Contents

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-Sooryanarayan S. Bhat

Assistant Professor and Principal Investigator

Chapter – I

Introduction

One of the 34 Biodiversity hot spots of the world, the Western Ghats, together with the west coast form an important ecological region, springing from the Arabian Sea coast to the mountain heights of over 2,000 m. The Western Ghats form a practically unbroken relief dominating the western coast of the Indian peninsula for almost 1600 km from the mouth of the Tapti river (210 N) to the tip of South India (about80 S), covering an area of approximately 160000 km^2. The Ghats have an elevation range of 300-2700 m and a latitudinal spread from 80 N to 200 N. Palghat gap in Kerala is a major gap in this mountain range which was a part of the Indian plate of the Gondwanaland. The flow of Deccan lavas resulted in horizontally stratified mountains in the Deccan traps north of the river Krishna (Nayar, 1996). The origin of the of Peninsular India, particularly that of the Western Ghats and its complexity and diversity need to be viewed against the back drop of much-researched phenomenon of plate tectonics (Ravenand Axelord 1974). India certainly appears to have remained connected to Madagascar and Africa until at least 100 m.y BP (million years before present) thereafter commencing its northward motion until it collided with Asia by mid-Eocene. The Western Ghats straddle the states of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, and southern Gujarat. Just as the Himalayas Preside over the biogeography of India, the Western Ghats to a large extent presides over the ecology and biogeography of Peninsular India (Subramanyam and Nayar, 1974). Its presence creates major precipitation gradients. This apparent unity in fact masks the great heterogeneity of the environmental conditions resulting from geographical, geological and demographic differences. The physiographic and geological diversity in the Deccan traps of basaltic rock north of the Krishna basin and of Precambrian crystalloid rocks formed of granites, gneiss south of the Krishna basin are conspicuous. The soil consists of black soil, laterites and red loam and coastal alluvium. The annual rainfall varies from 2350 in the north to7450 mm in the south which makes the Western Ghats the water shed of the Peninsula (Nair and Daniel, 1986). Godavari, Krishna and Cauvery are the major east flowing rivers from Western Ghats.

The West coast is intersected by over 80 rivers that run their shorter courses before joining the Arabian Sea.

Fresh water offers one of the more common and stable habitats of the Biosphere. Fresh water has its own physical and chemical characteristics and hosts a large communities which have adapted to dynamic environment, involving close interactions between organisms and physical and chemical constituents prevailing within the system. Fresh water has a well-defined food chain and food web through which energy is channelized and community develops through discrete successional stages. Fresh water involves such diverse system as lakes, pools, bogs, streams and rivers. Each has its own ecological peculiarities that has specific adaptations not only to cope up with the prevailing conditions, but entire life history of such organisms is moduled in a such way as to survive seasonal fluctuation and extreme conditions

The traditionally fresh water habitat is classified into lentic (standing water like lakes, ponds, and pools etc.) and lotic (Running water like streams and rivers). However, these two are rarely unconnected; because, many running water pass directly into standing ones or has standing water in the catchment, and most standing water may receive running water and exit by running out flow. In manmade reservoirs, ecological parlance, are the transformations of rivers into lakes (Lewis, 1974). Just as the estuaries are an ecotone between the river and the sea (Reid, 1961), the river impoundments are an ecotone between river and lake ecosystems. The ecological conditions prevailing in the reservoir are broadly midway between those of lake and a river.

Running water usually starts in mountainous area and evolves sequentially through the brook, creak, streams and lakes, eventually discharging into sea. These may arise from fixed head waters such as lake, spring or a glacier. Pursuing its course meanders gradually, sometimes suddenly by means of waterfalls, and finds its way from the hills to the flatter ground below and changes from a torrential hill stream to a slower running river.

The river provides a unique environment and the geomorphology. Hydrodynamics of river are moduled by a large number of factors. Current and flow direction affects life and

determines the kind of aquatic life that can live in such a habitat. In spite various mechanisms for maintaining positions, there is continuous drift of organisms down the stream. Drift may be a means of regulating population size to the carrying capacity of the habitat. As the watercourse slows down over flat land, suspended matter is deposited, permitting a wealth of higher plants to take roots.

India is a tropical country having a large number of river systems. It ranks one of the foremost among the countries of the world in having rich inland water resources (Jhingran, 1983). During the post independent period from 1947 to today in India, construction of dams across the rivers has received primary priority and it is anticipated that the number of dams are likely to increase enormously in the near future in order to provide the demand of more energy and food.

In India, extensive limnological studies on ponds and natural lakes have been made. The physico–chemical and biological conditions of some of the streams and rivers in India are reasonably well understood. However, there are no adequate reports on the fish diversity of streams and rivers, especially after manmade impoundments are created. It has been well recognized that river impoundments results in the formation of manmade lakes that are ecotone of multifaceted ecosystems displaying the ecological conditions transient between those of stagnant water and river, (Ganapati and Sreenivasan, 1968). Soli (1968) has opined that the running waters may be regarded as the 'urine' of landscape. The opinion holds good to the rivers too.

Uttara Kannada district of Karnataka state has a geographic area of 10,291sq^{2}m and situated strategically in the middle of the Western Ghats, of South India. Uttara Kannada is located between 13^0 55' to 15^0 32' N latitude and 74^0 05' to 75^0 05' E longitude. Uttara Kannada is predominantly hilly and has a narrow coastline interrupted in many places by wide outlets four major rivers, small creaks, coastal marshes and promontories of Western Ghats which ran almost to sea in several places. Western Ghats in Uttara Kannada are at their lowest and the crest line seldom rising above 600m, although there are isolated peaks with 700 – 800m heights. There are precipitous slopes towards the West and rivers running

through the deep gorges and valleys. The crest line of the Ghats gradually merges with Deccan plateau towards the East, rolling hills; shallow valleys and the plains are the major topographic features of Uttara Kannada district.

Uttara Kannada has a typical tropical climate with well-defined seasons and receives rainfall on an average 2500mm annually during the month from June to November. The entire Uttara Kannada is hilly and wooded district with tremendous variety of forest stands under varied degree of natural and anthropogenic influence. Uttara Kannada consists of rock formation of Achaean complex- the oldest rock of earth crust. Four major rivers of Uttara Kannada are 1) Bedti river 2) Kali river Bedti (Gangavali) river 3) Aghanashini river and 4) Sharavati river.

