STUDY ON THE FISH BIODIVERSITY AND FISHERY RESOURCES OF THE TINAU RIVER

By

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CERTIFICATE

This is to certify that Mr. Chhatra Mani Sharma has worked under my guidance and supervision for about one year. This thesis entitled "Study on the Fish Biodiversity and Fishery Resources of the Tinau River" submitted for partial fulfilment of the requirement for the degree in Zoology, embodies his own work.

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EVALUATION

We the member of the evaluation committee, went through this dissertation entitled **"Study on the Fish Biodiversity and Fishery Resources of the Tinau River"** presented by Mr. Chhatra Mani Sharma, and has been accepted for partial fulfilment of the requirements for master's degree in Zoology with Fish and Fisheries as special paper.

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ABSTRACT

Present Investigation reveals the existing fish fauna and their distribution pattern in the Tinau River which includes 35 species, belonging to 25 genera, 12 families and 5 orders. Physico-chemical and biological parameters have been studied in relation to the distribution, abundance and frequency occurrence of ichthyofauna in the Tinau River. This investigation also includes the socio-economic status of the fishermen, fishing implements and methods used in Tinau River. The impact of dam on fish distribution, management and conservation considerations for the development of fishery production in natural water bodies has been described. An attempt has been made to describe the ecological behaviour of some of the important fish fauna of Tinau River.

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1. INTRODUCTION

Nepal is a small country with amazing geographical regions, viz., low plain land, mid land and high land with snow cover. It is roughly rectangular and elongated in shape averaging about 885 km in length (east-west) and 193 km in width (north-south). The altitude ranges from 70 meter above sea level in the Terai region (south) to 8,848 meter at the peak of the world, Mount Everest (Sagarmatha) in the north. It is situated on the northern hemisphere in between 26°22' to 30°27' north latitude and 80°4' to 88°12' east longitude with the total area of 1,47,181 sq. km.

The kingdom of Nepal is located in between two big countries, China in the north and India in the south. In between Nepal and Tibetan territory of China, the Himalayan Mountain acts as the frontier. In the east, Nepal is separated from India by the Siwalik range in the north and Mechi River in the south. In the south there is no natural boundary and the artificial pillars at an average distance of 10 yards (locally known as 'Das Gaja Khamba') have been erected to demarcate the boundary between Nepal and India (Amatya and Shrestha, 1967).

1.1 TOPOGRAPHY

There are three distinct geographical regions in Nepal according to the altitudinal variation, viz., the Himalayan region, the Sub-Himalayan region and lower plain of Terai region.

The Himalayan region contributes about 15 percent (22,077 sq. km.) of the total area of Nepal. This region lies above the altitudinal range of 16000 ft (4800 m) from the sea level (Amatya and Shrestha, 1967). This region is always covered with snow and no fishes are recorded from this region.

The Sub-Himalayan region or mountainous region is located between the south of the Himalayas and the north of the Terai region with a chain of massive mountains running from west to east which constitutes about 68 percent of the total area of Nepal, lying in between 2000 ft (600 m) to 16000 ft (4800 m). This part consists of

many basins, valleys and Duns among which Kathmandu valley and Pokhara valley (*Schizothorax sps*) and Buduna (*Garra sps*) are found. But in the lower parts in between 9000 ft (2700 m) and 2000 ft (600 m) of this part fishes like Sahar (*Tor putitora*), (*Tor tor*), (*Barbus tor*), Catla (*Catla catla*), Rohu (*Labeo dero*), Sidre (*Puntius sps*), Fageta (*Barilius sps*) and Kabhre (*Glyptothorax sps*) etc. are found (Mandal, 1995).

The lower plain of Terai is a narrow belt of low land situated at an altitude above 70 meter from sea level to sub-Himalayan region which is the most important region from fishery point of view. The Terai region including inner Terai represents about 25 percent of the total area of Nepal. The important fishes found in this region are Rohu (*Labeo rohita*), Buhari (*Wallago attu*), Murrel (*Channa gachua*), (*Channa marulius*), Sidre (*Puntius sophore*), (*Puntius sarana*), Bam (*Xenentodon cancila*), and Mahaseer (*Tor tor*) etc.

1.2 CLIMATE

Nepal is a country with extreme climatic contrasts. The climate of Nepal is greatly influenced by altitudinal variation as well as by the location in a sub-tropical latitude. Within a small compass, almost all the climatic zones of the earth are represented in Nepal such as tropical jungle in the Gangetic plain, artic desert wastes in the higher region and the arid zones of the Tibetan plateau (Panday, 1987). The vertical variation causes much more contrasts in the Nepalese meteorological variables, mostly temperature, moisture, winds and precipitation.

Due to the altitudinal effect, the temperature distribution in Nepal is not uniform. As such, Lowlands like the Terai and inner Terai parts and midlands are warmer, and the Hilly and the Himalayan regions are cooler. The temperature rises from March to July while it decreases from October to January.

The land structure, latitude, altitude, distance from the sea, winds, clouds and rainfalls are the factors that create differences in the climate. On the whole, Nepal has a monsoon climate which is dominating all the agro-cultural activities of the country.

On the basis of temperature and condition of the precipitation, the climate of Nepal can be regionally divided into five belts (Panday, 1987).

Sub-tropical climate lies up to 1200 meter which includes the lowlands (Terai, inner Terai and deep valleys in the middle mountain of Nepal). The temperature remains high in this lowland area in comparison to other parts of Nepal. The average annual temperature ranges in between 15-40^{o}C in this region. The average annual precipitation is 2000 mm (1300 to 2600 mm) with a very little rain in the winter season.

Warm-temperate climatic region includes the upper parts of Chure and Mahabharat regions (1200- 2100 m) which are mild and moderately hot. The temperature ranges in between 24-30^{o}C in summer and winter falls less than 0^{o}C. Average annual precipitation is 1250 mm which decreases in the northern side considerably. This region (Midland Nepal) provides pleasant climatic condition to the human habitation and favourable climate for cultivation.

Cool-temperate region lies between 2100- 3300 meter in the higher parts of Mahabharat Lekh and lower parts of Himalayas. In the summer season the temperature is about 15- 20^{o}C and winter falls less than 0^{o}C cold. Rainfall in summer is about 1000 mm which decreases in the northern part.

The Alpine climate is seen between 3300- 5000 meter in the north, down the snowline region and the Himalayan valleys. In most of the Alpine regions the temperature rises up to 10- 15^{o}C in summer and fall 0^{o}C in winter. About three-fourth of the year remains snowy, thus, the winter is too cold and long. Annual precipitation in this area is about 400 mm.

Himalayan desert climate lies above 5000 meter where snow remains freezing above the snowline. This snow clad main Himalayan land has created rain shadow. Hence, the climate of this region is comparable to desert of the arid condition. Rainfall in this cold desert is nominal. In the summer season also, the temperature is very low and in the winter it falls more. Upper region gets snowfall and strong snowstorms round the year (Panday, 1987).

1.3 WATER RESOURCES

The inland water resources totalling 745,000 ha consist of river systems, lakes, reservoirs, village ponds, wet lands and irrigated rice fields (Table 1). Various types of inland water resources existing in the country provide a great scope for the expansion of fisheries. These resources can be categorized as i) open inland waters of rivers, lakes and reservoirs, ii) closed water bodies, ponds and wet lands, and iii) seasonal irrigated rice fields.

Table 1: Estimated Water Surface Area in Nepal.

S.No.	Resources	Estimated Area (ha)	Coverage Percentage	Potential Area (ha)
1.	Natural waters	401,500	53.8	
	a. Rivers	395,000	52.9	
	b. Lakes	5,000	0.7	
	c. Reservoirs	1,500	0.2	78,000
2.	Village ponds	6,700	0.9	14,000
3.	Wet lands	12,500	1.7	
4.	Irrigated rice fields	325,000	43.6	
Total		745,000	100.0	92,000

Source: Fisheries Development Division, HMG, 1993 (cited in Pradhan and Pantha, 1995).

1.3.1 Natural Water Resources

The natural water resources consist of rivers, lakes and reservoirs, comprising of approximately 54 percent of the total existing water area of Nepal.

1.3.1.1 Lakes

There are several lakes in Nepal which are scattered all over the country. The estimated area of the lake is 5000 ha (0.7 %) of the total existing water areas of Nepal. The lakes can be categorized to 3 types on the basis of their origin, viz., I) Glacial, ii) Ox-bow and iii) Tectonic. There are 17 major glacial lakes in the northern Himalayan region which are located above 4000-meter altitude. In most cases, the tectonic lakes have drained out, and have been replaced by flat basins which occur in the Hill region. The Kathmandu valley, Banepa area, Panchkhal, Mariphant (Palpa), Dang and

Surkhet valleys are the good examples of such basins. Ox-bow lakes are mainly confined to the southern part of the country (Terai and inner Terai). The presence of Ox-bow lakes indicates the shift of river course and there are more than two dozens of ox-bow lakes in Nepal (Sharma, 1977).

1.3.1.2 Reservoirs

There are few reservoirs in Nepal with a total area of 1500 (0.2 %). These reservoirs are mainly constructed for hydroelectric power and irrigation.

Among the existing reservoirs, the Indrasarobar reservoir, Kulekhani (1430 m) is a newly impounded reservoir for producing hydroelectric power by damming Kulekhani river in the mid hill region of Nepal. Other existing reservoirs are Jagadispur (Banganga, 125 ha), Trishuli (16 ha), Marsyangdi (62 ha), Panauti, Gandak, Sunkoshi, and Andhikhola, which are mainly constructed for irrigation and generating hydroelectric power. More than 33 small hydropower reservoirs are existing all over the country (Nepal Electric Authority, FY 1990/91, A year in review, August 1991, cited in Shrestha, 1992).

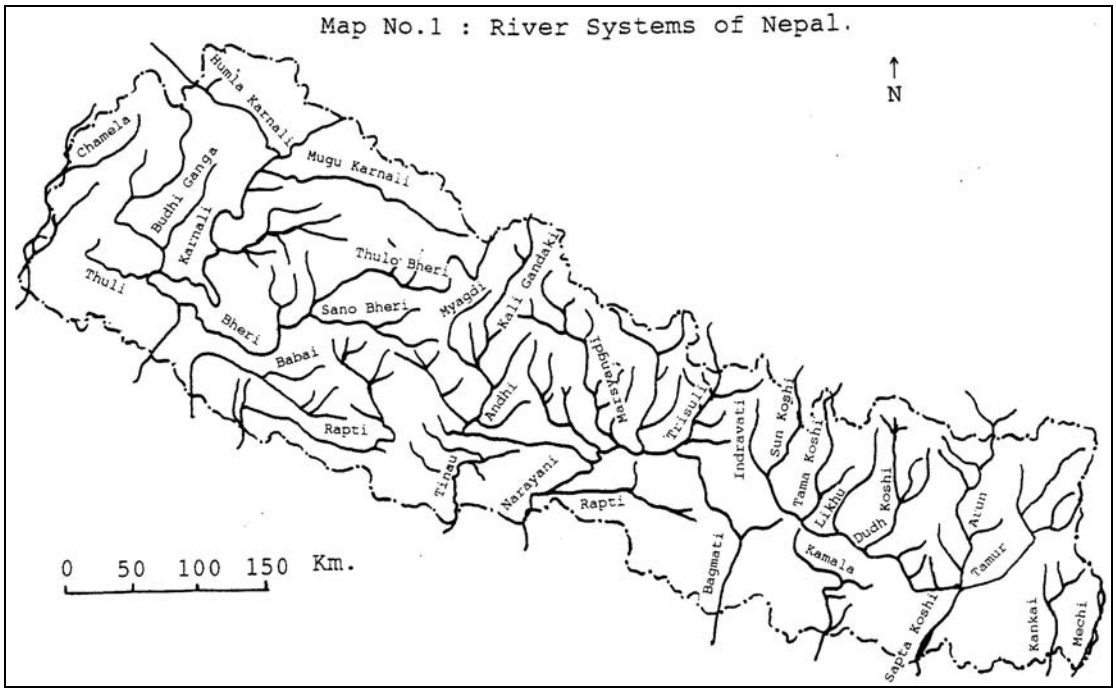
Furthermore, growth in hydroelectric and irrigation projects will add more water surface area in future. Development of the Gandaki basin (45,000 ha), the Bagmati river system (9,000 ha), and the Karnali river system (24,000 ha) will add 78,000 ha of reservoirs on their completion (FDD, 1993 cited in Shrestha, 1992).

About 4-5 percent of the irrigated areas in Terai are low lying, generally unsuitable for crops cultivation, and can suitably be developed into fishponds. Recently HMG/N has given priority to the construction of Kaligandaki 'A' hydropower project (reservoir of 60 ha), which will be completed by 1997 (Shrestha, 1992).

Collectively, these water bodies cover nearly 3 percent of Nepal's land area. It is estimated that some 500,000 hectares of waters surface may be available to fish production, of which approximately 100,000 hectares would be lakes, reservoirs and village ponds (NARC, 1991/92 cited in Pradhan and Pantha, 1995).

1.3.1.3 Rivers

Nepal has more than 6000 rivers and streams with total length of about 21000 km flowing from the north to the south. There are three major river systems in Nepal which drain out the country. Each river system has seven main tributaries, fed with numerous branches and are subsequently called i) the Sapta Koshi, in the east, ii) the Sapta Gandaki, in the centre and iii) the Sapta Karnali, in the west. Besides these, the Mahakali, the Kankai, the Kamala, the Mechi, the Rapti, the Babai and the Tinau are also equally important rivers (Map No. 1). All these river systems constitute about 53 percent of the total water area of Nepal (Table 1). All the tributaries of these river systems drain into the Ganges system in India. The combined run off through Nepalese rivers contributes 40 percent of the annual flow of the Ganges River and 71 percent of the dry season flow (Abbas, 1982 cited in Shrestha, 1992).



Hydrologically the rivers of Nepal can be divided into i) purely rain fed rives and ii) snow plus rain fed. The rivers of shorter lengths are seasonal and dry up from time to time. But in snow fed rivers, the melting of the snow in the Himalayas balances to check the further flow.

The rivers of Nepal loose their speed as they reach the southern plain or Terai region and deposit silt in the fertile flood plains. Some of the rivers in Nepal are used for irrigation. Up till now most of the Mahabharat rivers have been tapped such as the Kankai, the Kamala, the Bagmati and the Tinau (Shrestha, 1992).

In the Tinau River, which originates from the Mahabharat range, the water level during winter falls to considerable amount but doesn't dry up. It is, therefore, important from biodiversity standpoint. But the Tinau River is becoming polluted since few years due to landslides in hilly areas caused by deforestation (Gross soil loss 286950 ton/yr and soil loss rate 59.18 ton/ha/yr, DCSWM and DCSWMO, 1992), intensive use of fertilisers, pesticides and disposal of domestic wastages in the river. The biodiversities of the Tinau River, therefore, have been selected for the present study.

2. FISH AND FISHERIES STATUS OF NEPAL

2.1 STATUS OF FISH IN NEPAL

The Himalayan kingdom of Nepal occupies a large part of the central Himalayas which supports the varying array of water bodies supporting biologically diverse fish fauna. According to Shrestha (1995), there are one hundred and eighty five fish species included in 79 genera belonging to 31 families and 11 orders. Thirty-four threatened species (vulnerable, endangered and rare species) are recorded from Nepal consisting of 18 percent of total number species. Ninety species (49 % of total number of species) have the status of commonly/occasionally recorded. Sixty-one species (33 %) have the status of insufficiently known; this includes the ten species for which no accounts have been given (Table 2).

Table 2: Status Account for Fish Species of Nepal.

Status Account	IUCN Categories	Number of Species
Common/occasional		90
Insufficiently known	K	61*
Vulnerable	V	9
Endangered	E	1
Rare	R	24
Total		185

Source: Shrestha, 1995.

The Vulnerable species are *Acrossocheilus hexagonolepis, Chagunius chagunio, Tor putitora, Danio rerio, Schizothorax plagiostomus, Schizothorax richardsonii, Schizothoraichthys progastus, Psilorhynchus pseudecheneis, Anguilla bengalensis* and one endangered species is *Tor tor*. It is recommended that legal protection be accorded to these ten fish species (Shrestha, 1995).

2.2 STATUS OF FISHERIES IN NEPAL

Fisheries is a small but important sub-sector of agriculture which contributes about 1.46 percent to agricultural gross domestic product which amounts to 0.8 percent of the gross domestic product (NAPP, 1994 cited in NARC, 1994). Fish culture has a short history in Nepal, while capture fishery in rivers, lakes, reservoirs, wet lands and flood plains has been practiced for long time. Significant increase in the amount of fish production can be achieved through the development and management of culture and capture fisheries.

The per capita animal protein consumption in Nepal was 7.5 kg/yr in 1990 and fish contributed about 0.8 kg (10.8 %) of animal protein consumption. The total nutritive value in terms of calories, protein and fat available per caput per day in 1990/91 was 2288, 61.5 and 30.4 gm respectively. And the livestock based products contributed 7 percent, 15 percent and 47 percent for calories, protein and fat respectively (DFAMS, 1992 cited in NARC, 1994). This shows very low consumption rate of fish in Nepal.

The per caput supply of fresh and processed (dried) fish in Nepal was 0.8 kg and 0.01 kg in the year 1990/91. The estimated export of fresh fish declined from 3000 MT/yr in the mid eighties to a few hundred MT/yr by the end of the decade (Anon, 1990, cited in NARC, 1994). The demand of fish flesh is high and is mostly met by domestic product which is also supplemented by the import of fisheries products from the neighbouring countries. The domestic production comes from both the traditional capture fisheries as well as from the steadily increasing culture fisheries in ponds, lakes, reservoirs and wetlands.

Fish production is targeted to reach 50,000 tonnes by the end of the century, which is nearly four times the present production level. To achieve these goals, intensive fishpond culture has to be developed. Aquaculture production reached 8,364 tonnes in 1992793 (about 57 %) in a total fisheries production of 14,775 tonnes in Nepal (Table 3), (Pradhan and Pantha, 1995).

Table 3: Aquaculture Production in Nepal.

	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93
Total production (tonnes)	10717	12100	12522	14547	15595	16516	14775
Capture fisheries (tonnes)	5711	5661	5601	5561	5576	7115	6356
Rivers and lakes	5281	5281	5281	5281	5281	5281	5865
Other wetlands	430	380	320	280	295	1834	500
Aquaculture production (tonnes)	4939	6364	6845	8906	9935	9340	8364
Ponds	4889	6301	6770	8788	9812	9236	8215
Rice fields	-	4	9	10	10	13	17
Cage/enclosure	50	59	66	108	113	91	112
Other	-	-	-	-	-	-	20

Source: FDD, Department of Agriculture Development (Pradhan and Pantha, 1995).

The pond area and fish production between 1981/82 and 1993/94 increased by 413 and 377 percent respectively. In case of capture fishery from the natural water bodies, the increment is 164 percent only, while in capture fishery the increment between 1981/82 and 1993/94 was 1117 percent. During the same period, the pond productivity increased from 0.8 MT/ha to 1.99 MT/ha and per caput consumption of fish has increased from 235 gm to 859 gm.

For increment of fish production, captive fishery has the great potentiality, because there is an ample opportunity for the expansion of culture area. On the contrary, the potentiality of increased production by capture fishery is very less.

By the end of the Eighth Five Year Plan period (1996/97), national fish production is expected to reach 22,311 MT of which culture fisheries will contribute 13,278 MT (59.5 %) and capture fisheries 9033 MT (40.5 %). By the end of the Ninth Five Year Plan (2001/02), the respective contribution of culture fisheries and capture fisheries will be 16,192 MT (57 %) and 12,090 MT (43 %) amounting a total production of 28,282 MT. Similarly by the end of Tenth (2006/07) and eleventh (2011/12) Five Year Plan periods, the total fish production is envisaged to reach to 35,241 and 41,421 MT respectively of which culture fisheries and capture fisheries will contribute 55 percent and 52 percent respectively (FDD, 1994 cited in NARC, 1994). Similarly, per caput fish consumption is targeted to be increased by 2 kg from the present level of about 800 gm by the end of year 2000 A.D. (FDD, 1992 cited in NARC, 1994).

Due to the lack of trained manpower in river fishery management, and the unavailability of required investment for natural exploitation for aquaculture, very little is known about the physico-chemical and biological characteristics of these rivers and streams of Nepal at present. The fish production is also low in torrential rivers and streams of mountains due to the fast flowing currents of water, low temperature and low nutrients (Shrestha, 1991).

