through environmental education at the school level, public meetings and at the community level from government and non government organizations.
- Many non-conventional fishing methods like poisoning, dynamite, electrofishing should be stopped immediately.
- The Aquatic Animal Protection Act (AAPA) to protect the biodiversity of aquatic ecosystem should be implemented effectively through the concerned governmental agencies.

References

APHA, 1995 : Standard methods for the examination of water and wastewater, 19th Ed. Clesceri, L.S., Arnold E. Greenberg, Andrew D. Eaton (eds.). New York.

APHA, 1998 : Standard methods for the examination of water and wastewater, including bottom sediments and sewage, 20th Ed. Clesceri, L.S., Arnold E. Greenberg, Andrew D. Eaton (eds.). New York.

Beaven, R. 1877: Handbook of freshwater fishes. London : 125-135 pp

Bhatta D. D and Shrestha T. K. 1973 : The environment of Suklaphanta, C. D. C., T. U., Kathmandu, Nepal.

Boulenger, G.A. 1907: Reports on a collection of Batrachis, Reptiles and Fishes from Nepal and Western Himalayas Rec. Ind. Mus. 1. 261-267 pp.

Brehm, 1953: Some aquatic fauna from Kalipokhari, Eastern Nepal (Unpublished).

Das, S.M. 1967: Ecology and fish productivity in fresh water. Icthyol 13, 103-113 p.

Datta, J.S. and M.P.Shrisvastava. 1968: Natural History and systematic of Fresh Water Fishes of India. Narendra Publishing House, Delhi, India.

Day, F. 1889: The fauna of British India including Ceylon and Burna I & II, Taylor and fancies, Red lion court, Flect street.

Day, F. 1878: The fishes if India being a natural history of the fishes known to inhabit the seas and freshwaters of India, Burma and Ceylon. London, vols. I and II.

Dewitt, H.H. 1960: A contribution to the Ichthyology of Nepal. Standford Icth. Bull. 7(4) 63-88 pp.

Dibbs, J.L 1965: Development prospects of fisheries in Nepal. Food and Agricultural organization of United Nations, Rome, 1-17pp.

Directorate of Fisheries Development 2007/2008: Country profile-Nepal, Central Fisheries Building, Balaju, Kathmandu, Nepal.

Edds, D. R. 1985. New records of Fishes of Nepal. J. Nat. Hist. Mus.: Vol. 9 No. 1-4 T.U. Kathmandu, pp. 41-46.

Edds, D.R. 1989: Fishes of Kali Gandaki/Narayani rivers, Nepal, Journal Natural History Museum, T. U. , Kathmandu, vol. 8, 51-66 pp.

Ferrow, W. 1978: "Potential of fish production from manmade Lakes in Nepal" in; project working paper. Integrated Fishing and Fish culture Project NEP/73/025, Kathmandu Nepal.

Ferrow, W. 1980: "Data on the fisheries in Pokhara Valley (Nepal) and their implications for the fishery management" in; j.Inst. Sc; vol. 3(1). 221-236.

Ferrow, W. and P.R. Badgami. 1980: On the biology of commercially important speices of the fish of Pokhara Valley (Nepal). J. Inst. Sc. 3 (1): 237-250.

Ferrow, W. and D.B Swar 1978: Bathymetric maps from three lakes in the Pokhara valley, Neal. Jour. Ins. Of sc., T.U., Kathmandu, Nepal., 1: 177-188.

Forbes, S. A. 1887: The Lake as a microcosm Bull. Sc. A . Peoria. Reprinted in III nat. Hist. surv. Bull.

Forel, F.A. 1892: Le lemni Manographic limnologique F. progress lansace, 3 vols.

Gurung, M. 1998: Fish diversity and fishery resources of Begnas Lake, Kaski, A Dissertation paper submitted to Central Department of zoology, T.U. Kathmandu.

Gurung, T.B. and G.B. Pradhan. 1992: Wetlands conservation and productivity. In: T.B. Shrestha and Bishnu Bhandari (ed.6). Proceedings of first meeting in Wetlands management in Nepal; 29 May 1992, Kathmandu, Nepal.