Bedti River (also called Gangavali River) is a west flowing river that originates from the Western Ghats, south of Dharwad. The river is formed of two main streams Shalmala originating near the Someshvara temple (south of Dharwad) and Bedti taking its birth near Hubli. These streams join near Kalghatgi. Hubli urban sewage drains into this river and cause organic pollution. From here it flows for about 25 km. West wards and enters the Uttara Kannada district. In Uttara Kannada district it flows to a length 96 km (Out of total length 161-km), Bedti River flows west and south-west for a total distance of 96 km. This river has a catchment area of 3,574 sq km and has a total length of 152 km. On its course towards the Arabian Sea the river falls from a height of 180 m at a point on the western face of the Sahyadri to form a cataract by name Magod Waterfall at Magod village. The perennial river Sonda joins Gangavalli near Harigadde.

Objectives of the study:

1. To inventories the freshwater fishes of Bedti River and its major tributaries.
2. To identify major tributary streams of Bedti river.
3. To characterize the streams according to its microhabitats and relating the fishes to the microhabitats.
4. Land use analysis in the catchment area of selected streams.
5. Comparative study of certain physical properties of the river in different zones.
6. Conservation strategy for the fish fauna of Bedti River.

Chapter –II

Review of literature

Systematic and in depth study of various ecological aspects, hydrographic parameters and zoogeographic studies are most important in assessing fisheries potentialities of fresh water river and the catchment area. Several fresh water scientists and environmentalist are engaged in monitoring the ecosystems to understand the various physico-chemical processes governing the biological production. A perusal of literature reveals that there have been a good number of scientific studies pertaining to various aspects of fresh water ecosystem. The Indian subcontinent is occupying a position at the confluence of three biogeographic realms. These are the Pale-arctic, Afro – tropical and Indo- Malayan. All these exhibits a great variety of ecological habitats; harboring a rich Ichthyofaunal diversity, comprising about 2500 species including marine and fresh water. Out of 2500 species 930 species are fresh water inhabitants. The Indian species represent 11.72 per cent of the known fish species of the world, 24 per cent of the genera, 57 per cent of families and 80 per cent of orders. Burman (1998), Jingran (1999) listed 852 fresh water species of fishes under 272 genera, 71 families, and 16 orders, including primary and secondary fresh water fishes. A recent checklist of Menon (1999) lists 446 fresh water species under 33 families and 11 orders from Indian region alone.

A monograph on Cyprinoid fishes of genus Garra by Menon (Pisces, part I, II and part III, 1969, 1987, 1992) and checklist of fresh water fishes of India (Menon, 1993) are some of the monumental works in the Ichthyology. A valuable account on Mahaseer fishes of Western Ghats primarily based on the result of Trans – World Expedition in India (1994) is of considerable interest. Several attempts have been made to compile a checklist of freshwater fishes of the Western Ghats. These attempts mainly focused on evolving with a comprehensive checklist of freshwater fishes, which is an outcome of the patchy (may be of a river basin, a region in the Western Ghats, an administrative boundary within the Western Ghats, etc) taxonomic information available on the diversity of freshwater fishes. Daniels (2001) has listed 218 species from the Western Ghats of which 114 (52%) are endemic to Western Ghats. However, this report lacks a detailed checklist of fishes found in the Western Ghats. The subsequent checklist (Shaji *et al* 2001) listed 287 fishes with names of individual

species. This compilation considered certain estuarine fishes that are found to ascend freshwater for longer distances. The list highlighted the presence of 67% endemic species and 18 exotic or transplanted to the region. The most recent information available is by Dahanukar *et al* 2004 that lists 288 freshwater fishes, of which 118 (41%) are endemic to Western Ghats. The threat status of fishes found in Western Ghats suggests that at least 41% of fish fauna is threatened by either being vulnerable, endangered, or critically endangered. This study also necessitates the implication of potent conservation measures to conserve the fish fauna of Western Ghats.

Lots of fresh water ecosystems are being changed very rapidly by manmade activities, *viz.*, deforestation resulting in increase in flood, deposition of fine sediments, increase in suspended matter, and introduction of exotic species, exploitative fishing and pollution. Basic data on distribution and abundance of species in various river systems are of prime need to understand fish diversity, before the species and ecosystems disappear due to human activities. Already much damage has been done to our indigenous fish fauna due to habitat loss.

The inland fisheries of India have an important place as it contributes about 30% of the total fish production. In Indian fish production riverine fish production is equally important. Riverine fishery resources of India comprise five major river systems, namely Ganga, the Brahmaputra, and the Indus river systems in the north, together with the peninsular East Coast and West Coast River systems in south. The different river systems of the country having a combined length 29,000-kms are the traditional source of livelihood for the artisanal fishermen, since the time immortal.

The East Coast River systems comprise the river Godavari, which is the largest riverine system in the state of Maharashtra. The fish recorded from the catch of Godavari amounts 7 orders and Cyprinifomes dominated with 9 species, from only one village Raher of Nanded district of Maharashtra (Sakhare and Bidkar, 2001).

Day (1865, 1876 – 1883) was the first to give an account of fresh water fishes of Western Ghats. From his exhaustive work on the fishes of Asia, he opined that the Indian fresh water fish fauna resembles more closely with that of Eastern countries like Burma, China and

Malayan archipelago (Day, 1889). It is suggested that the Western Ghats harbor, approximately, 231 species of fresh water species of fish and 102 species are presently listed from Western Ghats water bodies between 750 and 2000 meters of altitude. Boote (1979) studied the fresh waters of Western Ghats and concluded that the streams lack large sized fishes.

The latest compilation of the checklist of the freshwater fishes in Western Ghats region lists 318 species of which 42.8% (136 species) are endemic to the region. Of this about 27 species are critically endangered and 55 endangered while 128 are data deficient. Altogether, 39.1% (123 species) of the freshwater fishes come under the category of critically endangered and vulnerable. Of the 27 critically endangered species 24 are endemic to the region. Similarly, of the 55 endangered species, 37 are endemic. Yet 49 endemic species are data deficient.

Sanjay kharat et al (1999) studied the changes in the fresh water fish fauna of Mula – Mutha river system of Maharashtra Western Ghats and observed that besides species richness, the characteristics of fish fauna have also undergone changes in terms of feeding habits. Recent studies have shown that increase in small and medium sized fish species, while proportion of very small, large and very large fish species has not changed significantly. The Yellow Mahaseer or Deccan Mahaseer (*Tor Khudree*) once abundant in streams of South Canara down the Western Ghats to the Travancore hills (Mc. Donald, 1948) now restricted to upper stream of Bhavani river reservoir and on the upper reaches of Chalkudy, Periyar and Pamba in Kerala State. A comparative account of fish fauna covering 12 river basins representing the state of Karnataka, Kerala and Tamil Nadu parts of Western Ghats revealed that, there were about 85 species of fishes belonging to 8 orders and 16 families (Arunachalam, 1998). Unninathan (1998) reported the decline in the endemic fish species in the reservoirs of Western Ghats. Raghunathan and Rema Devi (1994) have reported an inventory of biodiversity of fresh water fishes. A detailed account on Cauvery River systems and pattern of fish distribution has been studied by Jayram (1982, 1987 – 1990). The same author worked on bio-resources of Krishna River along with tributaries. The author has provided excellent information on physico – chemical parameters and fish fauna. A total of 142 species under 27 families have been reported.