Limited information is available on the fish fauna of the Tinau rive. Shrestha (1981) reported 8 species only from this river and its tributaries. No information about the distribution pattern, habitat ecology and status of fishes of Tinau River is known. Therefore, the present investigation has attempted to study the existing ichthyofauna of Tinau River, physico-chemical parameters of water in relation to the fish fauna distribution, their abundance, frequency etc. The attempt has also been made to study the socio-economic condition of local fishermen, fishing implements and the impact of dam on fish distribution in the Tinau River. The basic data of the study will be helpful to manage the conservation and production plan from fishery point of view of Tinau River in the future.

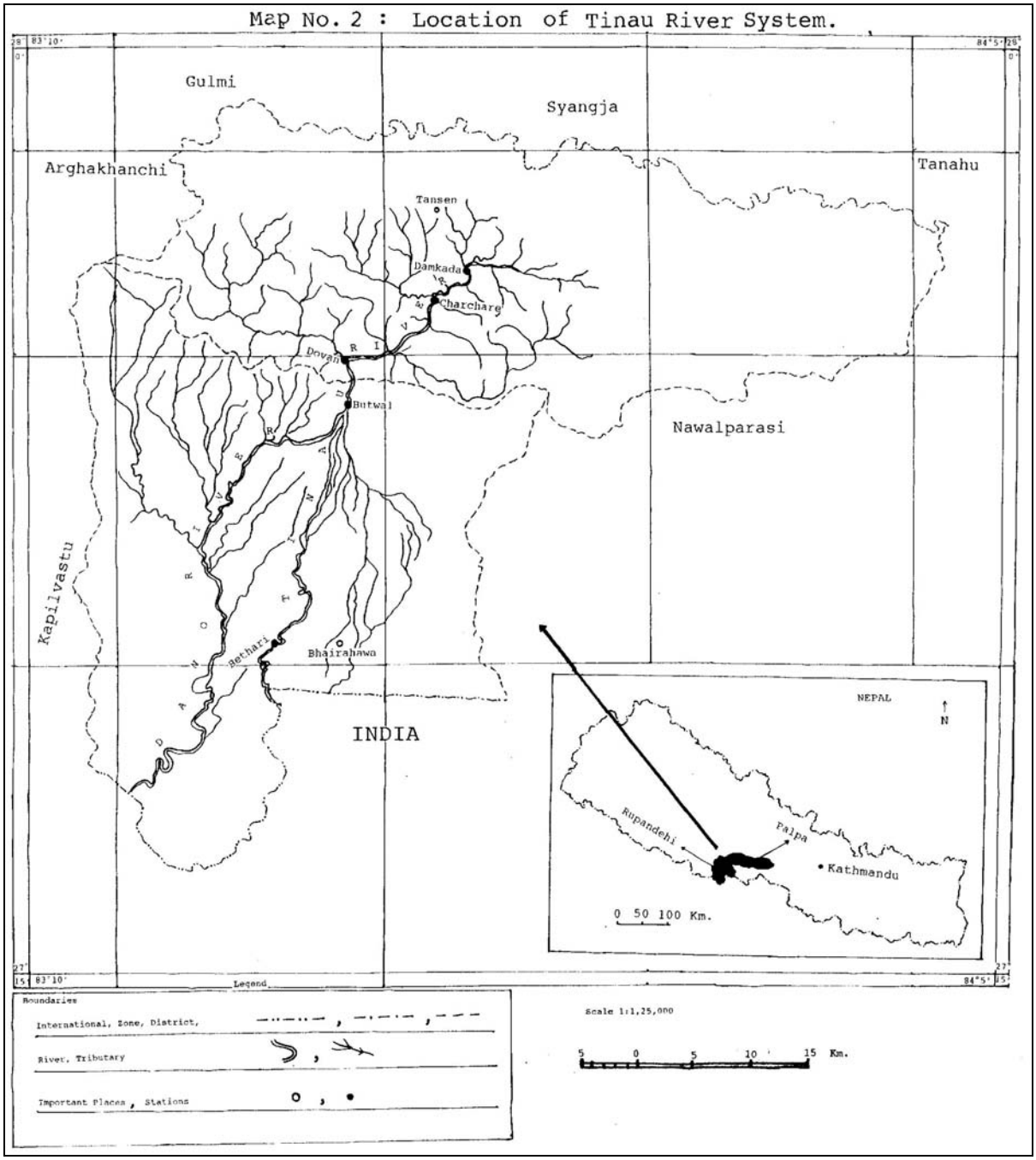
3. STUDY AREA

The Tinau River, originating from the Mahabharat range of Palpa district about 20 km east of Tansen, is selected as the study area for the present study. It is separate from the three major river systems of Nepal, lying at an altitude of about 100 meter to 800 meter from the sea level. It flows to southern direction joining many feeder streams along its way through a valley called Mariphant. About five kilometre south of Mariphant it meets two feeder streams at Charchare, viz., Dumre and Suke. The Tinau River on its way towards south direction meets Sisne Khola and Jhumsa Khola at Jhumsa and after Jhumsa it is also called Jhumsa River. The Tinau River then flows towards west and meets the largest feeder stream Dovan Khola at Dovan (Map no. 2). Before entering the Terai region it meets another feeder stream called Chidiya Khola at Siddhababa temple.

Tinau River bifurcates into two channels fro Butwal, one flows straight to south direction and enters into India crossing Bethari, while another channel flows to southwest direction and is then known as Dano River. Both of these rivers again meet each other in India.

Tinau River makes a journey of about 95 kilometres in Nepal and passes to India but the present study covers 51 kilometres from Mariphant to Bethari which includes valley, Hill region as well as Terai region. It makes terraces of about 200 meters at some places in the Hill region. The main stream is narrow in the northern region due to the presence of hard and strong rocks on the bank which has comparatively more depth and looks like gully but on reaching the Terai region it gets elaborated width towards south direction.

A number of villages are situated in the bank of the Tinau River including a town Butwal. Water resources in the Tinau River have been utilized for drinking, washing, bathing, hydroelectricity and irrigation purposes.


Map No. 2 : Location of Tinau River System.
Gulmi
Syangja
Arghakhanchi
Tanahu
Tansen
Damkada
Charchare
Dovan
Butwal
Nawalparasi
Kapilvastu
Bhairahawa
INDIA
NEPAL
N
Rupandehi
Palpa
Kathmandu
0 50 100 Km.
Legend
Boundaries
International, Zone, District,
River, Tributary
Important Places, Stations
Scale 1:1,25,000
5 0 5 10 15 Km.

3.1 STUDY SITES

Before starting regular sampling programme surveying techniques were followed up for the fixation of stations at the suitable places from the point of view that the samples taken might represent the average faunal composition of the Tinau River. For the present investigation five stations were selected taking into account the altitudinal variation, human settlements, confluences of other tributaries, dam sites etc. which are as follows from north to south direction.

Station I: Damkada (Mariphant)
Station II: Charchare
Station III: Dovan
Station IV: Butwal
Station V: Bethari

3.1.1 Station I (Damkada)

Station I was fixed at Damkada (Mariphant), Palpa district, with an altitude of 684 meter. This was the upper most station with less interference of human beings. The riverbed is composed of mud, sand, and gravels. This is a plain valley region where the average velocity of water is 0.54 m/s. the river water at this station remains clear throughout the year except monsoon during which this valley gets flooded. The water temperature varies in between 16.5^{o}C and 29^{o}C.

3.1.2 Station II (Charchare)

Station II was fixed at Charchare about 5 km down from Damkada at the confluence point with Dumre Khola. The characteristics of the Tinau River at this station are pools and rapids. The riverbed is composed of sand, gravels, boulders and bedrocks. The water temperature varies from 16.5^{o}C to 31^{o}C at this station which lies at an altitude of 574 m.

3.1.3 Station III (Dovan)

Station III was fixed at Dovan with an altitude of 250 m situated about 5 km north of Butwal. It was fixed at the confluence of mainstream to a feeder stream called Dovan, the largest tributary mixing to the Tinau River. Average width of the riverbed at this station is about 90 meter. Watercolour remains transparent and clear throughout the year except monsoon. The water temperature ranges between 17oC to 29oC. The river is broken into pools and rapids, which provides a good habitat for fishes. The riverbed consists of sand, gravels, pebbles, boulders and bedrocks. Some amount of mud and detritus are also present at the bank of the river. A dam has been built at this station to generate hydroelectric power.

3.1.4 Station IV (Butwal)

Butwal is the head quarter of Lumbini zone and is situated at an altitude of 188 meter above the sea level. This place was chosen as station IV that is the junction of Hilly and Terai region. After entering into the Terai region the river expands widely. The velocity of water gradually starts decreasing from this place towards Bethari. The water is clear and more transparent throughout the year except monsoon. The water temperature variation at this station is 17^{o}C to 26.5^{o}C. Some pools and rapids are present at this station also and this station has good sheltering places for fishes. The riverbed consists of silt, sand, gravels, pebbles, boulders and bedrocks. From this place Tinau River is bifurcated in two channels, one towards straight south direction and another to the southwest direction which are called Tinau and Dano respectively.

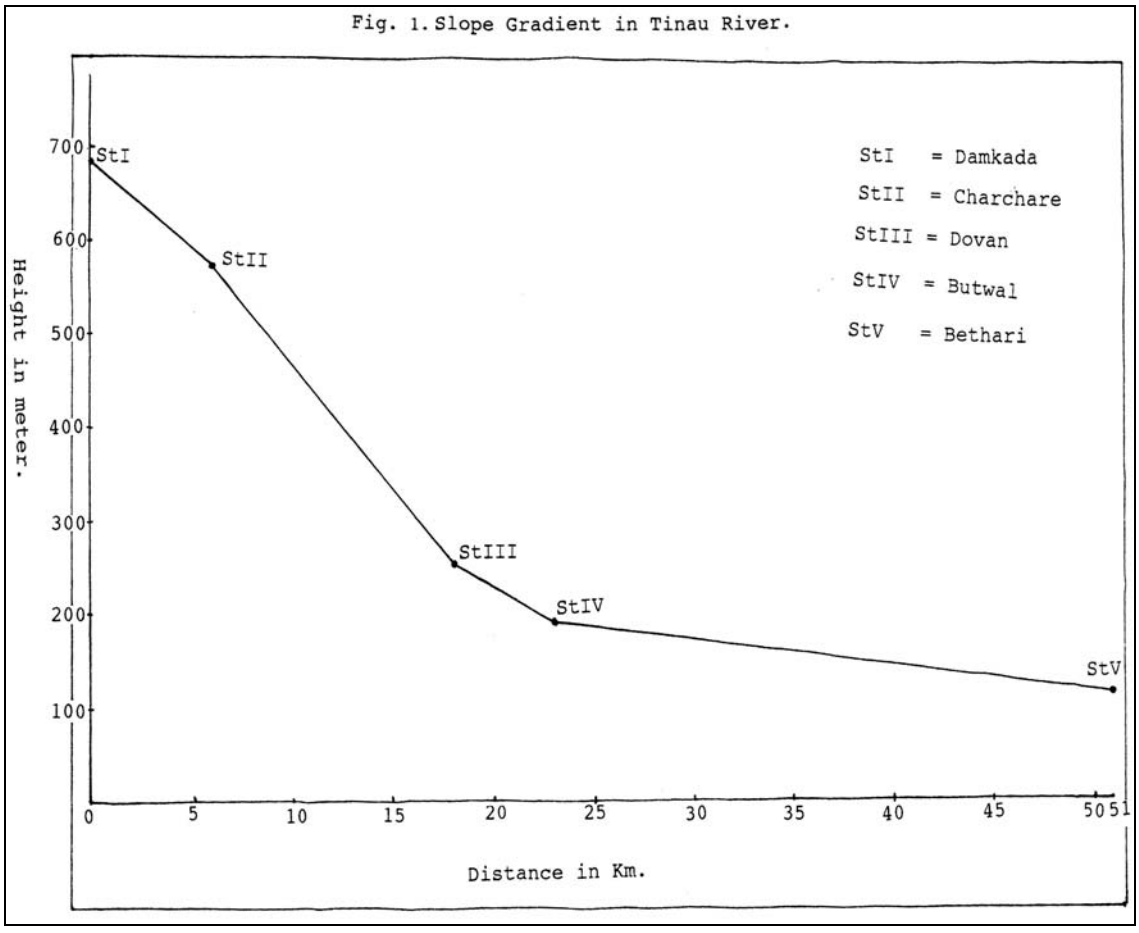
3.1.5 Station V (Bethari)

Bethari is situated about 5 kilometres west of Bhairahawa, the head quarter of Rupandehi district. It is situated at an altitude of 107 meter above the sea level. This station lies in the plain of Terai, therefore the velocity of water is very low (average 0.37 m/s). The transparency value of the river water is low (average 61.92 cm) at this station than that of other stations (Table 12). The average water temperature variation is found in between 18oC to 32.5oC. There is absence of pool and rapid zones. The riverbed consists of mud, silt, sand, clay and detritus. The altitude of each of the five

stations is given in the Table 4. The slope gradient of the study area is shown in Figure1.

Table 4: Altitude of Different Stations

Stations	Locality	Altitude (m)
I	Damkada	684
II	Charchare	574
III	Dovan	250
IV	Butwal	188
V	Bethari	107



3.2 RIVER ECOLOGY

The ecology of Tinau River has been studied in general as follows.

The water of Tinau River is highly saturated with dissolved oxygen which varies from 8.92 mg/l to 5.68 mg/l. The pH value of this river water varies from 8.6 to 7.8. The water temperature of the Tinau River ranges between 16.5^{o}C and 32.5^{o}C. The transparency of the river water remains high throughout the year except monsoon. Total alkalinity of water in the Tinau River varies in between 54.054 mg/l to 12.012 mg/l. Similarly total hardness varies in between 204 mg/l and 54 mg/l and free carbon dioxide varies in between 13.99 mg/l and 3.99 mg/l.

Thus, the conditions of water quality in the Tinau River such as higher concentration of DO, range of temperature variations, value of total hardness, slightly alkaline pH value etc. are favourable for many indigenous fish species.

Using hydrological data recorded from 1964 through 1990, mean discharge for the high water season was 87.3 m^3/s and mean discharge for the low water season was 2.39 m^3/s.

In the Tinau River the maximum flow of water was recorded in August (87.3 m^3/s) and the minimum flow in April (2.39 m^3/s) as shown in the table 5 (Department of hydrology and meteorology HMG/N). High flow in the Tinau River occurs during June to November and low flow in December to May, with little variation from year to year (Table 5).

In the Tinau River, there is a hydroelectric dam at Dovan which provides a threat for the migratory fishes like *Tor sps*. and *Psuedeutropius sps*. The riverbed of Tinau River consists of gravels, pebbles, sand and bedrocks in the hilly area and mud, sand and detritus in the plain part of Terai and Mariphant.

Table 5: Mean Monthly and Yearly Discharges in Tinau River (m^3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1964	4.24	2.75	1.85	1.57	3.56	18.70	41.7	93.8	67.2	22.20	9.35	6.80	22.9
1965	4.84	3.29	2.63	2.05	2.50	29.00	81.8	97.2	20.7	4.84	5.65	4.83	21.8
1966	4.62	2.93	2.52	2.09	1.93	13.70	68.5	230.0	28.0	26.30	12.1	6.16	33.7
1967	4.12	2.78	2.55	2.14	1.77	3.94	52.4	104.0	21.9	19.30	5.90	4.23	19.0
1968	4.45	3.71	2.86	2.50	1.68	22.50	77.0	63.6	92.6	64.90	6.28	3.06	28.9
1969	3.90	2.73	2.26	2.59	2.67	2.74	28.6	59.0	49.7	10.80	6.37	4.57	14.8
1985	37.99	25.90	3.03	2.45	3.56	10.30	50.8	13.3	13.9	2.78	0.17	0.002	13.6
1986	6.42	3.99	1.37	1.48	1.56	48.60	92.0	65.2	158.0	51.90	21.2	11.20	38.7
1987	8.52	6.68	4.50	3.15	2.58	3.66	91.8	94.0	65.9	25.20	14.5	8.24	27.6
1988	4.42	2.74	2.24	1.06	1.25	8.76	59.8	117.0	39.0	6.91	3.14	4.46	21.1
1989	5.29	4.68	4.22	4.20	4.56	9.10	44.6	51.6	32.4	16.00	9.98	7.54	16.3
1990	6.07	7.10	5.14	3.44	4.45	25.80	86.1	59.6	14.5	7.90	5.94	5.62	19.5
Avg.	7.90	5.77	5.77	2.39	2.67	16.40	64.6	87.3	21.6	21.60	8.39	5.57	23.2

Source: Department of Hydrology and Meteorology, HMG/N.

The climatological data recorded from 1982 through 1990 show the average maximum temperature record as 36oC in the month of April and minimum temperature as 11.6oC in January in Butwal locality. Similarly, the maximum precipitation was recorded 887.56 mm in July and minimum 1.75 mm in November in Butwal locality which was taken as mean from 1982 through 1990 (Table 6).

Table 6: Average Monthly Temperature and Precipitation at Butwal Locality (1982/90).

S.No.	Months	Temperature (oC)		Precipitation (mm)
		Maximum	Minimum	
1.	January	17.00	11.60	5.25
2.	February	24.90	12.70	15.87
3.	March	30.33	17.50	25.89
4.	April	36.00	22.50	24.22
5.	May	35.85	28.06	127.67
6.	June	34.98	25.42	382.00
7.	July	32.05	24.87	887.56
8.	August	32.90	25.30	541.22
9.	September	31.79	24.10	489.67
10.	October	31.30	21.30	135.12
11.	November	25.30	16.70	1.75
12.	December	24.50	13.50	30.62

Source: Department of Hydrology and Meteorology, HMG/N.

4. LITERATURE REVIEW

The first authentic information about the fishes of Nepal was given by Hamilton (1822) in his work entitled "An Account of the Fishes Found in the River Ganges and its Branches" which provided the description of 269 species of fishes of the Ganges and its tributaries.

Gunther (1861) reported some cold-blooded vertebrates including fishes collected by Hodgson in Nepal. Day (1886) mentioned the distribution of some fresh water fishes of Nepal in his historical work "Fishes of India, Burma and Ceylon". Boulenger (1907) reported a collection of Nepalese fishes and western Himalayan fishes. Regan (1907) reported a small collection Nepalese fishes. Hora (1937) obtained a collection of fishes from Nepal through Colonel Bailey which included 158 specimens of 22 species. Menon (1949, 1954) collected fishes from the Koshi Himalayan region belonging to 11 families comprising 26 genera and 52 species. He also provided informative description of zoogeography of the fishes of Nepal. Taft (1955) submitted a report on his survey of fishes of Nepal and collected 94 species of fishes from Kathmandu and adjoining areas. De Witt (1960) examined the collection of Taft (1955) and Swan (1954) and prepared a checklist of 102 species of fishes belonging to 21 families collected during California Himalayan Expedition to Makalu. Other important ichthyologists who have studied the taxonomy of fresh water fishes and described some of the fishes of Nepal are Das (1967), Misra (1959), Shaw and Shebbeare (1937) and Shrivastava (1968).

Most of the above mentioned studies were mainly based on taxonomic point of view and do not consider the ecology and behaviour of fishes. Thapa and Rajbanshi (1965) studied various aspects on the development of the fisheries in Nepal. Majupuria (1969) introduced a paper on socio-economic condition of fishermen of Kathmandu valley. Bhatta and Shrestha (1973) have studied the fish fauna of Suklaphanta and listed 27 species of fishes. Ferro and Swar (1978) made survey on biological and limnological condition of lakes and natural waters in Pokhara valley with reference to the existing fish population, their feeding habits and biology. Shrestha (1979) studied the resource biology and aquatic ecology of fresh water of Kathmandu valley with particular reference to fish production, marketing, management and conservation.

Shrestha (1981) in his book "Wildlife of Nepal" commented on ecology, distribution and biology of the fishes of Nepal. Shrestha (1970-1986) has worked extensively on the fish fauna of Nepal and published her findings in various journals. She has published a book entitled "Fishes of Nepal" in 1981, describing scientific details of 120 species.

Rajbanshi (1982) gave a report of a general bibliography on fish and fisheries of Nepal. Jha (1983) studied on the fishery resources of the Karnali River describing the distribution, economic importance and taxonomy of 51 fish species. Joshi (1988) studied the relation of physico-chemical parameters with the fish fauna of the Sunkoshi River.