Hamiltion, F.B. 1822: An Account of the Fishes found in the River Ganges and it's Branches, vol. VII,. Edinburn. 450 pp.

Hickel, 1973: Linmological investigation in lakes of Pokahra valley, Nepal. Int. Revue Ges. Hydrobialj., 58:.659-672.

Hirono, M 1955: Fresh Water algae, Fauna and flora of Nepal Himalaya. Scientific Result of the Japanese exedition to Nepal Himalaya, Kyoto.V.I.

Hora, S.L., (1937): Distribution of Himalayan fishes and its bearing on certain Paleographical problems, Rec. Ind. Mus 39(3), 251-259 pp.

Hynes, H.B.N.1970 The ecology of running water. University of Toronto press. Toronto.

Jones RJ, M.F. Knowlton and D.B. Swar. 1989: Limnological reconnaissance of water bodies in Central and Southern Nepal, Hydrobiologia.

Kato, K. and H. Hayashi. 1980: Limnological pre-survey of Lake Phewa, Nepal. J. Fac. Sci. Schishu Univ. 15(1): 27-29.

Regan, C.T. 1907. Report on collection of fish from Nepal and Western Himalayas, Rec. Ind. Mus.I.157-158 pp.

Loffler, 1969: High altitude Lakes in the Mt. Everest region. Verti.Internal. Verein.Limno. 17:373-385

Majupuria, T.C. and J. Shrestha (1968): Faunal studies of Nepal, UNESCO, Regional seminar on the econoly of tropical highlands, 4-7.

MC Clelland, J.1839. Indian cyprinidae. Asiat Reseraches 19, 217-468.

Menon, A.G.K 1949: Notes on fishes in the Indian Mus. XlIV. Fishes from the Koshi Himalayas, Nepal. Rec. Ind. Mus. 47, 231-237.

Misra, K.S. 1959: An aid to the identification of the common commercial fishes of India and Pakistan, Rec, Indian Mus, vol. 57, Part 1-4.

Nakanishi, M, M.M. Watanabe, A. Terashima, Y. sako. T. konda, K. Shrestha, HR Bhandary and Y. Ishida 1988: Studies on same Limnological vairables in limnol. 49(2):71-86.

Pokharel, K.K. 1998: Fish Bio-Diversity and feeding habits of fishes of lakes situated in Pokhara Valley. A report submitted to University Grants Commission (UGC), KTM.pp 56.

Pradhan, B.R. and B.C Shrestha, 1979: Economic importance of cage fish culture in Pokhara valley, Nepal.

Pradhan, B.R. 1998: Review of limnology of Lakes Begnas and Rupa. In; B.R. Pradhan, S. K. Wagle, O. Yamada and M. Takano (eds.). Proceeding of present status of fisheries research, development , and education in Nepal. NWFDP (JICA).

Rai, A.K. 2000: Limnological characteristics of Sub-tropical Lakes Phewa, Begnas and Rupa in Pokahra Valley, Nepal Limnology.1:1-13.

Shaw, G.E. and Shebberae, E.o.1937: The fishes of Northern Bengal, J. Royal Asiatic Society of Bengal, Science, vol. III.

Shrestha, P.1998: Aquatic weeds of the Pokhara valley lakes; Status review and management perspectives. In; Proceedings of present status of fisheries research, development and education in Nepal; B.R. Pradhan, S.K.Wagle, O.Yamada and M. Takano (eds.) NWFDP (JICA).

Shrestha, J 1994: Fishes, Fishing implements and, Methods of Nepal, published by smot. M.D Gupta, Lalitpur coloney, lashdar (Gwalior), India.

Shrestha, J. 1995: Enumeration of fishes of Nepal. Technical publication no.10.euroconsult Arnhem. The Netherland, HMG/Nepal. Dept. National parks and Wildlife conservation.

Shrestha, J. 1981: Fishes of Nepal. Curriculum Development centre (CDC), T.U. Kathmandu.

Shrestha, J. 1981: Cold water fish and fisheries of Nepal, FAO publication.