Mirza (1975) has listed 156 species of fresh water fishes, belonging to 58 genera from Pakistan. Almost all of the species of fish from Pakistan have been reported in India too (Talwar and Jingran, 1991). Ramachandran (1973) made an attempt to prove an illustrative list of local and scientific names of fishes of Karnataka region of Western Ghats.

Hamilton – Buchanan (1822) described numerous fresh water fishes from Gangetic system and a synthesis of this work and subsequent studies in the Ichthyofaunal of Ganga is detailed by Talwar (1991).Sykes (1838) described 46 species from fresh waters of south India comprehensive accounts of south Indian fresh water fishes were compiled by Jordon (1849). He listed 11 fishes from Canara districts of Karnataka both in rivers and tanks (Hora and Law, 1941).Negi (1994) studied cold water fishes Himalayas including habitat, techniques, and conservation etc. Encyclopedia Britannica (1971) gave a general picture of sports fisheries in the leading fishing nations (including India).

There are a few published accounts available on Physico- Chemical characteristics and ecology of cold water systems of Western Ghats. A few streams of Karnataka, Kerala and Tamil Nadu were worked out by Sehagal (1971, 1971a, 1971b).

A very interesting comparison of different Hydro-biological parameters of streams of Western Ghats with those of Himalayan region revealed that, the streams of Western Ghats have high temperature, free Carbon dioxide, total alkalinity and Chloride value and lower dissolved Oxygen and Silicates. (Jingran and Sehagal, 1978; Sehagal et al, 1984, Sehagal 1998).

An exhaustive literature survey from various sources made evident that, there is not much work has been carried out on the ecology of Bedti River and particularly its tributaries of Uttara Kannada district and its impact on the fish diversity. In recent years biodiversity and its conservation are regarded as one of the major burning issues of enabling sustainable use of natural resources. Hence it has become very necessary and inevitable to protect the biodiversity in all ecosystems. Therefore the work focuses on the ecology, fish diversity and some aspects of hydro-biological parameters of the Bedti River and its catchment area of Uttara Kannada district.

Chapter –III

Materials and Methods

The investigation was focused at asserting ecological changes and differences and its impact on the diversity and fish population in Bedti river of Uttara Kannada district, which has been greatly affected due to anthropogenic pressure.

3.1 Bedti River:

Uttara Kannada district has four major rivers having different ecological characteristics. In order to study the fish fauna in Bedti river study locations were marked out, so that at regular intervals, the study can be under taken in these specified locations. A total of 11 sites were selected. These sites were marked all along the river from upstream to downstream including the tributaries.

The locations were identified in such a way that two locations in downstream, two locations in middle stream and two more locations on up stream of the river and each locations in five tributaries. While choosing the locations the following criteria were also considered.

1) Diversity of the habitat
2) Accessibility of the location in all seasons
3) Human interference
4) Impact of different types of vegetation on the river
5) Dams, industries and pollution.

This would help to compare the fish fauna from location to location. To study the impact of natural vegetation, anthropogenic pressure, and pollution few of the locations were selected either at the source of pollution or near human habitation and at different vegetation types.

For the river upstream location was selected at higher altitudes near Bedti Bridge and above, middle stream locations along the slopes between Yellapur and Sirsi, more or less in the middle of the river course. i.e. at lesser altitude and down streams location below the Arbail Ghats. They were considered in such a way that location above the slopes of the Western

Ghats (Arbail Ghat) is considered up stream locations, along the Western Ghats slopes middle stream locations and below the Ghats downstream locations.

3.2 The River Bedti is characterized by the following ecological features.

3.2.1. Habitat:-

Based on width, depth, velocity, topography, terrain and geography of the river Bedti River has different habitat types. As these habitats are very important for the fish fauna an attempt was made to classify these habitats in each location. Even while selecting the locations care was taken to include habitat heterogeneity. The habitats that can be seen in any river can also be seen in the river Bedti and can be classified as Pools, Runs, Riffles and Cascade.

3.2.2. Pools:-

These were deep portions of the water body with standing water or with very low current velocity. These locations were usually found below the cascade or fall and provide shelter for the fishes during summer when most parts of the river dry up. Pools were natural and having enough water due to depth even during dry months also. At the same time they store lot of nutrients in them and most of the carps are found here. Pools can be seen at Kalleshwar, Gullapur, and also at Shalmala (Sonda).

3.2.3. Runs:-

This was the stretch of fast and swift flowing water with very little turbulence and agitation and flow was more or less uniform. Runs were observed where the river width is high and river bed is smooth. Runs were common expect in slopes. Runs were useful for navigation also.

3.2.4. Riffles:-

Where the water turbulence and surface water agitation was higher, pebbles and boulders were found on the river bed riffles were common. This was usually seen in shallow water where stone out crops were on the riverbed and the river flows along the slopes. Riffles help in enriching the Dissolved oxygen and nutrient mixing. Water velocity was high in this region. The main Riffles observed were at Sahasralinga (Hulgol) and below Bedti Bridge (Here water is stored artificially and made available for domestic purpose to the people of Yellapur town).

3.2.5. Cascade:-

This was common in all hill streams. Cascades were characterized by highly turbulent flow, where water flows through rocks and boulders along the slopes. The steep gradient may result in the formation of cascade. Only certain well-adapted fishes to this high water velocity were found here (Genus *Garra*).

3.3. Field work

Fishes were collected during post monsoon and pre monsoon period of the year with the assistance of the professional fisherman's. The surface water samples for the determination of physical and chemical parameters were collected using a clean plastic bucket and cans. Vegetation types and landscapes were also been studied and photographs were taken.

Fishes were collected and identified at the sites mainly on the basis of local names. Some fishes were brought to the laboratory and identified with the help of the identification key. Few fishes were sent to the ZSI, Kolkata and got identified.

3.3.1. Rainfall:-

The quantum of rain fall received in the region during the study period was also collected from the NRDM Karwar and KSNDMC Bangalore.

3.3.2. Air temperature:-

Air temperature was recorded at post monsoon and pre monsoon period of the year using a multi thermometer.

3.3.3. Water temperature:-

Immediately after collection of surface water sample, the water temperature was recorded by using a multi thermo meter and expressed in degree Celsius.

3.3.4. pH:-

pH of water samples were estimated by using a pH meter (Bench Top).

3.3.5 Latitude, Longitude and Altitude (Elevation) :-

The latitude, longitude and altitudes were recorded at selected locations by using GPS instrument and presented in Appendix -A (Table1 -11) and graphically depicted in Appendix- B (Graph1 -11).