With the development of Karnali Multipurpose Project, environment impact and mitigation studies have been made (Himalayan Power Consultants, 1989). Similarly environmental and socio-economic impact studies were made in Arun Hydroelectric Project (New ERA, 1989). Spawning ecology and behaviour and migration pattern of the fishes in the upper Arun have also been studied (New ERA, 1991). The fish fauna of Pokhara lakes have been studied by various authors (Ferro, 1980; John, 1982; Shrestha, 1981). The limnological studies of some of the lakes have been done by Loffler (1969), Hickel (1973) and Hirono (1955).

Masuda and Karki (1980) provided a checklist of fish fauna of the Trishuli River in which they have reported 6 families, 16 genera and 28 species. Shrestha (1991) reported 59 cold water fish species from the natural water bodies of mountainous and Himalayan region. Sapkota (1992) studied fishery ecology of swamplands of Koshi River. Shrestha (1992) studied fishery ecology of the fishes in the flood plain of the Koshi River. Karna (1993) studied on the fishery ecology of the Trishuli River. Shrestha (1994) reported fishes, fishing implements and methods of Nepal. She has described 66 genera and 129 species of fish reported so far by the authoress and by the other scholars interested in the area of fish. Biodiversity Profiles Project (1995) described the status of fish species in Nepal based on Shrestha (1995) who enumerated the fishes of Nepal. According to her enumeration there are one hundred and eighty five indigenous fish species found in Nepal.

Despite a large number of contributions cited above, much remains to be done on the ecology and behaviour of fishes living in the hill streams and their relationship with the water quality. Thus the present study entitled "Study on the Fish Biodiversity and Fishery Resources of the Tinau River" is carried out to contribute further knowledge about the fish fauna and productivity of Tinau River. It is hoped that this study will help in planning, conservation and management for the intensive aquaculture development of the fresh water hill streams.

5. AIMS AND OBJECTIVES

The main aims and objectives of the present study are as follows:

a. To study the existing ichthyofauna and their distribution pattern in the Tinau River.
b. To study the physico-chemical and biological parameters in relation to the fish distribution, abundance and frequency occurrence in the Tinau River.
c. To study the socio-economic status of the fishermen of the Tinau River.
d. To study the fishing implements used in the Tinau River.
e. To study the impact of dam on fish distribution in the Tinau River.

6. MATERIALS AND METHODS

For the present investigation the fieldwork was conducted from November 1994 to October 1995. To meet the aims and objectives the following materials and methods were used.

6.1 LIMITATIONS OF THE STUDY

A regular sampling of fishes was carried out monthly for a period of one year (November 1994 to October 1995) from the stations II, III, IV and V. But fishes were sampled tri-monthly during the study period at station I due to the inaccessibility to the station, lack of transportation facilities, limited working time in the field and unavailability of fishermen.

No feasibility study was performed in the Tinau River regarding their environmental impact assessment before and after the establishment of the dam so that the present comparative study became difficult. Although other methods as described in materials and methods were inserted for the study.

6.2 SOURCE OF DATA COLLECTION

The primary or basic source of data is based on the direct field observation, information sampling and photography. The data on hydrology and meteorology needed for the present study were procured by the Department of Hydrology and meteorology HMG/N.

Questionnaires were preferred to collect the information regarding changing pattern of the river with fish distribution, general environment of the river like the lowering of river water level, severe land erosion, siltation, severe flood etc. Monthly visits were conducted to study the fishing implements and methods used in the Tinau River as well as socio-economic status of the local fishermen.

The fishes were collected from Damkada (Mariphant), Charchare, Dovan, Butwal and Bethari (Map No. 3) by employing local fishermen which might represent the average

fish abundance and distribution pattern in the Tinau River. However, fishes were also collected from the local markets. The place between Charchare and Butwal is most important from fisheries point of vies (specially for hill stream fishes) because it is provided with gravels, pebbles and boulders on the riverbanks which provide the spawning ground for different types of fishes. The habitat condition like the spawning ground, shelter, and characteristic features of riverbed has been recorded during the field trips.

Various kinds of locally prepared fishing nets were used for fish sampling, e.g., cast nets were used for sampling different size of fishes. Scoop nets were used for capturing larvae, fingerlings and small fishes. To collect fishes from deep pools, hook lines were used.

The morphometric characteristics and measurement of all the collected fishes were noted in the field itself. The quantitative and qualitative assessments of fish catch were also done. All the collected fishes were carefully preserved in 4-8 percent of formaldehyde, however longitudinal incision along the abdomen was made for larger specimens. The preserved specimens were brought to the laboratory of the Central Department of Zoology for identification and further investigation. These collected fish samples were identified after Shrestha (1981), Shrivastava (1968) and Jayaram (1981).

6.3 ANALYSIS OF PHYSICALPARAMETERS

Physical properties of water in any aquatic system are largely regulated by the existing meteorological conditions and chemical properties. Some of the physical properties of the Tinau River were analysed during the present study period after APHA (1976), Adoni (1985) and Trivedy and Goel (1986). The main physical parameters studied are as follows:

6.3.1 Water Colour

Simple method was used to determine the colour of water in the Tinau River. A beaker of water from the river water was taken out and placed on a white paper and the colour was obtained.

6.3.2 Water Velocity

The velocity of the river water was measured monthly during the study period. A distance of ten meter was measured on a river section and marked. The current velocity of water was measured and calculated from different stations by simple method of timing a float with watch 8Adoni et al., 1985).

6.3.3 Temperature

The air and water temperatures were recorded by using a standard mercury thermometer graduated to an accuracy of 0.5 ^{o}C. the air temperature was recorded simply by holding the thermometer in the air while the water temperature was recorded by dipping the bulb of thermometer inside the water surface avoiding the direct sunlight.

6.3.4 Transparency

The transparency was measured by using a transparency meter which is based on Secchi disc method. The Secchi disc is a metallic plate of 20 cm diameter with four (alternate black and white) quadrants on the upper surface and hook in the centre to tie a graduated rope. The Secchi disc was lowered in the pool region of the river water and the depth was noted at which it just disappeared. Then the disc was slowly raised upward to note the depth at which it reappeared. The calculation was done by applying the following formula.

$$\text{Transparency (cm)} = \frac{\text{Just disappearance} + \text{just reappearance}}{2}$$

6.3.5 Turbidity

Turbidity of the river water is inversely proportional to the transparency. Therefore, the turbidity of the river water was calculated by using transparency value into the following equation.

$$\text{Turbidity (X)} = \frac{1000}{1.568\ Y - 1.275}$$

Where,
X = turbidity, and
Y = transparency.

6.4 CHEMICAL ANALYSI OF WATER

Water samples were collected monthly from every stations of Tinau River during the study period. The water samples were taken directly from the surface water in the polythene bottles. The main following chemical analyses were carried out using the standard methods of APHA (1976), Adoni (1985) and Trivedy and Goel (1986).

6.4.1 Hydrogen ion Concentration (pH)

A battery operated electrical pH meter was used to record the pH of water during the study period at every station in the Tinau River.

6.4.2 Dissolved Oxygen

Modified Winkler's method was used to determine the dissolved oxygen which was originally developed by Winkler in 1888.

Water samples were collected in a BOD (300 ml) without bubbling. Then 2 ml of manganous sulphate and 2 ml of alkaline iodide-azide solution were added and were shaken well. Thus obtained brown ppt was dissolved by adding 2 ml of concentrated

sulphuric acid in the laboratory. Then this sample solution was titrated against standard sodium thiosulphate solution (0.025 N) and the calculation was done by using the following formula.

$$\text{D.O. (mg/l)} = \frac{\text{ml x normality of titrant x 8 x 1000}}{V_2\ \{(V_1\text{-}V)/V_1\}}$$

Where,

V = Volume of $MNSO_4$ and KI added,

V_1 = Volume of BOD bottle, and

V_2 = Volume of the part of the content titrated.

6.4.3 Total Alkalinity

0.5 ml of methyl red bromo-cresol green indicator was added to the 50 ml of sample water in a conical flask. Then it was titrated against standard sulphuric acid solution up to the end point. Calculation for total alkalinity was done by applying the following formula.

$$\text{Total alkalinity (mg/l) as } CaCO_3 = \frac{\text{ml x normality of } H_2SO_4 \text{ x } 50.05 \text{ x } 1000}{\text{ml of sample used}}$$

6.4.4 Total Hardness

The total hardness of river water was estimated by EDTA titrimetric method. 50 ml of sample water was taken in a conical flask. 2 ml of ammonia buffer solution and 200 mg of EBT indicator was added to the sample solution till wine red colour appeared. This solution was titrated against standard EDTA solution (0.01 N) until a clear blue colour appeared. Calculation of total hardness was done using the following formula.

$$\text{Total hardness} = \frac{\text{ml of EDTA used x 1000}}{\text{ml of sample used}}$$

6.4.5 Free Carbon dioxide

For the determination of free carbon dioxide, 50 ml of sample water was taken in a conical flask and 2 drops of phenolphthalein indicator were added to it. The colourless solution indicated the presence of free carbon dioxide. This solution was titrated against standard alkali titrant (Sodium hydroxide 0.02272 N) to the slight pink end point. Calculation for free carbon dioxide was done by using the following formula.

$$\text{Free } CO_2 \text{ (mg/l)} = \frac{\text{ml x normality of NaOH x 44 x 1000}}{\text{ml of sample used}}$$

6.5 BIOLOGICAL PARAMETERS

The biological parameters are mainly planktons which are the free floating and drifting microscopic organisms having neutral buoyance capacity. The planktons are mainly of two types, viz., plant forms called phytoplankton and animal forms called zooplanktons.

The samples were collected in 10 ml plastic tubes by using plankton net (30 No. Bolting silk cloth) from the surface water of the bank of Tinau River, once in a month from each stations, for a period of one year (November 1994 to October 1995). Both types of planktons, i.e., phytoplankton and zooplanktons, were preserved in dilute formaldehyde solution in separate bottles. The qualitative analyses was done by placing a drop of concentrated sample on a glass slide and covered with a cover slip. This glass slide with sample was placed under 150X magnification of compound microscope and binocular. The identification of both types of planktons to the genus level was done after Edmondson (1959), Needham and Needham (1962), Masuda and Pradhan (1988), and Adoni (1985).

6.6 STATISTICAL ANALYSIS OF ICHTYOFAUNA

The co-efficient of correlation between some important physico-chemical parameters of water with composition of fish species in different months in Tinau River has been calculated by using Karl-Pearson's method (Gupta, 1988).

$$\text{Co-efficient of Correlation (r)} = \frac{N.\Sigma XY - \Sigma X.\ \Sigma Y}{\sqrt{N.\ \Sigma x^2 - (\Sigma x)^2}\ .\ \sqrt{N.\ \Sigma y^2 - (\Sigma y)^2}}$$

$$\text{Probable Error (P.Er. of r)} = 0.6745\ \frac{1 - r^2}{\sqrt{N}}$$

Probable error is useful in interpreting Karl-Pearson's Coefficient of Correlation.

7. OBSERVATIONS AND RESULTS

During the study period following observations were made and the results are cited below:

7.1 PHYSICAL ANALYSIS OF WATER

During the present investigation period following physical parameters were analysed.

7.1.1 Water Velocity

The water velocity of river is one of the main factors for determining the form and distribution pattern of fish fauna. Table 7 shows the velocity of water in the Tinau River at different stations in different months.

Table 7: Water Velocity (m/sec) Variations of Tinau River at Different Stations in Different months.

S.N.	Months 1994/1995	Stations				
		I	II	III	IV	V
1.	November	0.47	1.20	1.40	1.25	0.25
2.	December	0.40	1.35	1.35	1.30	0.32
3.	January	0.43	1.25	1.42	1.40	0.35
4.	February	0.48	1.30	1.46	1.32	0.32
5.	March	0.51	1.50	1.55	1.62	0.36
6.	April	0.57	1.60	1.80	1.65	0.34
7.	May	0.59	1.74	1.74	1.70	0.55
8.	June	0.72	1.73	1.88	1.75	0.45
9.	July	0.81	2.10	2.31	1.92	0.58
10.	August	0.68	1.65	1.60	1.50	0.46
11.	September	0.52	1.20	1.40	1.35	0.28
12.	October	0.30	1.45	1.50	1.55	0.20
Average		0.54	1.50	1.62	1.53	0.37

In the Tinau River the velocity of water ranged minimum from 0.20 m/s at station V in October to maximum 2.3 m/s at station III in July.

7.1.2 Temperature

The temperature plays very important role in the species distribution of flora and fauna in the river. Table 8 explains the condition of surface water temperature at all stations in the Tinau River. The surface water temperature was recorded to be the lowest as 16.5°C in January at both the stations I and II. The highest surface water temperature recorded was 32.5°C in June at station V.

Table 8: Surface Water Temperature (°C) Variations at Different Stations in Tinau River in different Months.

S.N.	Months 1994/1995	Stations				
		I	II	III	IV	V
1.	November	23.0	23.0	23.5	23.0	24.0
2.	December	21.0	20.5	22.0	19.5	23.5
3.	January	16.5	16.5	17.0	18.0	18.0
4.	February	18.5	18.0	18.5	21.5	19.0
5.	March	26.5	26.5	25.0	27.0	29.0
6.	April	25.0	24.5	27.5	30.5	29.0
7.	May	21.0	22.5	23.5	27.0	32.0
8.	June	29.0	31.0	29.0	25.5	32.5
9.	July	26.5	28.0	27.0	27.0	26.0
10.	August	28.0	28.5	27.5	26.5	28.5
11.	September	27.5	27.0	26.5	27.5	28.5
12.	October	26.5	24.0	25.0	26.5	26.0
Average		24.083	24.167	24.333	24.96	26.33

Similarly, Table 9 shows the atmospheric temperature at all stations in the Tinau River. The highest atmospheric temperature recorded was 34°C in June at station V. The lowest atmospheric temperature recorded was 17.5°C in January at station I.

Table 9: Air Temperature (°C) Variations at Different Stations of Tinau River in Different Months.

S.N.	Months 1994/1995	Stations				
		I	II	III	IV	V
1.	November	24.0	25.0	25.0	24.5	26.0
2.	December	22.5	22.0	23.0	22.5	25.0
3.	January	17.5	18.0	18.0	20.0	21.0
4.	February	22.0	23.0	23.5	23.5	24.0
5.	March	27.0	28.0	27.5	29.5	30.0

6.	April	29.0	30.0	31.5	32.5	33.0
7.	May	24.0	25.0	25.5	29.0	33.0
8.	June	31.0	31.0	30.0	27.0	34.0
9.	July	28.0	30.0	29.0	28.5	29.0
10.	August	29.5	30.0	29.0	28.0	31.0
11.	September	29.0	29.0	28.5	28.5	30.5
12.	October	28.0	27.5	28.5	28.0	28.5
Average		25.958	26.542	26.583	26.79	28.75

7.1.3 Transparency

The transparency of the river water remained high throughout the year except during monsoon. In the monsoon the transparency decreased to the minimum level at all five stations. Table 10 explains the transparency value at different stations in the Tinau River during the present investigation period. The lowermost transparency value was recorded 3 cm at station V in July. The highest transparency value was recorded 79 cm at both the stations I and II in January.

Table 10: Transparency (cm) Variations in Tinau River at Different Stations in Different Months.

S.N.	Months 1994/1995	Stations				
		I	II	III	IV	V
1.	November	77	76	77	72	68
2.	December	75	77	75	73	67
3.	January	79	79	76	75	71
4.	February	78	75	75	71	70
5.	March	78	76	72	70	65
6.	April	75	74	76	71	67
7.	May	72	78	32	39	70
8.	June	73	71	74	71	69
9.	July	5	3.5	3.5	5.5	3
10.	August	74	77	75	76	72
11.	September	78	74	72	75	54
12.	October	76	75	71	72	67
Average		70	72.25	67.25	64.21	61.92

7.1.4. Turbidity

The turbidity of water directly varies with the transparency value. Table 11 explains the condition of turbidity value at all stations of Tinau River in different months. The

highest turbidity value was 291.63 mg/l at station V in July. The lowest value of turbidity was recorded 8.16 mg/l at both the stations I and II in January.

Table 11: turbidity (mg/l) Variations at Different Stations of Tinau River in Different Months.

S.N.	Months 1994/1995	Stations				
		I	II	III	IV	V
1.	November	8.37	8.48	8.37	8.96	9.49
2.	December	8.60	8.37	8.60	8.83	9.64
3.	January	8.16	8.16	8.48	8.60	9.09
4.	February	8.26	8.60	8.60	9.09	9.22
5.	March	8.26	8.48	8.96	9.22	9.94
6.	April	8.60	8.71	8.71	9.09	9.64
7.	May	8.96	8.26	20.44	16.70	9.22
8.	June	8.33	9.09	8.71	9.09	9.35
9.	July	152.32	237.36	237.36	136.07	291.63
10.	August	8.71	8.37	8.60	8.48	8.96
11.	September	8.26	8.71	8.96	8.60	11.99
12.	October	8.48	8.60	9.09	8.96	9.64
Average		20.484	27.599	28.74	20.14	33.15

7.2 CHEMICAL ANALYSES OF WATER

The following chemical parameters were analysed during the present study.

7.2.1 Hydrogen Ion Concentration (pH)

The pH value of surface water at all five station is shown in the Table 12. The highest value of pH was recorded 8.6 at stations IV and II in September and October respectively. The lowest pH value was recorded 7.8 in October at station V. The pH value fluctuated throughout the study period in all the stations but the variation range was not more than 0.8.

Table 12: pH Value Variations in Tinau River at Different Stations in Different Months.

S.N.	Months 1994/1995	Stations				
		I	II	III	IV	V
1.	November	8.4	8.4	8.2	8.3	8.4
2.	December	8.2	8.3	8.3	8.3	8.4
3.	January	8.3	8.2	8.0	8.2	8.3
4.	February	8.3	8.3	8.2	8.3	8.4
5.	March	8.4	8.2	8.2	8.3	8.3
6.	April	8.2	8.1	8.2	8.2	8.2
7.	May	8.3	8.3	8.3	8.4	8.3
8.	June	8.2	8.4	8.4	8.1	8.2
9.	July	8.4	8.5	8.5	8.5	8.4
10.	August	8.2	8.4	8.2	8.4	8.3
11.	September	8.3	8.3	8.4	8.6	8.5
12.	October	7.9	8.6	8.5	8.1	7.8
Average		8.258	8.33	8.283	8.308	8.292

7.2.2 Dissolved Oxygen

Table 13 explains the dissolved oxygen at different stations of the Tinau River. The highest dissolved oxygen value recorded was 8.92 mg/l at station I in May and at station IV in July and August. Similarly the lowest dissolved oxygen value recorded was 5.68 mg/l at station IV in May, and at both the stations III and V in February.

Table 13: Dissolved Oxygen (mg/l) Variations at Different Station of Tinau River in Different Months.

S.N.	Months 1994/1995	Stations				
		I	II	III	IV	V
1.	November	6.89	6.89	6.49	7.29	6.89
2.	December	7.29	7.29	7.70	7.29	6.49
3.	January	7.70	6.89	6.49	6.89	6.08
4.	February	7.29	6.49	5.68	6.49	5.68
5.	March	6.89	6.49	6.08	6.89	6.08
6.	April	7.29	6.89	6.48	7.70	6.49
7.	May	8.92	6.49	6.08	5.68	6.49
8.	June	8.10	6.89	7.29	7.29	6.89
9.	July	7.70	7.70	8.51	8.92	8.10
10.	August	8.10	8.51	8.10	8.92	7.70
11.	September	8.51	8.10	8.10	8.51	8.10
12.	October	7.29	7.70	7.29	7.70	6.49
Average		7.66	7.19	7.02	7.46	6.79

7.2.3 Total Alkalinity

Monthly measurement of the total alkalinity at different stations is given in the Table 14. The highest total alkalinity value recorded during the study period was 54.054 mg/l at station V in January. Similarly, the lowest value of the total alkalinity was recorded 12.012 mg/l at station I in May.

Table 14: Total Alkalinity (mg/l) Variations at Different Station of Tinau River in Different Months.