Shrestha, J. 1998: Aquatic habitats and natural water fish and fisheries in Nepal. Paper presented in Environmental Assessment Background Training, ADBTA-2613-NEP, NEAED, Feb.2-6, Kathmandu, Nepal, 28pp.

Shrestha, J 2001. Taxonomic Revision of Fishes of Nepal. Jour. Environment and Agricultural : Biodiversity, Agricultural and pollution in south Asia, 2001. Published by Ecological Society (ECOS), P.O. Box 6132, Kathmandu, Nepal. 171-180 pp.

Shrestha, S.B., Shrestha T.K. and Pradhan, B.R. 1979: Report on the study of Aquatic ecology and the potential of fisheries development in Bagmati River Project, A report prepared for GTZ.

Shrestha, T.K. 1979: Studies on the Resource Biology and Ecology of fresh water of Kathmandu Valley with particular reference to fish production management, Marketing and Conservation, Research Division, T.U. Kathmandu, Nepal.

Shrestha, T.K. 2001: Birds of Nepal, published by Mrs Bimala Shrestha, G.P.O Box 6133, Kathmandu, Nepal.

Shrestha, T.K. 1994. Wetland fauna in Nepal. In: Bhandari, B.,Shrestha, T.B. and Mc Caschern. J. (eds.) Safeguarding wetlands in Nepal. Proceedings of the National workshop on Wetlands management in Nepal. IUCN. Pp 41-52.

Shrestha, T.K. 2001: Herpetology of Nepal. Published by Mrs. Bimala Shrestha, G.P.O. Box 6133, Kathmandu, Nepal.

Shrestha, T.K. 1981. Wildlife of Nepal. Curriculum Development Center. T.U., Kathmandu, Nepal.

Shrestha T.K.2008, Ichthyology of Nepal

Shrivastava, G. 1968. Fishes of eastern Uttar Pradesh, Vishwavidhyalaya Prakashan Varanasi, ppl-163.

Swar, D.B. and C.H. Fernando 1980: Some studies on the ecology of Limnetic Crustacean zooplanktons in Lakes Begnas and Rupa, Pokhara valley, Nepal. In Hydrobiologia, 235-245h pp.

Swar, D.B. 1980: Present status of limnological studies and Research in Nepal, Proc. First workshop on promotion of limnology in developing countries, Kyoto. 43-47 pp.

Swar, D.B. and T.B. Gurung 1988: Human impact on acquatic ecosystems and native fishes of Nepal, Swar, D.B., G.B.N. Pradhan and L.M. Westlund Fisheries and Aquaculture in the Economic Development of Rural Nepal, Nepal Fisheries Society. 35-48.

Swar, D. Band J. Shrestha 1996: Human impact on acquatic ecosystems and native fishes of Nepal. In: Swar, D.B. G.B.N. Pradhan and L.M. Westlund Fisheries and Aquaculture in the Economic Development of Rural Nepal, Nepal Fisheries Society. 35-48.

Swar, D.B. and B.R. Pradhan 1993: Cage Fish culture in the Lakes of Pokhara valley, Nepal and its impact on local fisheries. In: Asian Fisheries Sci. 5, 1-13.

Taft, A.C. 1955: A survey of the Fisheries of Nepal both present and Potential Regional Seminar on Ecology of Tropical Highlands, UNESCO National Commission, Kathmandu.

Talling, J. and J. Lemollae. 1998: Ecological Dynamics of Tropical Inland waters, Cambridge Unviersity. The Pitt building, Trumpington street, Cambirdge CB 21 RD United Kingdom, 441 pp.

Terashima, A. 1984: Three new species of the cypriniod Genus schizothorax from Lake Rara, North-western Nepal. Japanese Journal of Ich., Vol. 31, No.2, 122-135 pp.

Thapa, R.B. and K.G. Rajbansi 1968: Few hill streams fishes of Nepal, Regional seminar on ecology of tropical highland UNESCO, national commission, Kathmandu, Nepal.

Wetzel, R.G. 1983: "Limnology", W.B. Saunders Company, Philadelphia.

Whitton, B.A. 1975: River ecology, Blackwell Scientific Publication, London. Edinburg. Melbourne.