3.3.6. Vegetation types:-

The vegetation types were recorded in each stream by quadrate method.

3.4 Laboratory work

3.4.1. Determination of dissolved oxygen (DO) of water. The water samples were collected in clean glass bottles following all the precautions prescribed for the determination of dissolved oxygen. Two fixatives such as manganous sulphate and alkaline iodide – azide solutions were added to get the precipitate. The conc. sulfuric acid was added to the above mixture. The titrimetric method was followed for the estimation of dissolved oxygen. The titration for determination of dissolved oxygen was done within 6hrs of collection, after all the precipitate had settled. The samples were titrated against the 0.025N of sodium thiosulfate. The starch was used as an indicator.

The dissolved oxygen content of water (mg/litre) was calculated by using the following formula.

$$\text{D.O. (in mg/litre)} = \left(\frac{8^{*} \times 1000 \times N}{V}\right) \times v$$

Where V = Volume of sample taken (ml),

v = Volume of titrant used

N = normality of the titrant

* = 8 is the constant since 1 ml of 0.025 Sodium thiosulfate solution is equivalent to 0.2 mg oxygen.

3.4.2. Determination of biochemical oxygen demand (BOD) of water:-

The BOD of a water sample was measured by incubating the sample at 27^0 C for three days in the dark under aerobic conditions. To the sample 1ml of 0.5 % solution of allylthiourea was also added. Before keeping the BOD bottles with sample for incubation after adding the allylthiourea dissolved oxygen content of the water were recorded and the mean was taken (D_1).After three days of incubation oxygen concentration in all the three incubated bottles were estimated. Then mean was taken (D2).

The BOD of water samples were calculated by using the following formula.

BOD_3 in mg $1^{-1} = D_1-D_2$

Where D_1 = Initial DO in sample (mg 1^{-1})

D_2 = DO after 3 days incubation (mg 1^{-1})

3.4.3. Determination of total dissolved solids of water (TDS) :-

Total dissolved solids of water (TDS) were determined as the residue left after evaporation of the filtered sample. The total dissolved solids were calculated by using the following formula.

$$\text{TDS mg } 1^{-1} = \frac{(B-A)}{V} \times 10^6$$

Where A = Initial weight of the dish (g), B = Final weight of the dish (g)

V = Volume of the water sample taken (ml)

3.4.4. Bacteriological examination of water by multiple-tube fermentation test or multiple – tube test or most probable number test (MPN) :-

This test was performed to ascertain the presence or absence of bacteria in the water samples. The test was performed sequentially in three stages: presumptive, confirmed and completed test. Lactose broth tubes were inoculated with different water volumes in the presumptive test. Tubes that were positive for gas production were inoculated in to brilliant

green lactose bile broth in the confirmed test and positive tubes were used to calculate the most probable number (MPN) of coli forms in the water sample following the statistical table. The completed test, involving the inoculations of EMB agar plate, nutrient agar slant and brilliant green lactose bile broth and preparation of a Gram- stain slide form NA slant was used to establish that coli form bacteria were present in the samples. The complete process, including the confirmed and completed tests was required 4 days of incubations and transfers. The various stages of the experiments are shown pictorially in the Appendix C. The most probable number (MPN) of coli form bacteria present/ absent in 100ml of water for various combinations are represented in the Table II. *Modified from Mackie & Mc Cartney Practical Medical Microbiology, Eds Collee, J.G.et al 14th Ed. (1996) Churchill Livingstone Publisher, N.Y

3.5. Statistical Analysis (Tools of Analysis).

The information collected from various sources is tabulated and presented in the form of Tables and Graphs. Simple statistical tools like average, percentage, standard deviation, co-relation, factor loading, composite index, bar graph, line graphs are used to analyze the data.

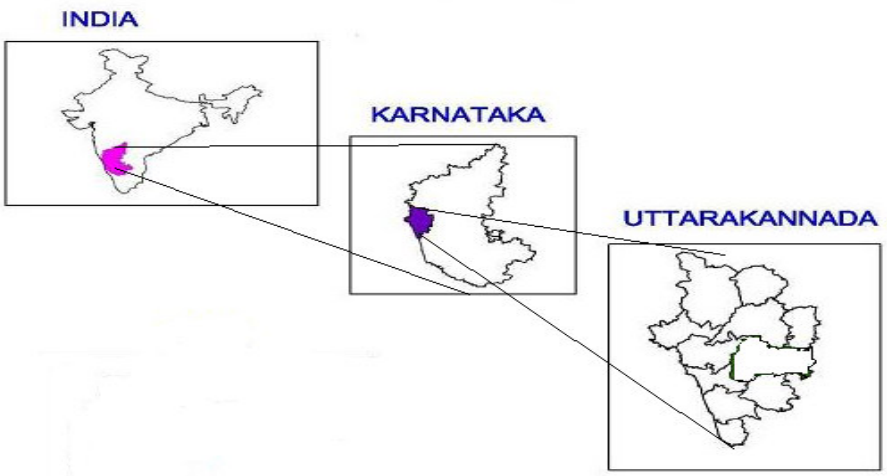
3.6. Main tributaries of Bedti River.

Table I- The major tributaries of the Bedti River

SlNo	Tributary	SlNo.	Tributary
1.	**Pattana hole**	9.	**Ganeshpal**
2.	Kalghatgi halla	10.	Koppad halla
3.	Hungunda halla	11.	Kaulgi halla
4	**Hulgol halla**	12.	Chandaguli halla
5	Tandi halla	13.	**Majjige halla**
6	**Shalmala (Sonda River)**	14.	Dabguli halla
7.	Bili halla	15.	Vajralli halla
8.	Hase halla	16.	Sunkasala halla

The above tributaries were identified during the research and five tributaries were selected for the research work. The tributaries selected for the study are shown in the bold letter. The study area selected is shown in the maps (Fig. No 1-4).