S.N.	Months 1994/1995	Stations				
		I	II	III	IV	V
1.	November	32.032	28.028	34.034	38.038	36.036
2.	December	30.030	34.034	34.034	36.036	50.050
3.	January	28.028	36.036	36.036	28.028	54.054
4.	February	26.026	30.030	38.038	30.030	38.038
5.	March	30.030	28.028	30.030	26.026	36.036
6.	April	24.024	34.034	36.036	34.034	48.048
7.	May	12.012	33.033	34.034	28.028	42.042
8.	June	18.018	24.024	30.030	26.026	28.028
9.	July	26.026	22.022	28.028	22.022	24.024
10.	August	30.030	28.028	26.026	26.026	34.034
11.	September	38.038	26.026	32.032	34.034	40.040
12.	October	36.036	30.030	36.036	32.032	38.038
Average		27.530	29.450	32.030	29.190	39.040

7.2.4 Total Hardness

Usually natural water resources of Nepal contain more than 100 mg/l of total hardness (Lind, 1974 cited in Karna, 1993). During the present investigation period the highest value of the total hardness was 204 mg/l in April at station V. The lowest recorded value was 54 mg/l at station I in May (Table 15).

Table 15: Total Hardness (mg/l) Variations in Tinau River at Different Stations in Different Months.

S.N.	Months 1994/1995	Stations				
		I	II	III	IV	V
1.	November	152	158	162	170	196
2.	December	162	164	166	158	200
3.	January	164	168	158	170	198
4.	February	130	150	152	166	188
5.	March	150	154	178	174	202
6.	April	120	162	158	160	204
7.	May	54	158	156	98	174
8.	June	79	120	138	105	140
9.	July	76	96	124	96	80
10.	August	102	107	123	102	109
11.	September	108	122	128	130	148
12.	October	98	110	117	124	135
Average		116.25	139.08	146.67	139.25	164.50

7.2.5 Free Carbon dioxide

Table 16 explains the monthly measurement of free carbon dioxide at all stations of the Tinau River. The highest value of free carbon dioxide observed was 13.99 mg/l in February at both the stations II and V. The lowest value was 3.99 in May at station I, II, III and in April at station IV.

Table 16: Free Carbon dioxide (mg/l) Variations at Different Stations of Tinau River in Different Months.

S.N.	Months 1994/1995	Stations				
		I	II	III	IV	V
1.	November	7.99	7.99	9.99	7.99	7.99
2.	December	9.99	7.99	7.99	9.99	9.99
3.	January	11.99	11.99	11.99	9.99	11.99
4.	February	11.99	11.99	13.99	11.99	13.99
5.	March	7.99	7.99	9.99	7.99	11.99
6.	April	7.99	5.99	9.99	3.99	5.99
7.	May	3.99	3.99	3.99	5.99	5.99
8.	June	7.99	5.99	7.99	9.99	7.99
9.	July	5.99	7.99	5.99	5.99	5.99
10.	August	9.99	9.99	7.99	7.99	7.99
11.	September	5.99	5.99	5.99	11.99	7.99
12.	October	5.99	7.99	5.99	7.99	9.99
Average		8.16	7.99	8.49	8.49	8.99

7.3 BIOLOGICAL PARAMNETERS

Planktons include the free-floating minute plant and animal organisms that have very feeble locomotory organs and simply drift with the water currents.

According to Whitton et al. (1986), the phytoplankton, though confine to the sheltered areas and back waters in common with emergent, submerged or free floating plants and grasses which die or rot, constitute highly productive community even in the high altitude streams. The phytoplanktons are the primary producers in the water ecosystems which usually include chlorophyll-bearing organisms which are responsible for the photosynthesis. During the investigation period, few phytoplankton were reported, viz., *Spirogyra, Lyngbya, Tabellaria, and Microcystis* (Table 17).

Table 17: Occurrence of Phytoplankton at Different Stations in Tinau River.

S.N.	Name of Phytoplankton	Stations				
		I	II	III	IV	V
1.	*Spirogyra sp.*	+	+	+	+	+
2.	*Lyngbya sp.*	+	-	-	-	-
3.	*Tabellaria sp.*	-	+	+	-	-
4.	*Microcystis sp.*	-	-	+	-	-

Index: + = present, and - = absent.

The zooplanktons are minute animals which form the secondary trophic level in the aquatic ecosystem. The zooplanktons feed on phytoplankton and which in turn are consumed by tertiary level in an aquatic ecosystem like larvae of fishes and fishes etc. During the study period, few zooplanktons were recorded, viz., *Cyclopes, Monostyla* and *Daphnia* (Table 18).

Table 18: Occurrence of Zooplanktons at Different Stations in Tinau River.

S.N.	Name of Zooplanktons	Stations				
		I	II	III	IV	V
1.	*Cyclopes*	+	+	-	-	-
2.	*Monostyla*	+	+	-	-	+
3.	*Daphnia.*	-	-	-	-	+

Index: + = present, and - = absent.

7.4 FISH BIODIVERSITY OF THE TINAU RIVER

The Tinau River provides a habitat for fresh water fishes of diverse types, viz., Snow trout, Catfishes, Stone loaches, Sucker heads, Barbs, Mahaseers, and Eels etc. Thirty-five species are reported from the Tinau River during the present investigation (plate 1, 2 and 3). The fishes reported from the Tinau River consist of 5 orders, 12 families, 25 genera and 35 species. The classification and systematic positions of fish fauna are given as follows (Table 19).

Table 19: Systematic Positions of Ichthyofauna Reported from Tinau River.

I. ORDER – CLUPEIFORMES
Sub-order – Clupeoidei
Super –family – Clupeoidae
Family – Notopteridae
Genus – *Notopterus* Lacepede
1. *N. notopterus*

II. ORDER – CYPRINIFORMES
Division – Cyprini
Sub-order – Cyprinoidei
Family – Cyprinidae
Sub-family – Cyprinini
Genus – *Barilius* Hamilton
2. *B. barila* (Hamilton)
3. *B. bendelisis* Var. Chedra (Hamilton)
4. *B. vagra* (Hamilton)
Genus – *Cirrhinus* Oken
5. *C. reba* (Hamilton)
Genus – *Danio* Hamilton
6. *D. devario* (Hamilton)
7. *D. rerio* (Hamilton)
Genus – *Esomus* Swainson
E. dandricus (Hamilton)

Genus – *Garra* Hamilton

8. *G. annandalei* Hora
9. *G. gotyla* (Gray)

Genus – *Oxygaster* Van Hesselt

10. *O. bacaila* (Hamilton)

Genus – *Puntius* Hamilton

11. *P. chilinoids*
12. *P. conchonius* (Hamilton)
13. *P. sophore* (Hamilton)

Genus – *Tor* Gray

14. *T. tor* (Hamilton)

Sub-family – Psilorhynchini

Genus - *Psilorhynchus* Mc Clelland

15. *P. pseudecheneis* Menon and Dutta
16. *P. sucatio* (Hamilton)

Sub-family – Schizothoracini

Genus – *Schizothorax* Heckel

17. *S. plagiostomus* Heckel

Genus – *Schizothoraichthys* Mishra

18. *S. esocinus*

Family – Cobitidae

Sub-family – Botini

Genus – *Botia* Gray

19. *B. lohachata* Chaudhuri

Sub-family – Cobitini

Genus – *Lepidocephalichthys* Bleeker

20. *L. guntea* (Hamilton)

Sub-family – Noemacheilini

Genus – *Noemacheilus* Van Hesselt

21. *N. beavani* Gunther
22. *N. botia* (Hamilton)
23. *N. rupicola* (Mc Clelland)

Division – Siluri

Sub-order – Siluroidei

Super-family – Siluroidea

Family – Bagridae

Genus – *Mystus* Gronovis (Emend. Scopoli)

24. *M. bleekeri* (Day)

Family – Sisoridae

Genus – *Glyptothorax* Blyth

25. *G. pectinopterus* (Mc Clelland)

Family – Schilbeidae

Genus – *Pseudeutropius* Bleeker

26. *P. atherinoides* Bloch

Family- Saccobranchidae

Genus – *Heteropneustes* Muller

27. *H. fossilis* (Bloch)

Family- Claridae

Genus - *Clarius* Gronovius (Emend. Scopoli)

28. *C. batrachus* (Linnaeus)

III. ORDER – OPHIOCEPHALIFORMES (CHANNIFORMES)

Family- Ophiocephalidae

Genus – *Channa* Gronovius

29. *C. gachua* (Hamilton)

IV. ORDER – PERCIFORMES

Sub-order – Percoidei

Super-family – Percoidae

Family – Nandidae

Genus – *Nandus* Cuv. And Val.

30. *N. nandus* (Hamilton)

Sub-order – Gobioidei

Super-family – Gobioidae

Family – Gobiidae

Genus – *Glossogobius* Gill

31. *G. giuris* (Hamilton)

V. ORDER – MASTACEMBELIFORMES

Family – Mastacembelidae

Genus – *Macrognathus* Lacepede

32. *M. aculeatus* (Bloch)

Genus – *Mastacembelus* Gronovius

33. *M. armatus* (Lacepede)

34. *M. pancalus* (Hamilton)

7.5 DISTRIBUTION, ABUNDANCE AND FREQUENCY OCCURRENCE OF FISHES IN THE TINAU RIVER

The upper reaches of Tinau River starts from Butwal to Damkada (Mariphant) with an altitudinal differences from 188 m to 684 m which includes Hilly region. Similarly the lower reach lies below Butwal (188 m) to Bethari (107 m) (Terai region) for the present investigation. The distribution patterns of fishes are according to the different characteristics of upper and lower reaches of the Tinau River.

Table 20 explains the distribution pattern, abundance, and frequency occurrence of fish fauna of the Tinau River. Only 8 species of fishes were reported from station I among which the dominant species of fishes were *Barilius bendelisis, B. vagra*, and *Puntius sophore*. At station II, only six fish species were reported among which the dominant species were *Barilius bendelisis, B. vagra* and *Garra gotyla*. Greatest numbers of fish species were reported from the station III, i.e., 21 species were found. The most dominant fish species at station III were *Barilius barila, B. bendelisis, Garra gotyla* and *Noemacheilus beavani*. Station IV consisted of 12 fish species 12 fish species among which *Barilius bendelisis, Garra gotyla* and *Puntius sophore* were the dominant species. Similarly, station V contained 13 fish species and the dominant fish species were *Puntius conchonius* and *P. sophore*. Similarly, Table 20 also shows the species-wise frequency occurrence of the fishes in the Tinau River. About 25 percent of total catch composition was constituted by *Barilius bendelisis*, 18 percent by *Puntius sophore* and 11 percent by *Garra gotyla*. Rest of the fish species formed about 46 percent of total catch.

Table 20: Distribution Pattern, Abundance, and Frequency of Fish Diversity in the Tinau River.

Family	Scientific Name	Local Name	No. of Species in Stations					Abundance	Total No. of Fishes	Frequency
			I	II	III	IV	V			
Notopteridea	*Notopterus notopterus*	Golhi	-	-	-	-	3	Rare	3	0.3012
Cyprinidae	*Barilius barila*	Fageta	-	-	23	20	-	Common	43	4.3173
	B. bendelisis	Fageta	24	26	132	68	-	Fairly common	250	25.1004
	B. vagra	Fageta	46	12	19	21	-	Fairly common	98	9.8394
	Cirrhinus reba	Raiya	-	-	-	-	8	Common	8	0.8032
	Danio devario	-	-	-	-	4	-	Rare	4	0.4016
	D. rerio	-	-	-	1	6	-	Common	7	0.7028
	Esomus dendricus	Darai	-	-	-	-	15	Rare	15	1.5060
	Garra annandalei	Buduna	-	-	3	6	-	Fairly common	9	0.9036
	G. gotyla	Buduna	13	9	47	42	-	Rare	111	11.1446
	Oxygaster bacaila	Chalwa	-	-	1	-	-	Rare	1	0.1004
	Puntius chilinoids	-	-	-	3	-	-	Common	3	0.3012
	P. conchonius	Sidre	3	-	-	19	37	Fairly common	59	5.9237
	P. sophore	Sidre	31	-	-	88	62	Common	181	18.1727
	Tor tor	Katle	-	-	15	-	-	Rare	15	1.5060
	Psilorhynchus pseudecheneis	Titemachha	-	-	2	-	-	Rare	2	0.2008
	P. sucatio	-	-	-	3	-	-	Rare	3	0.3012
	Schizothorax plagiostomus	Asala	-	-	3	-	-	Rare	3	0.3012
	Schizothoraichthys esocinus	Asala	-	-	2	-	-	Common	2	0.2008

Cobitidae	*Botia lohachata*	Baghe	-	4	18	15	-	Rare	37	3.7149
	Lepidocephalichthys guntea	-	-	-	-	-	5	Common	5	0.5020
	Noemacheilus beavani	Gadela	8	2	25	-	-	Common	35	3.5140
	N. botia	Gadela	-	-	12	18	-	Rare	30	3.0120
	N. rupicola	Gadela	-	-	5	-	-	Occasional	5	0.5020
Bagridae	*Mystus bleekeri*	Tengra	-	-	-	-	8	Common	8	0.8032
Sisoridae	*Glyptothorax pectinopterus*	Kabhre	-	2	7	-	-	Occasional	9	0.9036
Schilbeidae	*Pseudeutropius atherinoides*	Patasi	-	-	-	-	3	Rare	3	0.3012
Saccobranchidae	*Heteropneustes fossilis*	Singhi	1	-	-	-	-	Occasional	1	0.1004
Claridae	*Clarius batrachus*	Mungri	-	-	-	-	7	Common	7	0.7028
Ophiocephalidae	*Channa gachua*	Hile, Bhoti	4	-	2	8	-	Occasional	14	1.4056
Nandidae	*Nandus nandus*	-	-	-	-	-	8	Common	8	0.8032
Gobiidae	*Glossogobius giuris*	-	-	-	2	-	7	Rare	9	0.9036
Mastacembelidae	*Macrognathus aculeatus*	Gainchi	-	-	-	-	1	Occasional	1	0.1004
	Mastacembelus armatus	Bam	-	-	3	-	-	Occasional	3	0.3012
	M. pancalus	Gainchi	-	-	-	-	4		4	0.4016
Total			130	55	328	315	168		996	99.9998

Table 21 shows the family-wise fish species composition (no. of species in a family) in the Tinau River during the investigation period, according to which, 51.42 percent of reported species fall under the family Cyprinidae, 14.29 percent under family Cobitidae, 8.57 percent under Mastacembelidae and 25.71 percent under others. Table 22 shows the family-wise fish composition (in number) in the Tinau River during the present study period. Cyprinidae alone constituted about 81.73 percent of the total fish catch by number. Similarly, Cobitidae constituted about 11.24 percent of total fish catch. Others constituted about 7.03 percent of the total catch.

Table 21: Family-wise Fish Species Composition in Tinau River (1994/1995).

S. No.	Family	No. of Fish Species	Species Composition (%)
1.	Cyprinidae	18	51.42
2.	Cobitidae	5	14.29
3.	Mastacembelidae	3	8.57
4.	Others	9	25.71

Table 22: Total Catch (in number) and Fish Composition (%) in Different Families in Tinau River (1994/1995).

S. No.	Family	Total Catch No. of Fish Species	Fish Composition (%)
1.	Cyprinidae	814	81.73
2.	Cobitidae	112	11.24
3.	Others	70	7.03

7.6 MAJOR ICHTHYOFAUNA AND THEIR STATISTICAL ANALYSIS

The two families of ichthyofauna, viz., Cyprinidae and Cobitidae formed about 92.97 percent of the total collected fish fauna while the rest families constituted only 7.03 percent which has been shown in the Table 22. Among the collected fish fauna family Cyprinidae predominated throughout the study period and alone constituted 81.73 percent of the total, Cobitidae was found as a second dominant family and constituted 11.24 percent of the total collected fish fauna.

Correlation co-efficient between transparency and turbidity was highly negative (-0.9857). The co-efficient of correlation value between altitude and fish species composition was found to be highly negative (-0.6805). Similarly, fish species composition has positive correlation co-efficient value (0.383) with pH range and positive correlation (0.527) with dissolved oxygen. The fish species composition shown negative correlation value r = -0.803 with free carbon dioxide (Table 23).

Table 23: Co-efficient Correlation Between Physico-chemical Parameters and Fish Species Composition in Tinau River (1994/1995).

Parameters	R	P.Er.
Water velocity vs. dissolved oxygen	0.224	0.185
Altitude vs. fish sp. composition	-0.680	0.105
Water temp. vs. fish sp. composition	0.555	0.135
pH vs. fish sp. composition	0.382	0.166
Dissolved oxygen vs. fish sp. composition	0.527	0.140
Free carbon dioxide vs. fish sp. composition	-0.486	0.148
Transparency vs. turbidity	-0.986	0.005
Dissolved oxygen vs. water temperature	-0.783	0.117
Altitude vs. water temperature	-0.448	0.241

7.7 PREFERENTIAL FISH HABITAT IN THE TINAU RIVER

Habitat preferences of important species of fishes in Tinau River, based on present sampling and information from local fishermen, are described below (Table 24). Large games cum food fish such as Sahar (Tor tor) prefer stony rapids and pools and have ability to migrate from down-stream to up-stream. Small fishes such as *Schizothorax plagiostomus, Glyptothorax pectinopterus* have suction disc on their ventral side for clinging to stones and rocks and are found in rapids of upper reaches. Small fishes (loaches) like *Noemacheilus beavani, Noemacheilus botia* and *Noemacheilus rupicola* have restricted food habit in sandy bottoms hiding under stones.

Some species of fishes partially bury themselves in sandy or muddy bottoms such as Cat fish (*Heteropneustes fossilis*) and Snake headed fish (*Channa gachua*) etc. These fishes also have their tendency to overland through wet vegetation during dry season. Some fishes school near mid-water column for the purpose of predation, e.g., *Puntius sophore, Barilius bendelisis, Barilius vagra* and *Nandus nandus* etc., while others like *Esomus dandricus* and *Tor tor* school near sub-surface water for feeding purpose. Fish like stone loach, (*Noemacheilus rupicola*) mimic with dead log and dead woody material in water.

Generally, fish in Tinau River migrate upstream in early monsoon (May-June) and migrate downstream in September-October. Tinau River mainly consists of local migrants which include snow trout (*Schizothorax sps)* and Mahaseer (*Tor tor*) etc.

Table 24: Preferential Fish habitat in the Tinau River.

Family	Scientific Name	Local Name	Preferential Fish Habitat
Notopteridae	*Notopterus notopterus*	Golhi	Shallow pools
Cyprinidae	*Barilius barila*	Fageta	Shallow pools, riffles
	B. bendelisis	Fageta	Shallow pools, riffles
	B. vagra	Fageta	Shallow pools, riffles
	Cirrhinus reba	Raiya	Shallow pools
	Danio devario	-	Rapids, riffles
	D. rerio	-	Rapids, pools
	Esomus dandricus	Darai	Shallow pools
	Garra annandalei	Buduna	Pools, slow runs
	G. gotyla	Buduna	Pools, swift runs
	Oxygaster bacaila	Chalwa	Shallow pools
	Puntius chilinoids	-	Pools, runs
	P. conchonius	Sidre	Pools
	P. sophore	Sidre	Shallow pools
	Tor tor	Katle	Pools, rapids
	Psilorhynchus pseudecheneis	Titemachha	Rapids, riffles
	P. sucatio	-	Rapids, riffles
	Schizothorax plagiostomus	Asala	Rapids, riffles, runs
	Schizothoraichthys esocinus	Asala	Rapids, riffles, runs
Cobitidae	*Botia lohachata*	Baghe	Rapids, pools
	Lepidocephalichthys guntea	-	Shallow pools
	Noemacheilus beavani	Gadela	Shallow pools, riffles, gravel beds
	N. botia	Gadela	Shallow pools, riffles, gravel beds
	N. rupicola	Gadela	Shallow pools, riffles, gravel beds
Bagridae	*Mystus bleekeri*	Tengra	Shallow pools with muddy bottom
Sisoridae	*Glyptothorax pectinopterus*	Kabhre	Gravel bed, runs, rapids
Schilbeidae	*Pseudeutropius pectinopterus*	Patasi	Shallow pools
Saccobranchidae	*Heteropneustes fossilis*	Singhi	Shallow pools, sandy or muddy bottom
Claridae	*Clarius batrachus*	Mungri	Shallow pools with muddy bottom
Ophiocephalidae	*Channa gachua*	Hile, Bhoti	Pools, runs, sandy or muddy bottom
Nandidae	*Nandus nandus*	-	Shallow pools
Gobiidae	*Glossogobius giuris*	-	Pools, rapids
Mastacembelidae	*Macrognathus aculeatus*	Gainchi	Shallow pools with muddy bottom
	Mastacembelus armatus	Bam	Pools, rapids, stone crevices
	M. pancalus	Gainchi	Shallow pools

8 ECOLOGY AND BEHAVIOUR OF SOME IMPORTANT FISHES

Among 35 different ichthyofauna reported from Tinau River, some economically important fish species are described concerning their morphology, habitat, behaviour, fin formula etc.