Fig 1 -Map showing the Uttara Kannada district (A study area)



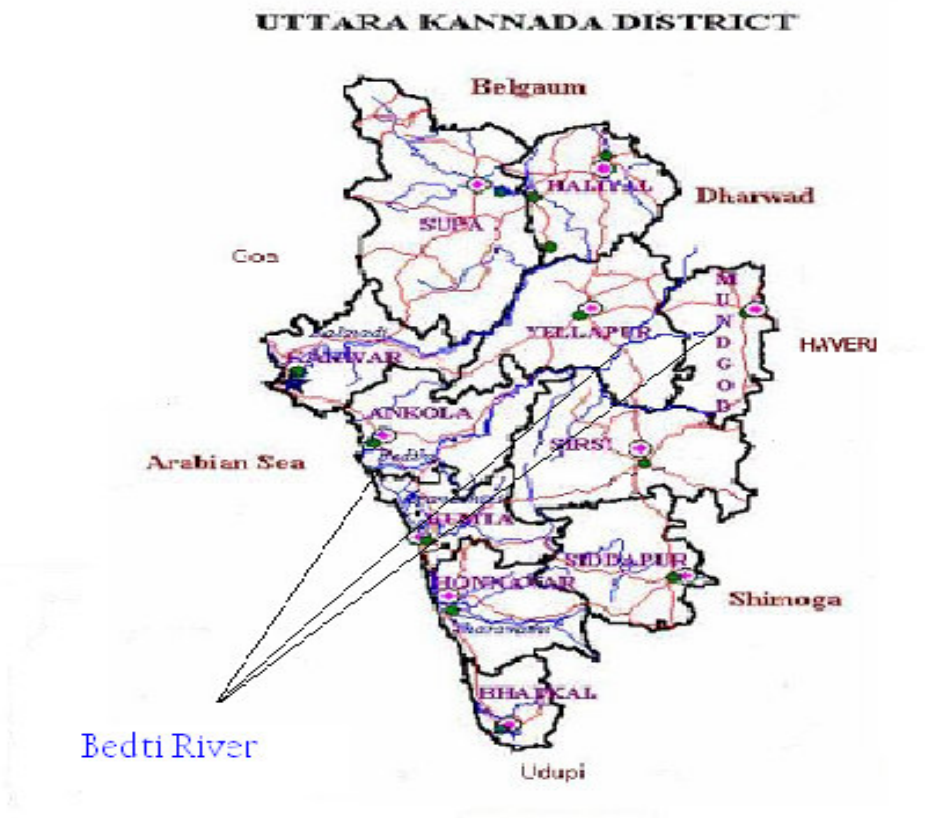


Figure 2- Map showing the Bedti River of the District

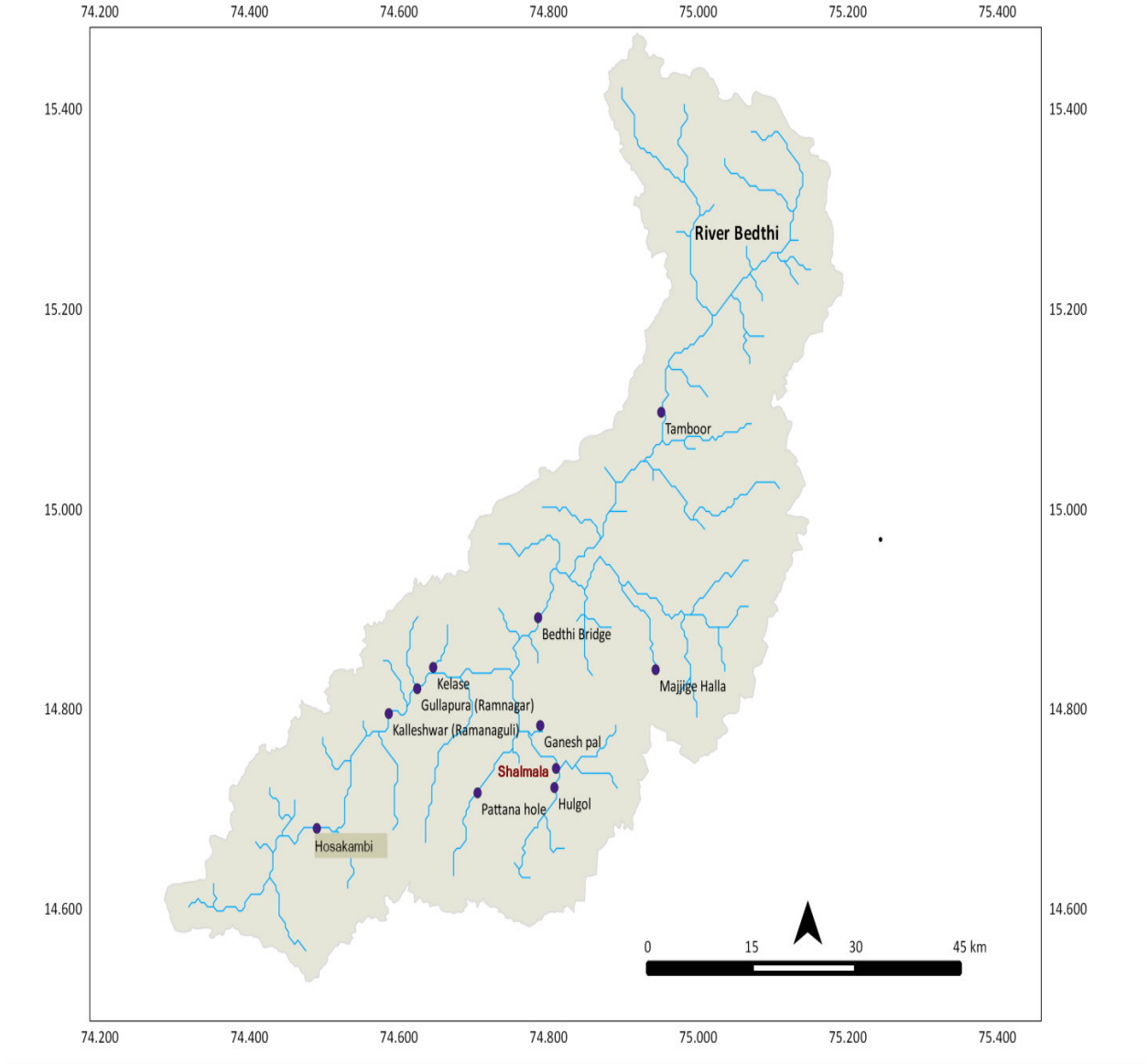


Figure 3 -Map showing the locations of sampling stations.

Fig 4 -Map showing Bedti River (also called Gangavali), Source from Google

(Study area includes part of Sirsi, Mundgod, Yellapur and Ankola and Kalghatagi Taluk)

Table- II.*Most Probable Number (MPN) of coliform bacteria present in 100ml water for various combinations of positive and negative results when five 10ml portions, five 1ml portions and five 0.1ml portions are used

Number of five tubes giving positive reaction			
10ml	1ml	0.1ml	MPN index per 100ml
0	0	1	2
0	1	0	2
1	0	0	2
1	0	1	4
1	1	0	4
1	2	0	4
2	0	0	5
2	0	1	4
2	1	0	5
2	1	1	5
2	2	0	7
2	3	0	7
3	0	0	11
3	0	1	7
3	1	0	9
3	1	1	9
3	2	0	13
3	2	1	13
3	3	0	16
4	0	0	16
4	0	1	11
4	1	0	14
4	1	1	16
4	2	0	20
4	2	1	20
4	3	0	25
4	3	1	25
4	4	0	31
4	4	1	32
5	0	0	38
5	0	1	22
5	0	2	29
5	1	0	41
5	1	1	31
5	3	0	43
5	3	1	75
5	3	2	110
5	3	3	140
5	3	4	175
5	4	0	210
5	4	1	130
5	4	2	170
5	4	3	220
5	4	4	280
5	5	0	345
5	5	1	240
5	5	2	350
5	5	3	540
5	5	4	910
5	5	4	1600

Result of MPN Test 1(Water Sample 1) Potable 2(Water Sample 2) Potable 3(Water Sample 3) Potable 4(Water Sample 4) Non Potable

Chapter –IV

Experimental Results

4.1. Meteorology

4.1.1. Rainfall

With a major part of the river lying in the Western Ghats, the Bedti (Gangavali) river basin receives a large amount of rainfall. Mean annual rainfall ranges from 1,700 mm (67 in) to 6,000 mm (240 in). About 95% of the rainfall occurs in the district during the month of June to September (July being the rainiest) when the southwest monsoon is at its climax. There is some rainfall in the post monsoon season in the form of thunder showers mostly during October and some rainfall also occurs during the summer months of April and May. During heavy monsoons, the river floods to nearby villages and dumps dirt and dead animals to lands creating havoc to villagers.

The total rain fall recorded during the year Jan 2013 to December 2013 in the district was 2957.3 mm and during the pre monsoon period (Jan 2014 to May 2014) 150mm.This is considered as normal rainfall. But the rainfall occurred only 384 mm in the month of June 2014 i.e.-40%. This is considered as deficient. These are presented in Table III and shown in the map. (Fig.5a, b & c)

4.1.2. Air temperature

April is usually the hottest month with the mean daily maximum temperature at 36˚C and the mean daily minimum at 22˚C.Variation of air temperature during post monsoon and pre monsoon is presented in Table IVA and IVB.

4.1.3. Water temperature

Water temperatures of the samples were recorded during post monsoon and pre monsoon period of the year. Variation of water temperature is also shown in the Table IV A and B. The physical parameters were taken in two lots as post and pre monsoon instead of recording monthly as the area selected for the study covers a wide range of geographical region.

4.2 Description of fishing locations in Bedti River and its tributaries.

4.2.1. Upstream – 1.Tamboor

The location was in the middle of the thick moist deciduous forest, very difficult to access. Riverbank was covered by many *Tamarindus indica* trees. At this location natural flow of water is obstructed and diverted to Tamboor village of Kalghatagi taluk for irrigation purpose. The large number of leaf litter falls in the river. River water was black and water temperature was more than the air temperature. River water was contaminated with the Hubli –Dharwad urban sewage.

4.2.2. Upstream – 2.Bedti Bridge

The location consists of pool, riffle and flow. River bank covered by thick moist deciduous forest. River side's muddy and river bed with lot of big black boulders. River flows in deep gorge. River bottom was full of organic litter. At this location natural flow of water is obstructed and diverted to Yellapur town for drinking purpose. As a result entire trees were submerged partially and shrubs and herbs fully.

4.2.3. Middle stream– 1. Gullapur (Ramanagar)

Anthropogenic pressure from the local settlements was seen. River partially covered by bamboo and riparian vegetation on one side. River bank is muddy. A small hill stream joins the river. Local people leave the Gillnets in the night and collect the fish early morning for subsistence. The habitat types were Run and Pool. Herbs and shrubs diversity was more.

4.2.4. Middle stream– 2. Dabguli

This was a small tributary of Bedti found immediately beneath the Arbail ghatt. Lot of anthropogenic pressure from the local settlements was seen. The Areacanut and Coconut plantation were also seen. River partially covered by bamboo and riparian vegetation on one side. River bank is muddy. A small hill stream joins the river. The habitat types were Run and Pool.

4.2.5. Downstream– 1 Hosa Kambi

On one side of the river thick evergreens forests and on the other side kali hydal project rehabilitation center were the salient features of the location. River forms flow, pools and riffle. River bed was sandy and filled with pebbles. Local people collect the fish. This place is covered by mainly *Pongamia pinnata, Syzygium cumini* and mat grass species.

4.2.6. Downstream– 2. Kalleshwar (Ramanaguli)

This location was fully disturbed by the tourists as local authority permitted for rafting and other recreations. In general lot of anthropogenic pressure from the local settlements was also seen. River partially covered by bamboo and riparian vegetation on one side. River bank is muddy. A small hill stream joins the river. Local people leave the Gillnets in the night and collect the fish early morning for subsistence. The habitat types were Run and Pool. Herbs and shrubs diversity was more. The hanging bridge was seen from one end of the river to another end of the river. The village Kalleshwar and Ramanaguli was connected by the hanging bridge.

4.2.7. Tributary– 1. Hulgol

. The location consists of pool and flow. River bank covered by thick moist deciduous forest. River side's muddy and river bed with lot of big stones God Shiva's curvature can be seen on the riverbed rocks. This place is known for ecotourism and for performing Shiva pooja on the special occasion of Mahashivaratri by Hindu community. River flows in deep gorge. The varieties of *Mangifera indica* are more common in addition to *Syzygium cumini, Terminalia arjuna* and *Pongemia pinnata***.** The grass species were common in the river. The grass species and other species are responsible for reducing the flow of water. The *Pondanus unipillatus* grass species were the specialty of the tributary.

4.2.8. Tributary– 2. Sonda River (Shalmala)

The location consists of pool and flow. This is one of the main tributaries of Bedti and is formed by the confluences of Tadaguni and Kengre halla (small tributaries). The riverbank was covered by mud and thick deciduous vegetations were found along the sides of the river. The lot of leaf litter falls in the river.

4.2.9. Tributary– 3. Pattana hole

This is another tributary to Bedti River near Sirsi. River bed was full of aquatic vegetation with small pebbles having thickly vegetated river bank. Rotting woods and leaf litter fills the river bed. The habitat types here were runs and riffles. The riverbed partly exposed during summer, but the stream is perennial. The river was pure and uncontaminated and very transparent. This place was covered by paddy and areca nut plants on one side and on the other side evergreen forest. The river bed was also covered by lot of sand and the sign of sand smuggling was being noticed. The *Pongamia pinnata* species were common.

4.2.10. Tributary– 4. Ganesh pal

This is also a main tributary to the Bedti river .The location consist of run, riffle, pool and a small cascade as habitat types. This is the known Evergreen forest in Sirsi taluk also known for Shivaganga falls. Black granite boulders are exposed on the river bed and lot of litter falls in the river. No human activities except by occasional tourists. River flows in a deep gorge. River bank was muddy. This place was one of the dangerous spot. The main tributary was covered by *Allium aquatica* (wild onion species), *Mangifera indica* and *Syzygium cumini*. The paddy and areca nut field were seen on one side of the tributary.