Tor tor (Hamilton)

(Deep bodied Mahaseer)

It is an important food and game fish which is called "Sahar" in Nepal. It inhabits in many snow-fed as well as other small hill streams of Bagmati, Bheri, Gandaki, Koshi, Lumbini, Narayani and Mechi zones (Shrestha, 1981).

Generally body colour is silvery green or greyish green dorsally along upper half of the body, sides are slightly golden and the abdomen is silvery white with golden colour. It is a stoutly built fish with a deep body whose dorsal side is more convex and the head being shorter than the depth of the body. It has a fleshy mouth, the gape of which does not extend beyond the eye. It has two pairs of barbels, viz., maxillary and rostral among which former pair is longer. Lower fins are reddish orange in colour while that of the dorsal fin is slightly darker and the caudal fin is deeply forked. It attains a maximum size of about 1200 mm.

This fish generally inhabits the deep pool-zone of Tinau River. It shows migratory behaviour in June/July towards upstream for breeding while the breeding season for this fish lies between August and September. It is omnivorous in habit feeding upon filamentous algae like *Spirogyra*, *Oscillatoria*, insects like mayfly (*Ephimera*) and small crabs (*Cancer*) etc.

Fin formula: D. 3/9(12), P. 17, V. 9, A. 2/7(9), L.l. 25, L.tr. $4^{1/2}/4^{1/2}$, B. 2 prs.

Schizothorax plagiostomus Heckel

(Spotted snow trout)

It is commonly known as "Buche Asala" in Nepal. The body shape is elongated and slender. A suctorial disc or adhesive apparatus is present on the thorax. The body is

extensively spotted with black dots on the background of greyish black on dorsal and silvery on belly and sides. It has four small barbels. The body is covered over by minute silvery scales. All the fins are with reddish tinge except dorsal and the caudal fin is deeply forked. It mostly occurs in Bagmati, Bheri, Dhaulagiri, Gandaki, Janakpur, Koshi, Lumbini, Mahakali and Seti zones (Shrestha, 1981). It attains a maximum size of 600 mm.

It mostly prefers to live in clean water of Tinau River with swift flow, shallow and gravel riverbed which is the ideal spawning ground of this fish. It is herbivorous in nature feeding upon filamentous algae and small pieces of aquatic plants. The spawning period of this fish species begins in September.

Fin Formula: D. 3/7(10), P. 16-17, V. 10, A. 2/5(7), C. 19-20, L.l. 105, L.tr. 24/23. B. 2 prs.

Barilius bendelisis Var. Chedra (Hamilton)
(Carp-minnow)

It is commonly known as "Fageta" in Nepal. They are small sized fishes of which paired fins are enlarged, which, flesh and horizontally placed in males especially during breeding season. Colour if the body is silvery white with black spots on each scale except lateral line scales, where two spots are found. There are about 9 to 10 vertical dark bands on the body. Caudal fin is deeply forked, lower lobe being slightly longer. It is mostly distributed in the rivers of Bagmati, Bheri, Gandaki, Lumbini and Narayani zones. The maximum size recorded for this fish is 178 mm. This fish is very sluggish in habit (Hora, 1921 cited in Bhagat, 1985).

Generally it inhabits in the low depth but the adult form occurs in rapids as well as pools of the streams. It is a resident fish species of Tinau River feeding upon insects, earthworm and green algae like *Spirogyra*, *Oscillatoria* etc. Breeding season of this fish starts from June to September.

Fin Formula: D. 2/7(9), P. 14-15, V. 8, A. 3/8(11), C. 19, L.l. 43, L.tr. $3/3^{1/2}$, B. 2prs.

Barilius vagra (Hamilton)

(Carp-minnow)

It is commonly called "Fageta". It is distinguished from other species by its mouth cleft extending up to middle of the eye and short vertical bands throughout the body. Upper jaw is slightly longer than lower jaw. Barbel two pairs one pair short maxillary, while other rostral extends up to half of the head length. Scales are of moderate size. Caudal fin is deeply forked. It is found in rapids and pools generally in groups. It attains a size up to 152 mm. It feeds upon large amount of algae and some insects and their larvae. The breeding season for this fish starts from June.

Fin Formula: D. 2/7(9), P. 12-13, V. 9, A. 3/10(13), C. 19, L.l. 44-48, L.tr. $8^{1/2}/2^{1/2}$, B. 2 prs.

Noemacheilus beavani Gunther

(Stone loach)

It is commonly known as "Gadela". It has tapering body with 9 to 10 brown vertical bands just behind head to the base of caudal. The general body colour is yellowish. A dark band is also present on the caudal base. Barbels are three pairs, viz., two pairs rostrals and one pair maxillary. Scales are minute and embedded in the skin. Generally dark bands are present on dorsal and caudal fins. Caudal fin is slightly forked. It is distributed in the hill streams of Bagmati, Gandaki, Koshi, Lumbini and Narayani zones (Shrestha, 1981).

Generally it inhabits in the cold water of torrential streams while the fingerlings of this fish species prefer the shoreline of the stream. It feeds on crustaceans like *Cyclopes*, worm like *Pheretima* and algal materials like *Oscillatoria*. It is the resident species in the Tinau River, the breeding season of which starts from April to May.

Fin Formula: D. 2/8(10), P. 10, V. 8, A. 2/5(7), C. 9, B. 3 prs.

Noemacheilus botia (Hamilton)

(Stone loach)

It is commonly known as "Gadela". It can be distinguished from other species by long barbels and 10 vertically molted bands from dorsal side towards lateral line. The maxillary pair of the barbels reaches up to the posterior boarder of the eye. The colour pattern slightly differs in adult specimens where these vertical bands become thin and broken into numerous small patches. Caudal and dorsal fins are tinged with black dots forming a distinct clear straight line in dorsal, and become wavy in caudal in shape. It attains a maximum size of 100 mm.

Generally it inhabits in the cold water of torrential streams at bottom. It feeds upon large amount of *Pheretima* and algal filaments like *Spirogyra* and *Oscillatoria* etc. Mostly it breeds in April to June in Tinau River.

Fin Formula: D. 2/10-12(12-14), P. 11, V. 8, A. 2/5(7), C. 18, B. 3 prs.

Garra gotyla (Gray)

(Sucker head)

It is commonly known as "Buduna" in Nepal. The body is elongated and sub-cylindrical in shape. Mouth is inferior and semicircular in shape with upper lip fringed. A suctorial disc is present on chin which is large and rounded. Snout is covered with spiny conical tubercles and a deep groove is present across it. Two pairs of barbels are present, viz., rostral and maxillary. General body colour is black with greenish tinge and a black spot is present just behind the gill opening. It attains a maximum size up to 150 mm.

It feeds on large amount of algal materials like Spirogyra and Oscillatoria etc. It is distributed in the rivers of Bagmati, Bheri, Lumbini and Narayani zones. The breeding season for this fish starts in the month of June.

Fin Formula: D. 2/8(10), P. 15, V. 9, A. 2/5(7), C.17, L.l. 32-34, L.tr. $5^{1/2}/3^{1/2}$, B.2 prs.

Channa gachua (Hamilton)
(Murrel head)

It is commonly known as "Hile" or "Bhoti". Body is elongated and sub-cylindrical with depressed head which is dorsally covered with plate like scales. Gill openings are wider. Caudal fin is round in shape. Lateral line is broker in 12 to 15 scales and slightly curve. Body colour is dark on dorsal and the sides and belly is dirty white. Pectoral fins are with three reddish orange bands alternating with blue. A blue block is present on the base of pectoral fin while the tip is black. Ventral fin has orange tinge while other fins are dark. Dorsal and anal fins are long. About 12 vertical bands or stripes are present on the lateral sides of body. It can attain a maximum size of 180 mm.

It is widely distributed on the rivers of hills and plains. It is carnivorous in nature. Breeding season of this species ranges from June to August.

Fin Formula: D. 34-37, P. 13-15, V. 6, A. 21, L.l. 42-45, L.tr. 4/7

Heteropneustes fossilis (Bloch)
(Spiny catfish)

It is commonly known as "Singhi". It is found occurring in ponds, pools, ditches and rivers of plains and mountains of Nepal. The body colour is dark brown. It has a short dorsal fin originating opposite to the ventral fin, and long anal fin. The anal fin is separated from caudal by a deep notch. It bears 4 pairs of long barbels among which maxillary pair reaches beyond pectoral fin. The pectoral fins are slightly long with a strong spine serrated internally which is capable of inflicting wound acting as a horn hence the name "Singhi". It is provided with a long air sac, accessory respiratory organ, therefore, can able to live in muddy water. Caudal is rounded. It is a resident fish species. It can attain a maximum size of 175 mm.

It is predatory fish feeding on insects, worms, algae etc. The breeding season rages in between April to June.
Fin Formula: D. 6, P. 1/(8), V. 6, A. 66, C. 19, B. 4 prs.

9 FISHING IMPLEMENTS OF TINAU RIVER

In Tinau River varied kinds of fishing implements and methods are being used. The fish capturing methods in the Tinau River are similar to those of the other parts of Nepal. Most of the methods used in the Tinau River are seasonal which are described below.

9.1 DIVERSION OF RIVER CHANNEL, (DUWALO THUNNE)

This method is occasionally used in Tinau River for which the river is made dry, deflecting the flow of water to one of the either side from the main riverbed by constructing a rough stone dam. At the distal end of diverted channel a bamboo fish trap (Dhadiya) is set so as to catch the fish escaped from the main river. The blocking is made by using stones, logs, sand, branches of trees and clay. The fish are caught with bare hands or with the help of scoop nets. But the pool regions and stone crevices, herb poisons Khirro (*Sapium sps*), bark of Kafal (*Myrica esculanta*), stem of Siudi (*Cactus sps*) or chemical poisons like Malathion and Metacid are also used.

9.2 NETS (JAL)

Various kinds of nets are used in Tinau River for fishing, viz., Cast net, Bhureli jal (small type of Cast net), Scoop nets and Helka.

9.2.1 Cast net

It is a large casting type of net which is used to catch large and medium sized fishes. It is made up of cotton or nylon thread and its body is bell shaped. The rim of the net is the widest part and it tapers gradually towards the apex. The rim is folded inside by 5-10 inches, the margin of which is tied with the body of the net at a regular distance of 3-4 inches to give bag like structure, each knot consisting of a pair of iron or lead beads. It is mostly used throughout the year in the Tinau River. The mesh size of the net ranges from 1.5 cm- 2.5 cm and catches Katle (*Tor tor*), Fageta (*Barilius sps*), Buduna (*Garra sps*) etc.

9.2.2 Bhureli Jal

Shape and texture of Bhureli jal are like that of Cast net but it is smaller in size with smaller mesh size from 0.5 to 1.5 cm. It is generally used for catching smaller or juvenile fishes. The practice of this jal is harmful for the fishes which wipes our larvae of fishes and destructs fishery resources.

9.2.3 Scoop net

It consists of a rectangular wooden or steel-frame which is supported by a short handle of wood. The rectangular frame carries an oval net which is made of jute or mosquito net. It is generally used in muddy water or in diverted channel of river to catch fishes like snake headed fish (*Channa sps*), Gadela (*Noemacheilus sps*), and Buduna (*Garra sps*) etc. but very few fishermen use this type of net in the Tinau River.

9.2.4 Helka

It is bag-like in structure with wooden frame of carious shapes such as elliptical, triangular etc. which is made up of small nets, e.g., mosquito net. It cannot be used in the rapid flow of water. It is mostly used in the Terai region where the shallow and stagnant water body is found near the bank of Tinau River (e.g. Bethari). Sometimes mosquito net is also used for capturing small fishes in shallow part of the river.

9.3 ROCK STRICKING

In the shallow water of Tinau River, rock-striking method is also used. Generally flat stones are used for this purpose on which a weighty iron hammer is struck with full force. The intensity, vibration and sound thus produced impair acoustico-lateralis system of fishes due to which both large and small fishes float over water-surface. This fishes are scooped with bare hands or scoop nets. Mostly Asala (*Schizothorax sps*), Fageta (*Barilius sps*) and juvenile fishes becomes victim of this method. Thus this is one of the harmful fishing practices which cause a great loss of young fish.

9.4 DYNAMYTING (BOMBING)

Appropriate size of dynamite (explosive) is tied in a sinker (stone) which is ignited and thrown instantly in the middle of the pool region. Violent sounds produced by explosion of dynamite impair acoustico-lateralis system of fishes as in rock striking. Sometimes rice grains are thrown into the pool as a bait to collect fishes in a particular area before explosion. This is a more destructive fishing practice which kills all types of fishes and is practiced illegally by the local people inhabiting near the Tinau River.

9.5 FISHING-ROD (HOOK-LINE)

Fishing rods are locally known as "Balchhi hanne" which consist of a lone and slender rod slightly curved at the tip. Fine cotton or nylon thread is tied at the curved tip of rod and a hook in the distal end of thread. Just above the hook there is a sinker made up of lead or stone. Bait generally consists of earthworms, small fishes, insects or maize etc. Stout rod with thick string and a bait of small fishes is generally used for catching fishes like *Tor sps* and *Schizothorax sps* etc.

9.6 FISH SPEARING

Fish spearing method with the help of a spear is noticed in Tinau River especially during the summer season when the water level becomes low. Mostly it consists of a spear fixed at the tip of long bamboo or wooden pole which is used at the crevices of stones and is effective to catch eels.

9.7 ELECTRIC FISHING

Electric fishing is done at some places in the Tinau River with the help of 12-volt battery. For this, two rods of opposite poles are dipped in river water so as to kill the fishes lying between these rods. Generally Asala (*Schizothorax sps*) becomes victim *sps*), Fageta (*Barilius sps*) and juvenile fishes becomes victim of this method. Thus this is one of the harmful fishing practices which cause a great loss of young fish.

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10. SOCIO-ECONOMIC STATUS OF FISHERMEN OF TINAU RIVER

A set of questionnaire was developed and administered to local inhabitants of villages located near Tinau River such as Damkada, Charchare, Dovan, Butwal and Bethari to know the socio-economic status of local fishermen. The information obtained were analysed critically and the conclusions were made which are described below:

Although survey revealed that about 12, 240 families are engaged in aquaculture activities and about 36, 7000 people have been estimated to be actively involved in fishery profession in Nepal (Pradhan and Pantha, 1995), an extensive study on the actual number of fishermen and their socio-economic conditions are needed to evaluate the actual production from capture fishery.

Fishermen of Tinau River are locally known as “Majhi” and “Mallah” who generally inhabit the places near the bank of the river which includes Majhi, Tharus, Magars, Danuwars, Darahis, and Dhimals etc. In the Terai region they live by making separate territory due to social barrier, feeling for them as a lower caste. But such conditions are rarely found among the fishermen of Hilly region near Tinau River where Magars are mostly involved in fishing activities. Fishermen are always dominated by the people of higher caste and they get a lot of social harassment from the other communities.

About eighty three percent of the total fishermen of Tinau River are totally illiterate, ten percent have an education up to fifth standard and seven percent with an education up to eight grades are found among surveyed fishermen. They are very much interested to give education to their children, among which fifty three percent are sending their children to school, seventeen percent send only sons, neglecting their daughters towards education and thirty percent are unable to send their children for study. They are not aware of the facilities of free education in the government schools. About forty percent of the fishermen know about the family planning idea but only few (about 20 %) of them have taken benefit from it and the rest think that there is no need of family planning system because children are the bless of God for them. Majority of the fishermen are having the family of 6 to 11 members. Though their main job is fish catching, they depend for their livelihood not on the fish catch,

but they also have some their own land [average 8 kattha (0.26 ha) per family] which they cultivate to grow agricultural products. Only 27 percent of fishermen earn their livelihood by fishery profession and no one of the family members are engaged in other job, neither in the government sector nor in the private sector. Others (73 % fishermen) told that many of their household problems were fulfilled by fishing.

Fishing activities continue throughout the year except the monsoon during which they are engaged in the work of agriculture. About fifty seven percent of the fishermen are living in small huts made up of bamboo (*Dandrocalmus strictus*) and Khar (*Imperata cylindrical*) and the bamboo wall is lapped with alluvial soil, seventeen percent have their houses made up of brick wall and have roofs of tiles and about 26 percent have their houses made with stone walls and have roofs of Khar and Zinc plates (Karkatpata).

Nearly eighty six percent males and fourteen percent females are engaged in fishing, but during off seasons male work as labour also. The females are engaged in their household affairs such as cooking, preparing bamboo basket implements, cleaning the house, collection of fire-wood, making dung-cake etc.

Local fishermen themselves make different types of fishing implements especially during leisure periods with the help of locally available plant fibres (bamboo) and nylon strings. According to the local fishermen, the best fishing season in Tinau River is from March to July for fishing good-sized fishes. In average a fisherman can collect fishes weighing ½ to 2 kg per day according to the fishing season. They sell about 90 percent of the total catch composition of fishes at local markets at the rate of Rs. 60/- to 120/- per kg depending upon the species of fishes. The rest catch will be consumed by the family.

The condition of fish market is very poor in the Tinau River area. During the investigation period, a few temporary fish shops had been noticed at Butwal, Bethari, and Bhairahawa. According to the local fishermen, the government has no plan to set up the fish market in the area.

11. EFFECTS OF DAM ON FISHERIES

Hydro dam of Tinau River is located at Dovan, about 4 km away from Butwal, for producing hydroelectricity of 1000 kilowatt. This hydropower plant was established in 2022 B.S. by Butwal Power Company with the financial support of UMN to Nepal which was completed in 2o32 B.S. In B.S. 2037 it was handover to Nepal Electricity Authority. There is only one iron-gate especially used to direct the flow of water towards the turbine through tunnel. The powerhouse is located near the Siddhababa temple which is approximately 1 km away from the dam.

The effect of dam in Tinau River is more pronounced and has affected the abundance and distribution of fish population in the river. The dam in Tinau River has obstructed the seasonal migratory fishes from the Terai as well as local migratory fishes from the lower parts of Hilly region. According to the local people and fishermen, before the establishment of dam in the river, shoals of Gounch (*Bagarius bagarius*) and Thedi (*Labeo angra*) used to visit the areas above dam, and now they are completely disappeared from this area while they were reported from the lower region by fishermen in the month of July during the present investigation period.

The dam is generally disadvantageous to current loving and migratory fishes and also has reduced the surface area of fishing water to downstream. At the place of dam the course of river channel is directed towards the west bank of river where the tunnel has been made and there is absence of reservoir. A continuous flow of water is regulated to the downstream from the dam. Many current loving species of fishes can not cross the physical barrier of the dam as a result their upstream migration have been checked and many good sized Gounch (*Bagarius bagarius*), Thedi (*Labeo angra*), Jalkapoor (*Pseudeutropius sps*) have ceased to visit the upstream reaches of the river. Similarly the number of upstream migrant like Tor sps are reduced considerably in the downstream while the fishes which are totally inhabiting in low water are not affected and have got a good hydro biological condition such as Sidre (*Puntius sps*), Fageta (*Barilius sps*), Gadela (*Noemacheilus sps*) and Buduna (*Garra sps*). they have undergone a rapid increase due to the absence of their predatory fishes like *Tor tor* etc. As a result, the abundance of large sized migratory fishes have been gradually replaced by small fishes, certainly such a

replacement reason plays a negative role in fishing occupation and finally fishermen are enforced to do other baseless jobs to maintain their lives.

No environmental impact assessment (EIA) of Tinau Hydroelectric Project before the establishment of hydro dam was conducted. Therefore, the present author could not study the comparative study of fish biodiversity before and after the dam construction. In the Tinau Hydroelectric Project only engineering feasibility study was performed. There is no doubt that the Tinau River system has undergone great many changes and structure and function of natural water courses as well as its physical, chemical and biological characteristics.

12. CONSERVATION AND MANAGEMENT CONSIDERATIONS OF TINAU RIVER

The Tinau River supports 35 fish species of biologically diverse ichthyofauna with predominance of family Cyprinidae. There are serious problems in Tinau River regarding fish conservation and management.