4.2.11. Tributary– 5. Majjage halla

This is a small tributary of the Bedti river 45 kames from Sirsi town This tributary is covered by dry deciduous forest and on one side paddy fields are seen. The water is little contaminated by the anthropogenic pressure. River bank was muddy.

In all sites latitude, longitude, altitude was recorded by using GPS instrument. In addition to this we have not forgotten to note the rate of water flow, depth and width of each location. All these data's are given in the Table –V

4.3. Fish sampling method:

Fish sampling was the major fieldwork at all the specified locations in all the seasons. Fish sampling was conducted two times a year i.e. Post monsoon, and Pre monsoon for one year. Totally 11 samplings were made in all the locations.

Sampling was done early morning 6.30 am to 11.00 a.m. and in the afternoon from 3.30p.m to till evening. This was the time when more fishes can be caught. One night sampling was also made in few locations. Usually minimum one to two hours was spent in each location. The effort continued for more time if the fishes were abundant in the location. The professional fishermen were employed for the fish catching.

For collecting the fish variety of methods were involved. The use of different types of nets, hooks, and other traditional methods like plant based fish poisons and trapping etc. were employed. Though there were many methods were used major collection was by the use of nets.

Here we have used Gill nets, Cast Nets and dragnets of different mesh size. The net fishing was one of the most popular fishing methods. Nets were an effective way of catching the fishes though there are several drawbacks to using them. The descriptions of the various methods used during the investigation are given below.

4.3.1. Gill nets:

Gill nets work by snagging fish behind their gill cover (That is why this net is called gillnet). Gillnets are panels or sheets of netting either mono filament or nylon. A number of floats are threaded on to a line and fixed to upper portion of the sheet net while a lead line is attached to the bottom portion of the net. This keeps the net afloat and the lead line keeps the invisible sheet net vertically in water. The net can be either anchored or dragged along the bottom. The size of the mesh and way the sheet netting is fixed to the float and lead line is important when determining the species and size of fish that will be caught. Small mesh nets generally catch small fish. If a large mesh net is loosely fixed to the float and headline, this will also catch small fish by tangling rather than gilling the fish. Generally gillnets were used in runs and pools across the course of water. These nets were left in water for a minimum period of one hour in each location.

During the investigation I used three gill nets with the specifications mentioned in Table VI.

Table VI-Gill nets with different dimensions.

	Gill net-1	Gill net-2	Gill net-3
Length (in m)	17.1	16.1	15.2
Width (in m)	2.3	2.3	2.3
Mesh size (In cm)	1.6	1.8	1.9

4.3.2. Cast Nets:

It is made up of nylon with a very small mesh and conical in shape. A rope is attached to the net apex for retrieving. This is used by one person, usually in a shallow area of a sandy or muddy bottom, with a little or no rough substrate to destroy the net. This was a good method to catch small schools of fish. In each locality near the river bank fisher cast the net very quickly to avoid scaring the fish and to ensure the net open fully. It takes a lot of practice to use the cast net efficiently.

During fishing I had taken the help of professional fishermen for the perfect casting. Here I have used two cast nets. The cast net-1 was having a height of 2.5m with circumference of 12m and mesh size of 1 cm. The cast net-2 is slightly larger with a height of 2.4m, circumference 14.2m and mesh size was 1.1 cm. At every location a minimum of 10 casts were made. The effort continued beyond 10 casts only if new species of fish is caught in each successive cast.

4.3.3. Drag Net:

Drag nets were used for sampling the fish in shallow water near the river bank or where the water is lees deep. This net is made up of nylon sheet bottom line. The nylon sheet is pores. Two persons have to operate it by dragging in shallow water scooping the small sized fishes. During collection we have used two dragnets with length of 6m and 1m breadth.

4.3.4. Hooks:

This is one of the oldest methods of catching the fish. Hooks are made from steel and monofilament or nylon as fishing line. A lead ball is attached to hook as sinker. The 'J' shaped hook is baited and thrown in water. The fisher must jerk the hook when he feels a fish taking the bait. Here we have used two hooks for catching the fish.

4.3.5. Traditional Methods:

Local people of Uttara Kannada district use many traditional methods to catch fish. As many as 20 species of plant based fish poisons are used to catch the fish. The plants parts are crushed and mixed with water especially during summer where water flow is small or in pools. One of the plant species used for the fish catching was *Strychnos nux-vomica*.

Bamboo traps were also used to catch the fish. During the investigation we have not tried any of these methods, but few fishes were collected by the local people caught by either of the methods**.** For all type of fish catching professional fishermen's assistance were taken**.**

4.3.6 Fish Preservation:

The fishes caught alive or narcotized state was preserved in 4% Formaldehyde. The fishes caught in the net are immediately separated from the net and the number of fishes caught is counted and representative sample of every specimen was preserved in plastic jars using 4% formaldehyde solution. All colors, color patterns, spots blotches number and design were noted in the field note book as soon as the fishes were caught and when they were fresh.

For all fishes of length 10 cm an incision was made on left abdominal wall. For fishes larger than 30 cm. undiluted concentrated formaldehyde was injected by using the syringe at the abdominal region.

4.3.7. Identification of the fishes:

Classification of the fishes for the study was done through taxonomy or systematic. Some of the very common fishes were identified in the field itself with the help of the regional or local names. Those, which could not be identified in the field, were brought to the laboratory and

identified. Few species were sent to the Zoological survey of India and got the species identified. For identification we used the Identification keys from "The fresh water fishes of India, Pakistan, Bangladesh, Burma and Sri Lanka" - A hand book by K.C. Jayaram (1981) and "Inland Fishes of India and adjacent countries" by Talwar and Jhingran (1991). I have taken the assistance of Dr. Pandit for the identification of fishes initially latter slowly and steadily I also learnt the method of identification of the fishes. For identification the following morphological characters were considered.

A) Total Length: - The distance between the anterior most part of the snout and posterior most tip of the caudal fin.

B) Standard Length- The straight distance from the anterior most part of the snout to end of the vertebral column.

C) Body depth: - Vertical distance from the dorsal to the ventral side at the highest point of the specimen.

D) Head length: - A straight measurement of the distance from tip of the snout to base of operculum.

E) Head Width: - The distance straight across the head in a vertical position

F) Eye Diameter: - The distance between the margin of the two eye balls.

G) Position of mouth: - Supra terminal, terminal, sub terminal and Ventral.

H) Presence or absence of barbells, number of barbells, and location and length of barbells

I) Height and length of Dorsal fin

J) Length of Pectoral and Pelvic fins

K) Length and height of caudal peduncle

L) Length of longest fin ray

M) The number and position of spines and rays

N) Lateral line scale count

O) Spots, Blotches, bands and marks etc.