12.1 MANAGEMENT PROBLEMS IN THE TINAU RIVER

There are no management activities under way in the riverine fishery in Tinau River. Some of the important management problems associated with the Tinau River are as follows:

12.1.1 Destruction of Natural Habitat by Land Slides

Improper land use system and heavy deforestation in the Hilly area cause landslides which destroy the natural fish habitat in the Tinau River (Gross soil loss 286956 ton/yr and soil loss rate 59.18 ton/ha/yr, DSCWM and DSCWMO, 1992).

12.1.2 Destruction of Natural Habitat by Dam Construction

Construction of dam without fish ladder for generating electricity in Tinau River has consequently checked the upstream and downstream migration of fishes for their breeding and feeding purposes, e.g., *Tor tor*. Such a dam may eventually reduce the production which also creates circumstances of extermination of local fish species (Shrestha, 1991).

12.1.3 Use of Destructive Fishing Methods

In the Tinau River fishes are being killed by destructive methods like poisoning and dynamiting in the diverted river channel and pool regions respectively. Such fishing methods not only kill the fries, fingerlings and brood fishes but also destroy the breeding habitats of the fish themselves.

12.1.4 **Lack of Awareness**

Lack of awareness about the importance of riverine fishery in the local inhabitants is the major problem for the destruction of riverine fishes. Uneducated local fishermen do not understand the destructive nature of the use of poison, dynamite and the importance of natural habitat of fish.

12.2 **RECOMMENDATIONS**

Although a work on soil conservation and watershed management has been continuing in Palpa district by a project of HMG in combination with Germany and Switzerland, no work has been done for the conservation strategy of fish fauna in the Tinau River by any sector so far. Due to the absence of due priority on the conservation and management of riverine fisheries in Tinau River in the past, there is a degradation of riverine fishes. Therefore, for successful conservation and management of indigenous fish species in the Tinau River, following recommendation can be made.

12.2.1 **Ban of Harmful Fishing Implements**

The fine meshed net like Cast net, Bhureli jal, and mosquito nets which catch fish juveniles must be banned because they reduce the survival rate of fish species.

Fish poisons are widely used in diverted river channel, most of which are derived from plant parts such as Khirro (*Sapium sps*), bark of Kafal (*Myrica esculanta*), stem of Siudi (*Cactus sps*) etc. Sometimes very dangerous chemical pesticides like malathion and Metacid are also used which wipe out all the biomass of aquatic life. Hence, public should be made acquainted with the importance of fish conservation and the destructive effects of the poisons.

Dynamiting has been reported from the large pool regions of the Tinau River which is a destructive method killing all the types as well as age groups of fishes. Hence, it must be checked and totally banned. Sometimes fishes are being hunted by rock

striking method. Although it is less destructive than poisoning and dynamiting, but fish of all the stages is destructed by rock striking, therefore, this should also be banned.

Hence, all of these harmful means and methods of fishing must be checked and totally banned for the proper conservation and management of fish biodiversity.

12.2.2 **Closed Fishing Seasons**

Different kinds of fishes breed in different seasons; spawning run of Asala (*Schizothorax sps*) and Sahar (*Tor sps*) begin during September and October while many small hill stream fishes spawn in March. Usually, female fishes with thousands of eggs in their ovary are caught in high number during breeding seasons due to which a large quantity of egg resources is being perished by the killing of brood fishes. Thus, fishing activities should be stopped during these months. Setting up of close season increases spawning opportunity and will enhance increase in fish population.

12.2.3 **Provision of Fish Way through Dam**

The hydroelectric dam in Tinau River at Dovan has created a great problem for migratory fishes which has practically obstructed the upward movement of fishes such as Sahar (*Tor sps*), Gounch (*Bagarius bagarius*) and Thedi (*Labeo angra*) etc. The dam should be provided with fish lifts, fish ladder and other by pass facilities to enhance upstream migration of fishes. At the same time, there should be provision for monitoring of the physico-chemical properties, fish fauna and other aquatic life of natural water bodies before and after the construction of hydropower or irrigation dams to enhance the fish production and protection of indigenous species as well as to study the effect of dam on aquatic life and fish fauna.

12.2.4 **Fish Sanctuary**

Closed seasons or prohibited areas are also common devices for protection of rare fish stock as well as common fish stock. The basic aim of such areas is to allow the fish freedom to complete their spawning cycle and early life cycle without being hindered.

The area inhabited by rare species of fishes should be protected as fish sanctuary to protect them. Similarly, some of the areas of Tinau River are densely populated with fish fauna (e.g., Dovan locality), which should be protected as fish sanctuary to provide constant and quantitative, increase of fish population throughout the river.

12.2.5 **Habitat Improvement**

Foe maximum yield, rivers should be maintained in good hydro biological condition. The fluvial processes such as water level, discharge and siltation should be controlled by check dams and further winter desiccation should be avoided by the management of suitable pools by constructing natural rocks or boulder dams across the river during dry spell of summer and winter. Such a practice will improve the fish habitat quality. Deforestation, soil erosion and silting of riverbed have greatly changed the natural environment of the Tinau River. Therefore, management practices must be done to restore the ecological balance for natural fish habitat.

12.2.6 **Need for Pollution Control**

Pollution caused by the disposal of unwanted domestic materials and toxic substances carries adverse effects on biotic communities by impeding reproduction at various levels of food chain which ultimately lead to low fish yield. Therefore, there is an urgent need to check these substances before discharging into the river.

12.2.7 **Stocking Fish Population**

Population of economically important fishes is going down owing to high fishing pressure such as Mahaseer (Tor sps), Snow trout (Schizothorax sps) and many others. Hence, the fishing water of Tinau River may be enriched with fish by releasing hatchery-reared larvae of such important fishes.

12.2.8 **Protection of Feeder Stream**

Most of the fishes spawn in the feeder streams of Tinau River like Dovan Khola, Jhumsa Khola, Sisne Khola, and Dumre Khola etc. Hence, these feeder streams should be declared as fish sanctuary so that it will help to protect migratory spawners.

13. DISCUSSION

A river and its watershed are normally considered as being physically and chemically a single system. Within the running surface waters of any such system, however, considerable differences can occur in water velocities, volumes, depth and riverbed materials. All of these parameters give to a river system a wide and diverse range of habitats for fishes. Factors of ecological significance which exhibit a progressive change in value along the length of rivers are: current velocity, substratum, flow, temperature, dissolved oxygen, hardness and other organisms which are interdependent (Whitton, 1975).

13.1 DISTRIBUTION OF ICHTHYOFAUNA IN TINAU RIVER

A total of one hundred and eighty five indigenous fish species are reported to exist in river systems and other natural and man made water bodies of Nepal (Shrestha, 1995) included in 79 genera belonging to 31 families and 11 orders. Shrestha (1981) has reported eight fish species from the Tinau River belonging to the families Cyprinidae, Cobitidae and Amblycipitidae which are; *Barilius bola, Danio devario, Garra annandalei, Garra gotyla, Tor putitora, Noemacheilus botia, Noemacheilus rupicola, Amblyceps mangois*, among which *Barilius bola, Tor putitora* and *Amblyceps mangois* were not observed in the present study period.

According to the local fishermen, *Bagarius bagarius* was abundant in this river system before the construction of dam. After the construction of the dam (at station III) this fish species no longer exists in the upper regions of the dam, i.e., station I, II and III. Only few small *Bagarius bagarius* were observed by local fishermen at station Iv, in the month of July during the present investigation period. They also gave the information about the existence of *Acrossocheilus hexagonolepis* and *Labeo angra* in the Tinau River.

Majority of fish species in Tinau River fall under the family Cyprinidae (about 82 % of the total catch, Figure 2), of which sub-family Cyprinini includes *Barilius barila, Barilius bendelisis, Barilius vagra, Cirrhinus reba, Danio devario, Danio rerio, Esomus dandricus, Garra annandalei, Garra gotyla, Oxygaster bacaila, Puntius*

chilinoids, Puntius sophore, Puntius conchonius and *Tor tor*. Sub-family Psilorhynchini includes *Psilorhynchus pseudecheneis* and *Psilorhynchus sucatio*. Similarly, sub-family Schizothoracini includes two genera; *Schizothorax* and *Schizothoraichthys* which, according to Shrestha (1994), are commonly distributed at an altitude ranging from 784 meter to 3323 meter. These two genera were collected from the lower altitude (251 meter) at station III in the Tinau River.

Family Cobitidae which consists of about 12 percent of total catch includes genus *Botia, Lepidocephalichthys* and *Noemacheilus* are distributed at stations I, II, III and IV.

Family Bagridae includes only one species, viz., *Mystus bleekeri*. Similarly, each family Sisoridae, Schilbeidae, Saccobranchidae, Claridae, Channidae, Nandidae, Gobidae also includes one species such as *Glyptothorax pectinopterus, Pseudeutropius atherinoides, Heteropneustes fossilis, Clarius batrachus, Channa gachua, Nandus nandus, Glossogobius giuris* respectively. Among them *Mystus bleekeri, Pseudeutropius atherinoides, Clarius batrachus* and *Nandus nandus* were reported from station V. *Glyptothorax pectinopterus* was reported from station II and III, *Heteropneustes fossilis* from station I, *Channa gachua* from stations I, III and IV; and *Glossogobius giuris* from stations III and V respectively.

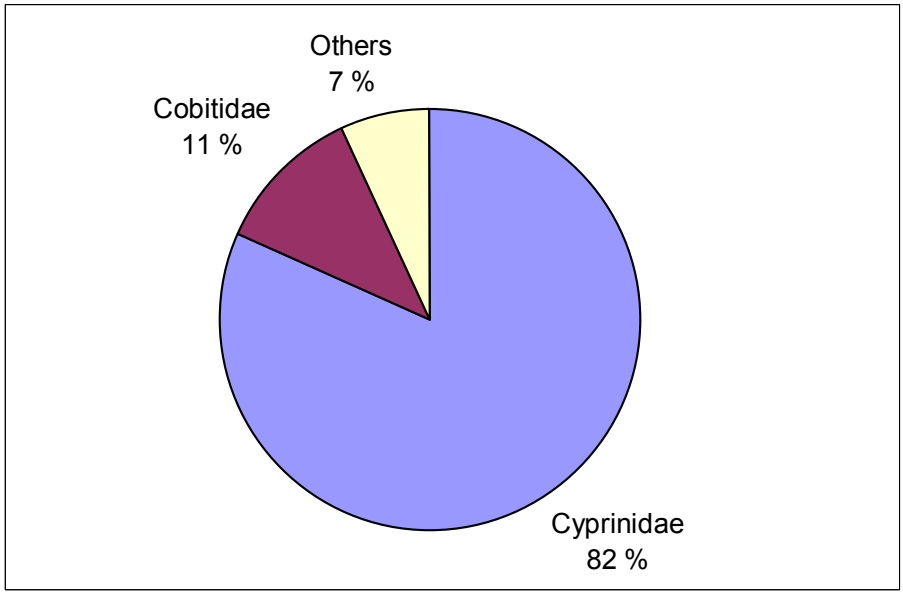


Figure 2: Family-wise Fish Species Composition (in total catch number) in Tinau River (1994/1995).

Family Mastacembelidae includes only 3 species; *Macrognathus aculeatus, Mastacembelus armatus* and *Mastacembelus pancalus* among which *Mastacembelus armatus* was reported from station III while the rest were reported from the station V.

Family Notopteridae includes only one species *Notopterus notopterus* which was distributed at the station V.

The most dominant fish species are *Barilius bendelisis, Puntius sophore* and *Garra gotyla* which form about 54 percent of the total catch.

13.2 EFFECTS OF PHYSICO-CHEMICAL PARAMETERS ON FISHES IN TINAU RIVER

While in many respects the physical quantities of the environment appear to be basically more important than the chemical ones in governing the distribution of fishes (Hynes, 1970).

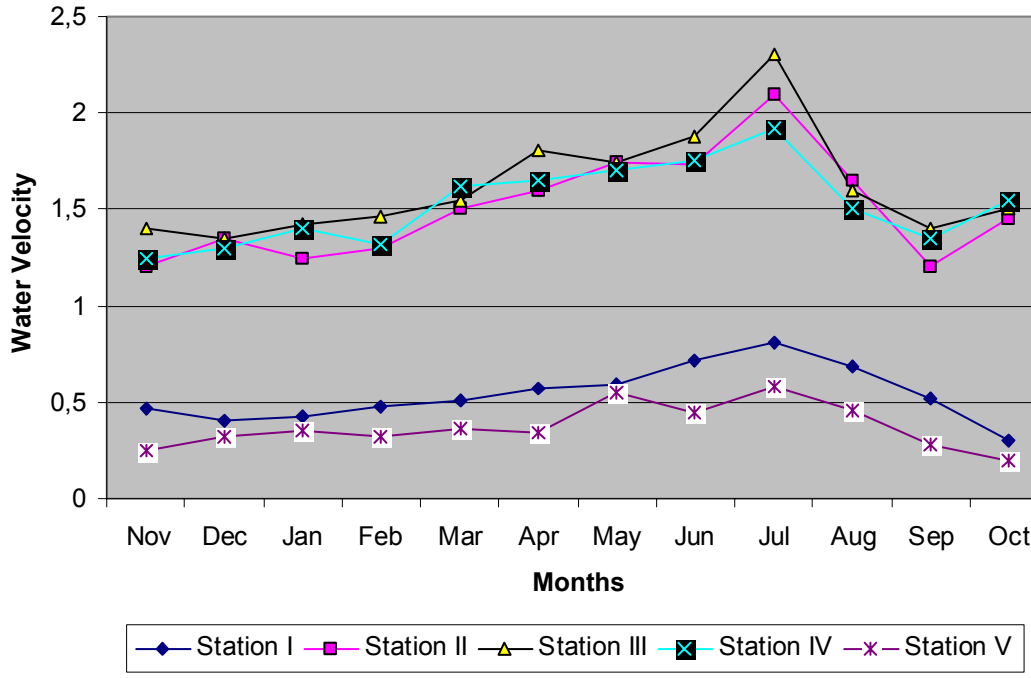
The watercolour indirectly affects the fish population by fascinating the sunlight penetration which in turn increases plankton production. The river water was clear throughout the year except in monsoon when the watercolour was greyish (muddy).

The water velocity plays a major role in the determination of the habitat and abundance of the flora and fauna in a river by grading the riverbed and material and maintenance of high levels of dissolved oxygen (Whitton, 1975). In Tinau River the velocity of water has positive correlation co-efficient value (r = 0.224) with dissolved oxygen which explains the increment of dissolved oxygen with the increase of water velocity (probable error, P.Er. = 0.185).

Water velocity is mainly regulated by the slope gradient of the river bed which is highest at the station III (Figure 1) where the large number of torrential hill stream fishes were reported, e.g., *Tor tor, Schizothorax plagiostomus, Schizothoraichthys esocinus, Garra gotyla, Glyptothorax pectinopterus* etc.

Figure 3 explains that the current velocity of water in Tinau River is not uniform. Stations II, III and IV have comparatively higher velocities (1.5, 1.62 and 1.53 m/s respectively) than the stations I and V (0.54 and 0.37 m/s respectively), this is because of the slope gradient of river bed which is higher at the stations II, III and IV than at stations I and V. Stream velocity is merely the function of slope gradient of the river bed (Jhingran, 1975). In the present investigation, low velocities in the stations I and V may be due to the maximum flatness as well as minimum slope gradient of the riverbed.

Figure 3: Water Current Velocity (m/s) Variations at Different Stations of Tinau River in Different Months 1994/1995.

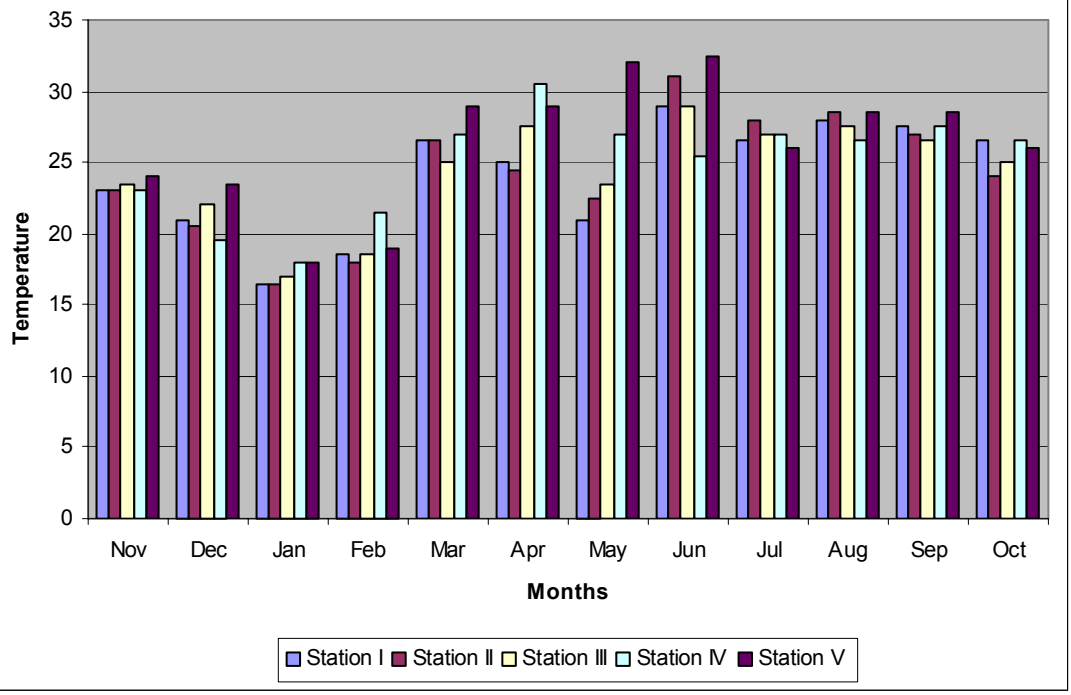


Slope gradient is maintained by the altitudinal variations in riverbed and the altitude has a negative correlation (- 0.6805) with composition of fish fauna with probable error 0.105 in the Tinau River, i.e., composition of fish fauna increases with the decrease of altitudinal range in the Tinau River.

All the aquatic organisms including fish have well defined limits of temperature tolerance. Temperature has an important influence on the physical and physiological

activities of fishes, affecting growth rate, for example, the places with boulders, pebbles, gravels and fine sandy substrate with water temperature 15°C to 18°C and current velocity 3 to 9 m/s are dominated by Sucker head fish, Garra sps, Shrestha, 1990). The water temperature range in the Tinau River was in between 16.5°C and 32.5°C which is favourable for different types of hill stream fishes (Figure 4). Similarly, Figure 5 explains the air temperature pattern in the Tinau River at all the stations.

Figure 4: Water Temperature (oC) Variations at Different Stations of Tinau River in Different Months 1994/1995.



Present investigation shows that the surface water temperature usually follows the air temperature pattern (Figure 6). Same type of relationship between air temperature and water temperature was also observed by Karna (1993).

Figure 5: Air Temperature (oC) Variations at Different Stations of Tinau River in Different Months 1994/1995.

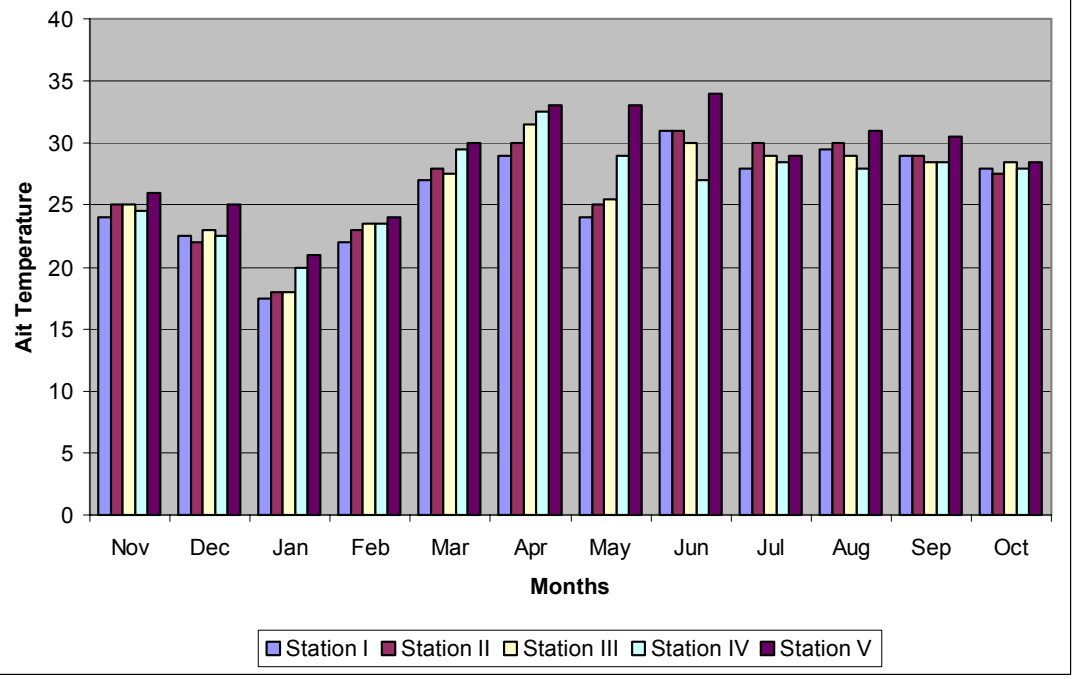
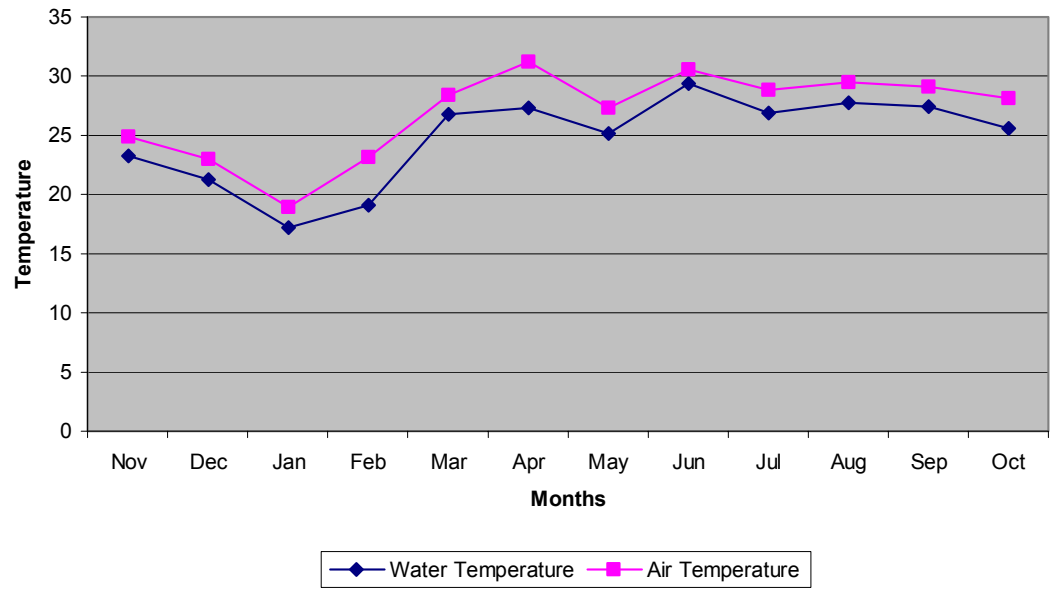


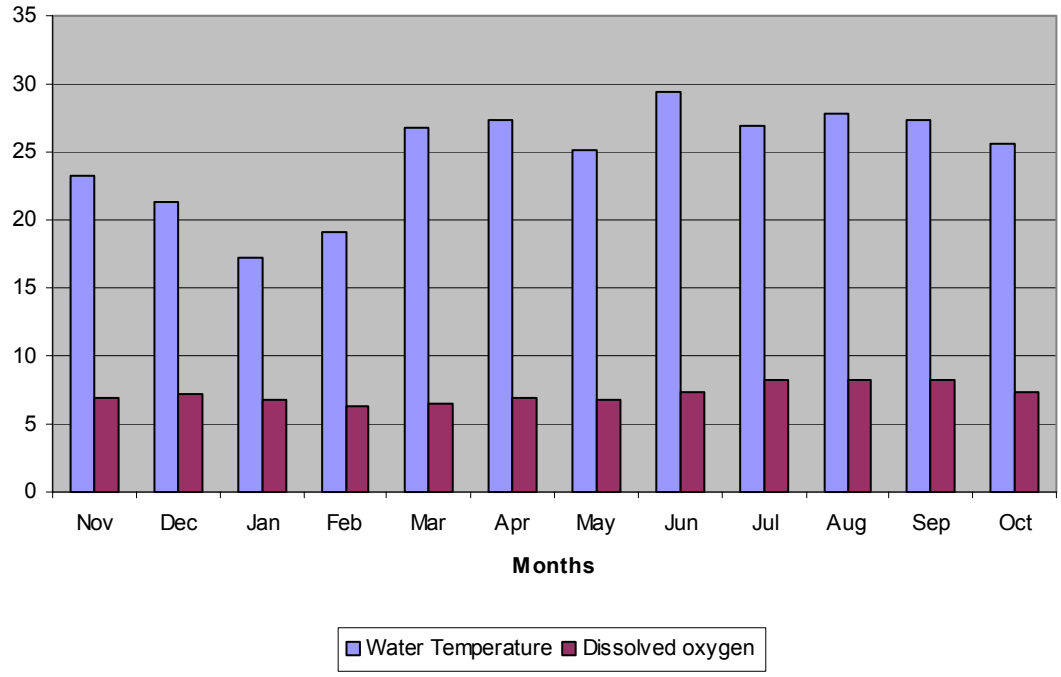
Figure 6: Relation between Air Temperature and Surface Water Temperature (oC) in Tinau River 1994/1995



Temperature greatly influences the dissolved gases, for example, dissolved oxygen. The increase in the water temperature of the river decreases the concentration of

dissolved oxygen and vice versa which is shown in the Figure 7, and is also explained by the negative value of correlation coefficient in between dissolved oxygen and water temperature (r = - 0.783) with probable error (P. Er. = 0.117).

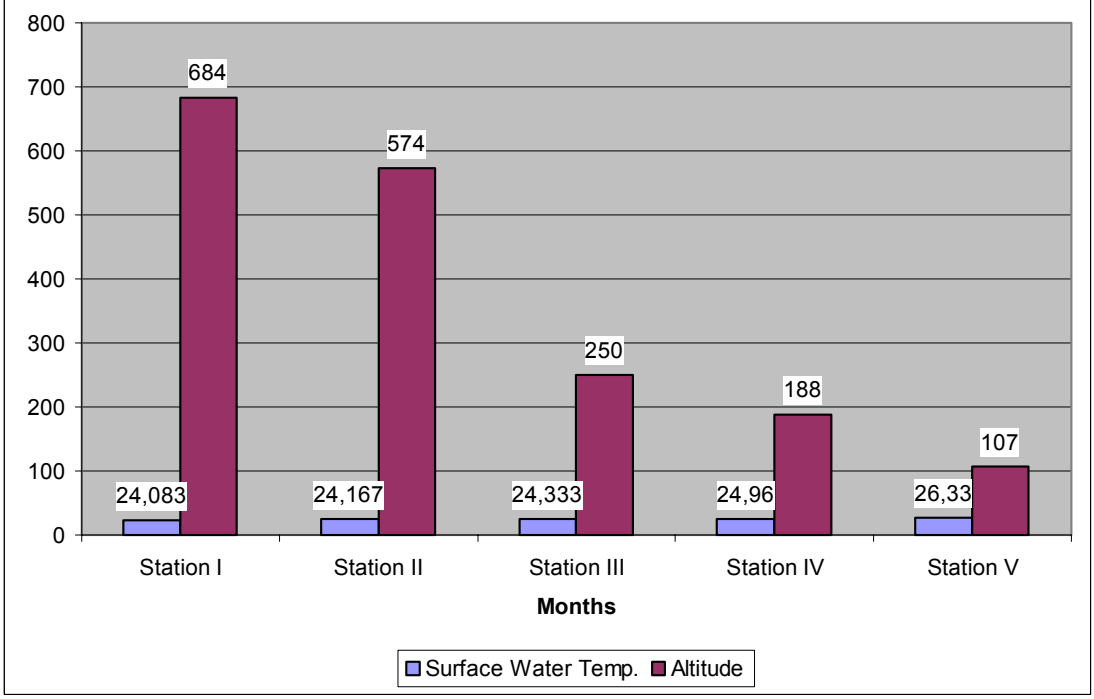
Figure 7: Correlation between Surface Water Temperature (oC) and Dissolved Oxygen (mg/l) in Tinau River 1994/1995.



Generally stream temperature ranges from about 0°C in high latitude and at high altitudes to about 30°C in the tropics. In the present investigation the temperature increases with the decrease of altitude in all the stations (Figure 8). In the whole, Tinau River shows negative correlation in between altitude and surface water temperature (r = - 0.448) with probable error (P. Er. = 0.241) which explains the decrease of temperature with increase in the altitude.

Fish species composition shows the positive correlation (r = 0.555) with surface water temperature, with the probable error 0.263, i.e., fish species composition increases with the rise in temperature in the Tinau River.

Figure 8: Correlation between Altitude (m) and Average Surface Water Temperature (oC) in Tinau River 1994/1995.



Transparency, that directly or indirectly determines the productivity of the river by controlling the penetration of solar radiation, seems to be one of the major physical parameters. During the present investigation period the river water remained highly transparent throughout the year except in monsoon (Figure 9). This temporary decrease in transparency value in monsoon was caused by the rainfall and flood. The transparency shows the highly negative correlation (- 0.9854) with the turbidity value in the Tinau River which restricts the penetration of sunlight and hence reduces photosynthesis activity, which in turn is related to the productivity of water mass.

During the present investigation period the highest turbidity value recorded in the month of July at all the five stations (291.63 mg/l at station V) in the Tinau River which has been explained in Figure 10. According to Jhingran (1975), the turbidity of natural water system may be due to the suspended inorganic substances such as silt and clay or due to planktonic organisms. In the present study the turbidity was mainly caused by the mixing of sand and clay particles resulting from soil erosion and rainfall during monsoon.

Figure 9: Transparency (cm) Variations at Different Stations of Tinau River in Different Months 1994/1995.

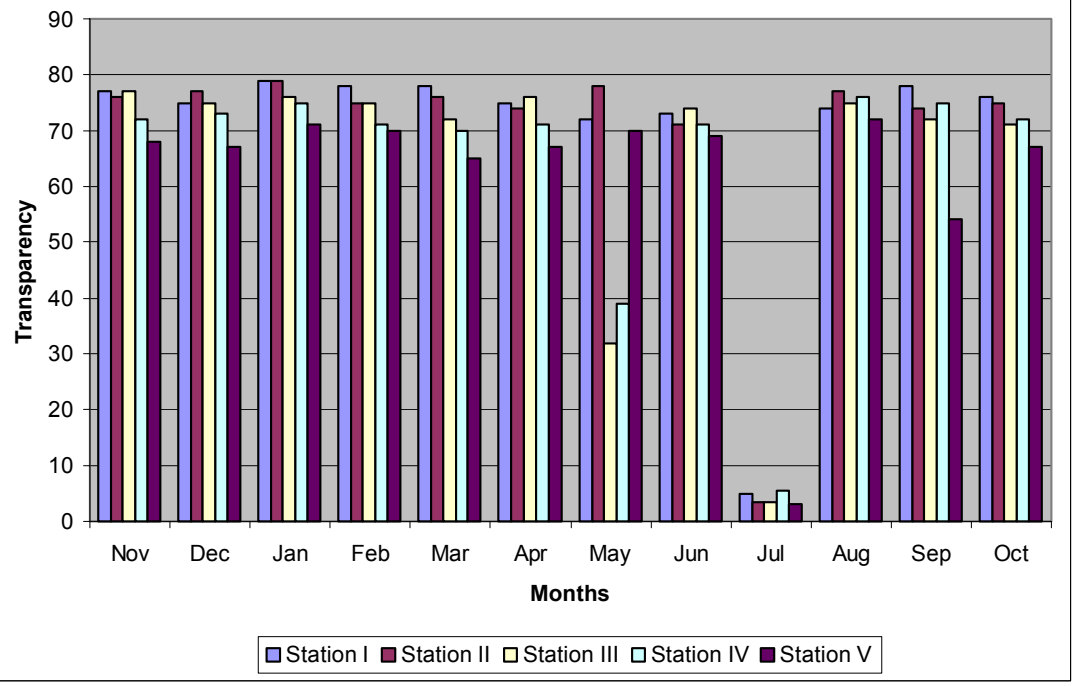
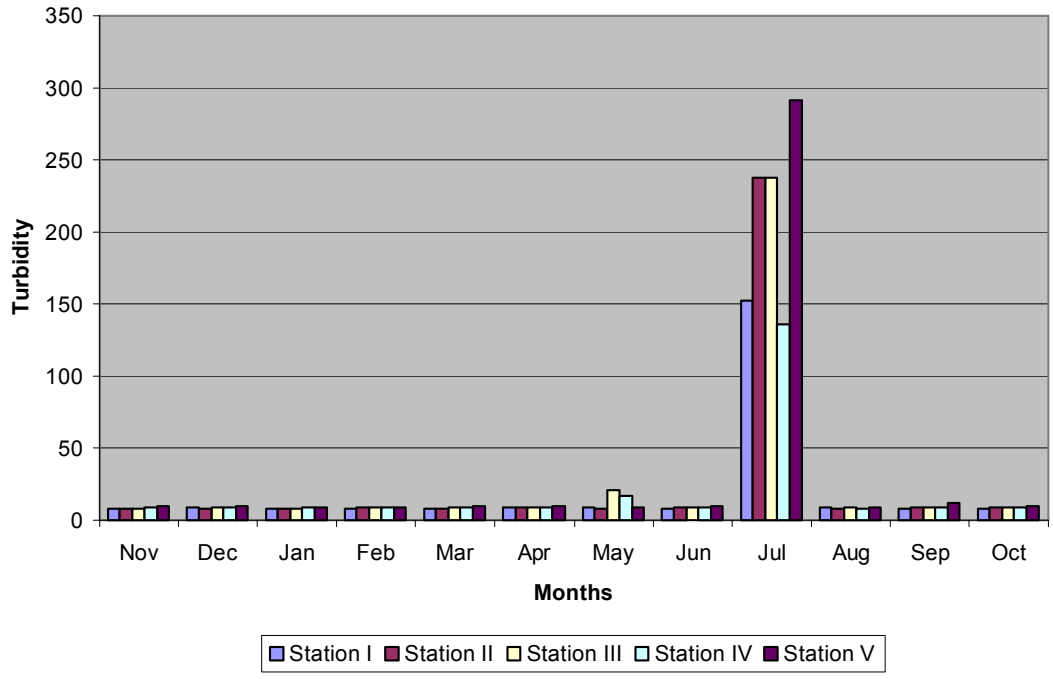
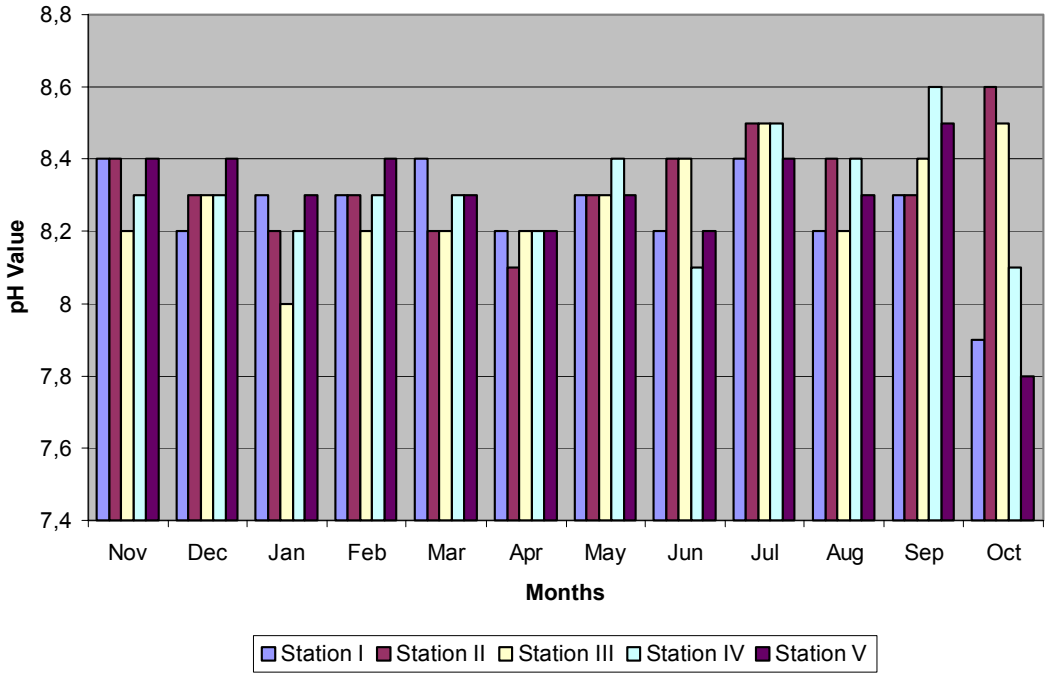


Figure 10: Turbidity (mg/l) Variations at Different Stations of Tinau River in Different Months 1994/1995.



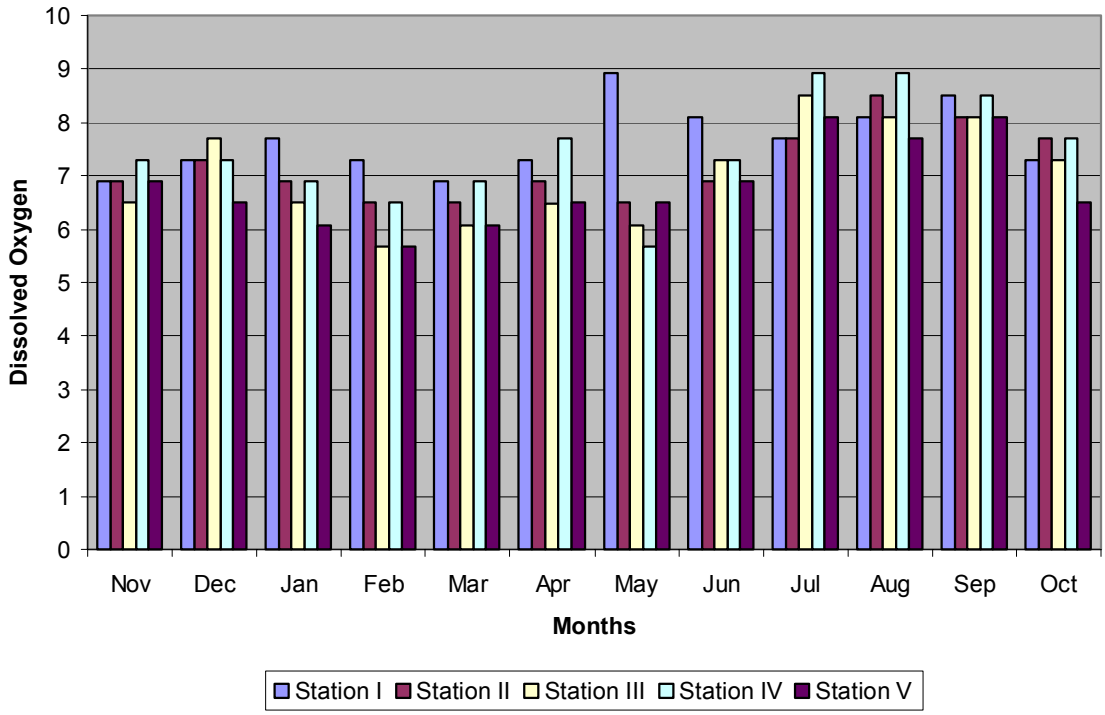
Under most natural conditions variation in pH value has little effect on fishes, which can tolerate the normal daily pH range (Whitton, 1975). According to Welch (1952, cited in Manandhar, 1994), the currents in lotic environment tend to keep pH uniform over considerable distances. In the Tinau River the pH value fluctuated narrowly (0.8) with an average value of 8.294 which is explained in Figure 11. In Tinau River the pH value shows positive correlation r = 0.382 and probable error 0.166 with fish species composition, which shows slightly increment of fish species composition with the rise of pH value within this range in Tinau River.

Figure 11: pH Value Variations at Different Stations of Tinau River in Different Months 1994/1995.



Perhaps the most important chemical quality which affects the distribution of fishes is that of the concentration of dissolved oxygen. According to APHA (1976) the dissolved oxygen concentration above 5 mg/l is suitable for the support of diverse biota. The dissolved oxygen of Tinau River was never below 5.68 mg/l throughout the year (Figure 12); hence, it is good for fish habitat.

Figure 12: Dissolved Oxygen (mg/l) Variations at Different Stations of Tinau River in Different Months 1994/1995.



Dissolved oxygen of the Tinau River shows the positive correlation (0.527) with the composition of fish fauna, and the probable error is 0.14, i. e, composition of fish species increases with the increase of dissolved oxygen in this river.

Jhingran (1975) suggested about the fluctuation in total alkalinity of natural water bodies, stating that the hill streams, sandy and rocky areas, flooded rivers in the rainy season usually have low total alkalinity. During the present investigation the total alkalinity value of the water sample was recorded 54.054 mg/l as maximum at station V in January and 12.012 mg/l as minimum at station I in May (Figure 13).

Sum of the concentrations of alkaline earth metal cations (e.g., Ca^{++} and Mg^{++}) forms the total hardness in natural water. Lind (1974, cited in Karna, 1993) reported that hardness more than 100 mg/l of $CaCO_3$ is common in Nepal. During the present investigation period the total hardness ranged between 54 mg/l to 204 mg/l (Figure 14) which is favourable for riverine fishes.

Figure 13: Total Alkalinity (mg/l) Variations at Different Stations of Tinau River in Different Months 1994/1995.

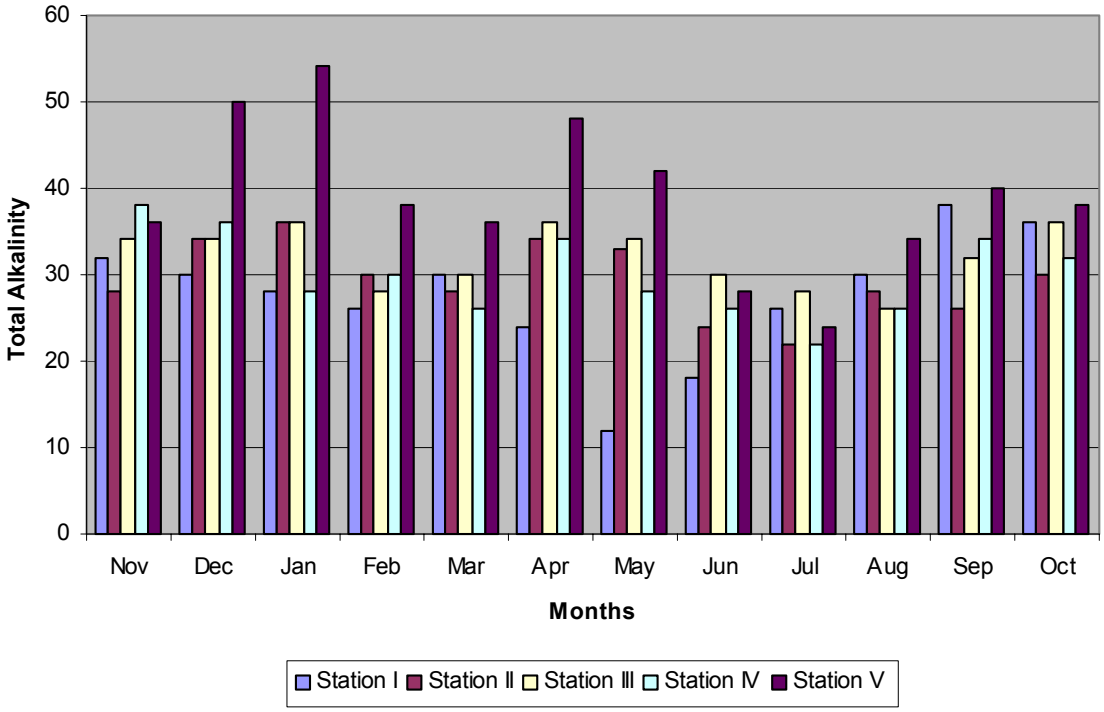
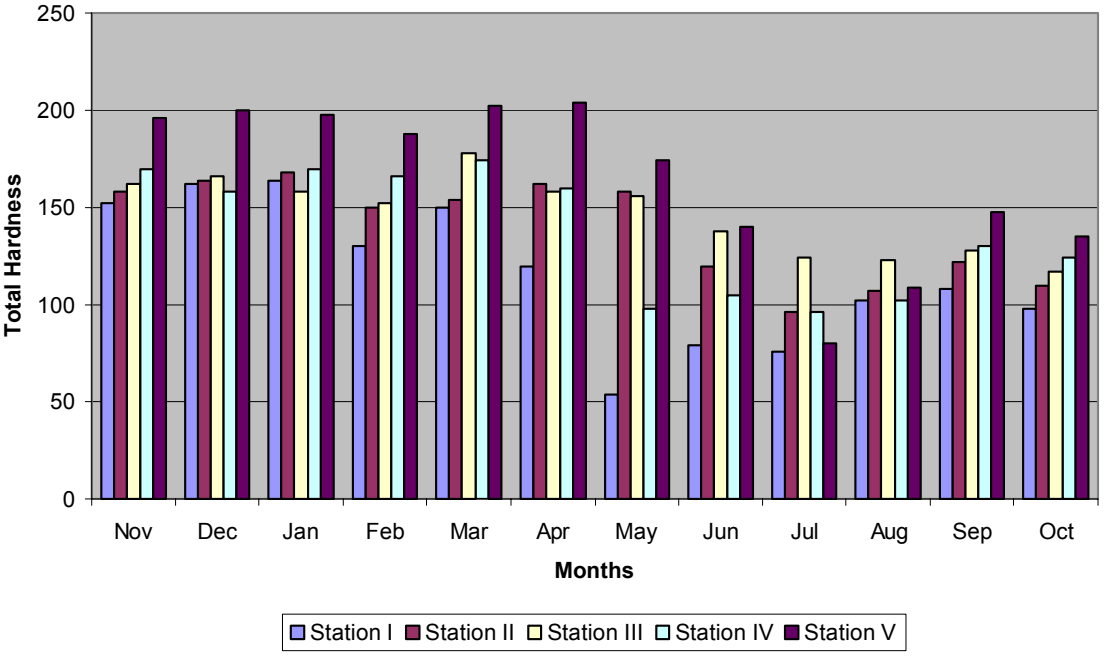
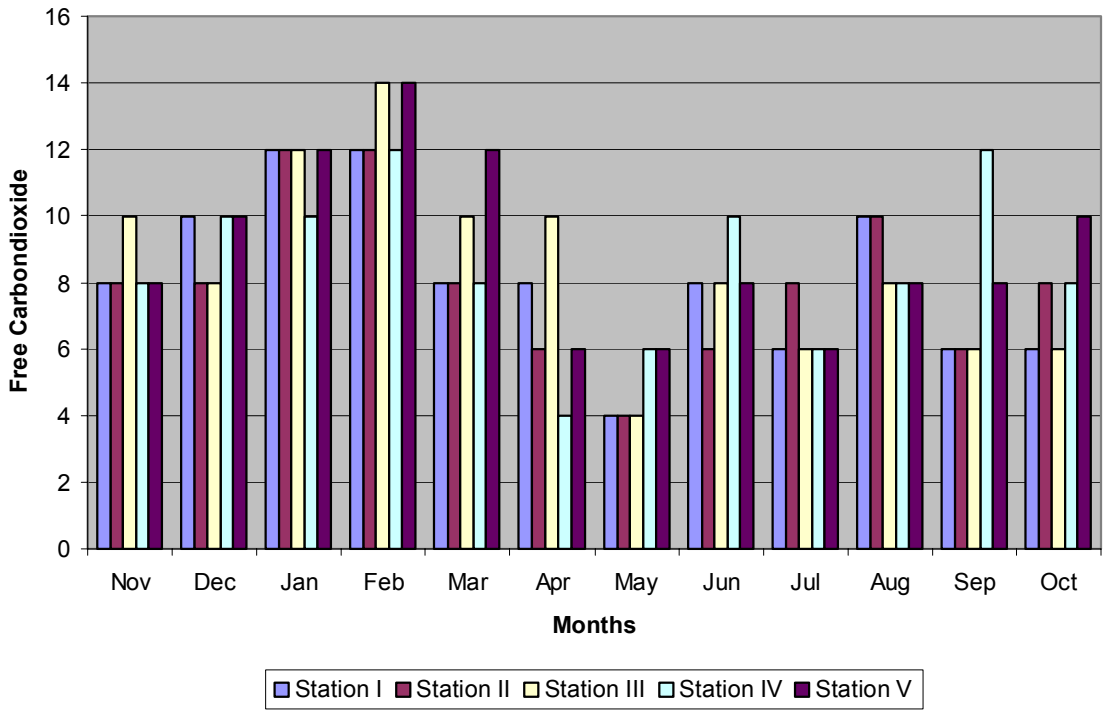


Figure 14: Total Hardness (mg/l) Variations at Different Stations of Tinau River in Different Months 1994/1995.



During the present investigation period, the free carbon dioxide of the Tinau River was recorded in between 3.99 mg/l and 13.99 mg/l (Figure 15). Most of the CO_2 in water comes from the decomposition of organic matter and from respiration of organisms which helps in the formation of bicarbonates and carbonates and keeps fluctuation of pH under check. Variation of free carbon dioxide value in the Tinau River shows the negative correlation (r = - 0.486) and probable error is 0.148 with the composition of fish species, which explains the negative effect of free carbon dioxide on the composition of fish species.

Figure 15: Free Carbondioxide (mg/l) Variations at Different Stations of Tinau River in Different Months 1994/1995.



Few planktons could be reported during the present investigation period among which *Spirogyra* (phytoplankton) was abundant which form the main food for fishes.

Fishermen of Tinau River are poor and are dominated by the people of higher caste, about eighty three percent of whom are totally illiterate. They are not aware of free education in government schools and family planning systems so that they have got a huge family member which is the main reason of their poverty. Insufficient

agricultural land and huge family member led them to over-fishing which causes the degradation of riverine fishery. Bhagat (1985) and Joshi (1988) have also found the poor economic conditions of the fishermen in Morang district and Sunkoshi river area respectively.

According to the local inhabitants, the Tinau River has undergone many changes in structure and function of natural watercourses as well as its physical, chemical and biological characteristics which in turn have affected the distribution pattern of fish fauna. During the present investigation period, the fish fauna reported just below the dam site (station IV) are; *Barilius barila, B. bendelisis, B. vagra, Danio devario, D. rerio, Garra annandalei, G. gotyla, Puntius conchonius, P. sophore, Botia lohachata, Noemacheilus botia* and *Channa gachua*. While the fish fauna reported from the upper reaches of dam site (station III) are; *Barilius barila, B. bendelisis, B. vagra, Danio rerio, Garra annandalei, G. gotyla, Oxygaster bacaila, Puntius chilinoids, Tor tor, Psilorhynchus pseudecheneis, P. sucatio, Schizothorax plagiostomus, Schizothoraichthys esocinus, Botia lohachata, Noemacheilus beavani, N. botia, N. rupicola, Glyptothorax pectinopterus, Channa gachua, Glossogobius giuris* and *Mastacembelus armatus*. The important food cum game fishes like *Tor tor, Puntius chilinoids, Noemacheilus sps* and many other species are affected for their migration (both local and long migrants) across the dam site. Present investigation also shows that the good sized fish species like *Tor tor* and delicious fish species like *Schizothorax plagiostomus* etc. are replaced by the small sized fishes as *Barilius bendelisis* (about 25 % of total catch composition), *Puntius sophore* (about 18 %) and *Garra gotyla* (about 11 %) etc. which plays negative role in the fishery occupation.

One hundred and eighty five species of fish have been recorded from Nepal, of which eight are endemic (BPP, 1995c) one of which, *Psilorhynchus pseudeucheneis* is reported from the Tinau River. According to Shrestha (1995), thirty-four of the 185 fish species in Nepal are threatened and merit Red Data Book status. The majority of these species belong to the genera *Labeo* (five species), *Puntius* (seven species) and *Schizothorax* (four species) but only five threatened species of fishes are reported from the Tinau River, viz., *Puntius chilinoids, Tor tor, Danio rerio, Schizothorax plagiostomus* and *Psilorhynchus pseudeucheneis*. It is recommended that legal protection be accorded to ten fish species out of which four species, viz., Tor tor

(endangered), Danio rerio (Vulnerable), Schizothorax plagiostomus (Vulnerable) and Psilorhynchus pseudeucheneis (Vulnerable) are reported from the Tinau River.

The study of ecology of the Tinau River and its tributaries is important for the development of fishery resources in this region as well as for the protection of threatened species of fish fauna which are reported from this river during the present investigation. Thus, recommendations are also made for conservation and management in the Tinau River.

SUMMARY

The present study, entitled "Study on the Fish Biodiversity and Fishery Resources of the Tinau River", was conducted for a period of one year (from November 1994 to October 1995). This study has dealt with the fish fauna, their distribution pattern in the different sections of the river, some of the physico-chemical and biological parameters, and management consideration of Tinau River. This study has also included the study of socio-economic status of fishermen and fishing implements and methods used in Tinau River. A total of 35 species of fish fauna was collected from the different stations of Tinau River which belongs to 5 orders, 12 families, and 25 genera. A large number of fishes were collected with the help of local fishermen mostly by using cast net but other methods were also used for sampling the fish species.

The physical condition of the river and chemical nature of the water were specified at different sections of the Tinau River. The current velocity ranged between 0.20 m/s to 2.3 m/s. The surface water temperature varied from 16.5^{o}C to 32.5^{o}C at different stations in different months. Despite pollution created by different factors, the chemical nature of river water seems to be an ideal environment for fish habitat yet. The river water was always saturated with dissolved oxygen. A good concentration of total hardness was found and the water body was never found acidic in nature.

Among the eight endemic fish species found in Nepal, categorised by NRDB (BPP, 1995), *Psilorhynchus pseudeucheneis* has been reported in the Tinau River. Similarly, among ten fish species recommended for legal protection, four species namely, *Tor tor, Danio rerio, Schizothorax plagiostomus* and *Psilorhynchus pseudeucheneis* have also been reported in this river during the present investigation period.

Fishes are not distributed uniformly in the Tinau River which is influenced by the current velocity, water temperature, altitude and riverbed etc. Upper reaches of the Tinau River are inhabited by *Tor tor, Garra gotyla, Barilius bendelisis, Noemacheilus sps* and *Glyptothorax sps* etc. while the lower reaches (Terai region) are dominated by *Puntius sps*.

Although, both types, i.e., migratory and resident, of fishes were reported from the Tinau River, there is only one migratory fish species, viz., *Tor tor*. Rest of the ichthyofauna reported from this river during the study period are resident or local migrant species. Tinau River consists of some of the economically important fishes such as *Tor tor, Schizothorax plagiostomus, Garra gotyla, Channa gachua, Barilius bendelisis, Heteropneustes fossilis, Noemacheilus sps* etc.

Present study shows the poor socio-economic status of fishermen in Tinau River area; about 83 percent of whom are totally illiterate. Lack of productive agricultural land (average 0.26 ha per family) and huge family (6-11 family members) are the main causes for their poverty. They use both types, i.e., destructive and non-destructive fishing implements, without caring harmful effects in fishery production.

Hydroelectric dam constructed in the Tinau River at Dovan has negative effects for the distribution of migratory fishes (both long and local migrants) such as *Tor tor, Pseudeutropius atherinoides* etc. which migrate for the purpose of breeding as well as feeding. Similarly, *Bagarius bagarius* which used to visit the upper reaches of Tinau River are now totally disappeared from upstream of the dam site.

The present study on the fish biodiversity and fishery resources of the Tinau River and their management and conservation considerations would help for the development, management and conservation of the riverine fishery in the mountainous country like Nepal.

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APPENDIX – I

CHECKLIST OF ICHTHYOFAUNA IN THE TINAU RIVER

ORDER: CLUPEIFORMES

FAMILY: NOTOPTERIDAE

Genus: *Notopterus* (Lacepede 1800)

1. *Notopterus notopterus*

ORDER: CYPRINIFORMES

FAMILY: CYPRINIDAE

Genus: *Acrossocheilus* Osima, 1919 or *Neolissocheilus* Rainboth 1985.

2. **Acrossocheilus hexagonolepis* (Mc Clelland) 1939.

Genus: *Barilius* Hamilton 1822.

3. *B. barila* (Hamilton) 1822
4. *B. bendelisis* Var. Chedra (Hamilton) 1822
5. **B. bola* (Hamilton) 1822
6. *B. vagra* (Hamilton) 1822

Genus: *Cirrhinus* Oken 1817

7. *C. reba* (Hamilton) 1822

Genus: *Danio* Hamilton 1822

8. *D. devario* (Hamilton) 1822
9. *D. rerio* (Hamilton) 1822

Genus: *Esomus* Swainson 1839

10. *E. dandricus* (Hamilton) 1822

Genus: *Garra* Hamilton 1822

11. *G. annandalei* (Hora) 1921
12. *G. gotyla* (Gray) 1832

Genus: *Labeo* Cuvier 1817

13. **Labeo angra* (Hamilton) 1882

Genus: *Oxygaster* Van Hesselt 1823 or *Salmostoma* Swainson 1839

14. *O. bacaila* (Hamilton) 1822

Genus: *Puntius* Hamilton 1822

15. *P. chilinoids* (Mc Clelland) 1839
16. *P. conchonius* (Hamilton) 1822
17. *P. sophore* (Hamilton) 1822

Genus: *Tor* Gray 1833-34

18. **T. putitora* (Hamilton) 1822
19. *T. tor* (Hamilton) 1822

Genus: *Psilorhynchus* Mc Clelland 1839

20. *P. pseudecheneis* Menon and Dutta 1961
21. *P. sucatio* (Hamilton) 1822

Genus: *Schizothorax* Heckel 1838

22. *S. plagiostomus* Heckel 1838

Genus: *Schizothoraichthys* Mishra 1859 or *Schizopygel* Heckel 1843

23. *S. esocinus* (Heckel) 1838

FAMILY: COBITIDAE

Genus: *Botia* Gray 1831

24. *B. lohachata* Chaudhuri 1912

Genus: *Lepidocephalichthys* Bleeker 1863

25. *L. guntea* (Hamilton) 1822

Genus: *Noemacheilus* Van Hesselt 1823

26. *N. beavani* Gunther 1868
27. *N. botia* (Hamilton) 1822
28. *N. rupicola* (Mc Clelland) 1839

FAMILY: AMBLYCIPIDAE

Genus: *Ambliceps* Blyth 1858

29. **Amblyceps mangois* (Hamilton) 1822

FAMILY: BAGRIDAE

Genus: *Mystus* Scopoli 1777

30. *M. bleekeri* (Day) 1878

FAMILY: SISORIDAE

Genus: *Bagarius* Bleeker 1853

31. **Bagarius bagarius* (Hamilton) 1822

Genus: *Glyptothorax* Blyth 1860

32. *G. pectinopterus* (Mc Clelland) 1842

FAMILY: SCHILBEIDAE

Genus: *Pseudeutropius* Bleeker 1862

33. *P. atherinoides* Bloch 1794

FAMILY: SACCOBRANCHIDAE

Genus: *Heteropneustes* Muller 1840

34. *H. fossilis* (Bloch) 1785

FAMILY: CLARIDAE

Genus: *Clarius* Scopoli 1777

35. *C. batrachus* (Linnaeus) 1758

ORDER: CHANNIFORMES

FAMILY: CHANNIDAE

Genus: *Channa* Scopoli 1777

36. *C. gachua* (Hamilton) 1822

ORDER: PERCIFORMES

FAMILY: NANDIDAE

Genus: *Nandus* Valenciennes 1831

37. *N. nandus* (Hamilton) 1822

FAMILY: GOBIIDAE

Genus: *Glossogobius* Gill 1859

38. *G. giuris* (Hamilton) 1822

ORDER: MASTACEMBELIFORMES

FAMILY: MASTACEMBELIDAE

Genus: *Macrognathus* Lacepede 1800

39. *M. aculeatus* (Bloch) 1787

Genus: *Mastacembelus* Scopoli 1777

40. *M. armatus* (Lacepede) 1800

41. *M. pancalus* (Hamilton) 1822

* means fish species reported by Shrestha (1981) and local fishermen of Tinau River.