Considering the above information and also with the help of the identification keys the fishes were classified into respective orders, families and genus and up to species level.

4.3.8. Species Diversity Analysis:

Species diversity or species heterogeneity, a characteristic, unique to the community level of biological organization, is an expression of community structure. A community is said to have high species diversity if many equally or nearly equally abundant species are present. On the other hand, if a community of composed is very few species or if only a few species are abundant, then species diversity is low. The ecologists agree that the concept of species diversity as measure of community stability (the ability of community structure to be unaffected by the disturbance of its components.)

This indicates the extent of Biodiversity in the ecosystem. The species diversity is made up of two components- Species richness and species abundance. The diversity is often represented in the form of indices. These diversity indices attempt to incorporate both richness and abundance into a single numerical value. A given value of diversity index can result from different combinations of species richness and abundance. A large number of measures of diversity have been proposed and many are in contemporary use. Of those available I used Simpson's index and Shannon – Weiner's diversity index.

4.3.9. Simpson's diversity index:

Simpson (1949) considered not only the number of species and total number of individuals, but also the proportion of the total that occurs in each species. This gives the probability with which, when two individuals selected at random, from a habitat, will belong to different species.

Simpson's index (Ds) is calculated as follows.

$$Ds = 1 - \sum_{i=1}^{s} (Pi)^2$$ Where

Ds—Diversity index

Pi --- the proportion of i^{th} species in a sample

s---- Number of specie

***The value of Simpson's index varies from 0 to 1. A value of 0 indicates the presence of only one species, while that of 1 means that all species are equally represented.**

4.3.10. Shannon – Weiner's Index:

This index represents the average degree of uncertainty in predicating, to which particular species or individuals chosen at random from a sample. This index considers total number of individuals of all species, the number of individuals of every species and the proportion of individuals of each species, in the total number of individuals of all species. The Shannon – Weiner's index is represented as follows.

$$H' = -\Sigma pi \log pi$$

Where

Pi –Proportion of total number of individuals that occur in the species: i.e (ni/N)

ni - Number of individuals of a species i and I = 1 to K

K – Total number of species

N – Total number of individuals of all species in the sample.

The value of Shannon - Weiner index varies from 0 to K. A value of 0 indicates the presence of only one species, while that of K means all species are equally represented.

During the analysis of the fish data that we had collected, the diversity indices were mainly used to compare the different at different periods of time. It is also used to compare the Downstream, Middle stream and upstream locations of the river Bedti.

4.4. An introductory note on the diversity of fish:

It is well recognized that hydrological regions of rivers, controls the quality and abundance of food; hence, it is not surprising that fish population varies according to the quality of river.

A list of fishes found in Bedti (Gangavali) river main stream during the study period is presented in the Table-VII. During the study a total of 12 families were recorded. Among 12 families 9 families such as Balitridae, Mugillidae, Claridae, Belonidae, Aplochilidae, Ambassidae, Gobiidae, Cichlidae and Syngnathidae were represented by a single species.

In the river Bedti (Main stream) our study revealed 28 species of fishes classified under 12 families. . The river exhibited highest number of Cyprinidae with 15 species. Out of 1681 total

fish catches Cyprinidae alone was found to constitute 1246 fishes. These are represented in Table-VII. The family Cyprinidae almost constituted 74per cent of the total fish species of the entire main river. This is graphically depicted in figure 6a, 6b and 6c. Family Bagridae and Siluridae were the next major families with 2 species.. All other families, Balitridae, Mugillidae, Claridae, Belonidae, Aplochilidae, Ambassidae, Gobiidae, Cichlidae and Syngnathidae were having only one species each.

Channa orientalis of family Channidae which was one of the popular fish of Western Ghats now appeared to be on the verge of extinction in Uttara Kannada as we could not collect even single individual in Bedti River of the district during the course of our field study.

Puntius amphibius was the most abundant species in the Bedti River. A total of 332 individuals of the above fish were caught during the fieldwork and this is the maximum number of individuals of a species that were caught during entire fieldwork. *Garra gotyla stenorhynchus(235),Rasbora rasbora (223,) Salmostoma boopis 152), Puntius filamentosus (90), Mugil cephalus (84) and Pseudambassis ranga* (77, glass fish) were the other fishes that were collected in abundance (Table-VII). *Icthyocampus ,* Mystus cavasius (Hamilton-Buchanan), Mystus malabaricus (Jerdon), Clarias dussumieri (Valenciennnes), Xenentodon cancila , Etroplus suratensis, Danio aequipinnatus and Labeo fimbratus were the fish species exclusive to Bedti river. The abundance of various families of fishes and their richness in three streams of main Bedti River is represented in Table –VIII and depicted graphically in figure -6d and 6e.

4.5. (A) Study of fish fauna in upstream of Bedti River:

The up Stream of Bedti River recorded 19 species under 6 families (Table-VII). Among the families Cyprinidae dominated with 12 species, family Bagridae recorded 2 species, family Siluridae 2 species, family Claridae 1 species, family Ambassidae 1 species and family Aplocheilidiae 1 species.

The upstream of Bedti documented a total of 476 individuals. The family Cyprinidae with 286 individuals contributed 60 per cent of the total fish catch. The high value was due to the abundance of *Garra gotyla stenorhynchus, Pseudoambasis ranga,* Ompok bimaculatus (Bloch)

Salmostoma boopis (Day), Puntius jerdoni and *Puntius amphibius*. The genus *Puntius* appeared to be less abundant compared to other zones with only 65 individuals, which was estimated to be about 13to14 per cent of the total catch (Figure-9a). The family Bagridae with 43 individuals contributed 9 per cent of the total catch. The family Ambassidae with 62 individuals contributed13 percent of the catch, Siluridae with 51 individuals contributed 11 percent of the total catch, Claridae with 32 individuals contributed 7 percent and Aplocheilidae with 2 individuals contributed very least per cent of the total catch. These are represented in table IXA and depicted in figure 7a.

The dominant family Cyprinidae with 12 species classified under 8genera. The *Puntius* was the largest genus with 4 species. The genus Gara with 2 species and all other genera Labeo, Devario, *Tor, Salmostoma, Danio,* and *Rasbora* recorded only one species. The next family was Bagridae with 2 species under one genera. Two species of *Mystus* were recorded under family Bagridae. The family Siluridae was recorded 2 genera with one species each. All other families listed only one species each (Table –VII).

4.5. (B) Study of fish fauna in middle stream of Bedti River:

The middle stream of Bedti River recorded 14 species under 6 families (Table-VII). Among the families Cyprinidae dominated with 9 species. The family Belonidae, Aplocheilidae, Ambassidae, Gobiidae and Cichlidae recorded one species each.

The middle stream of Bedti documented a total of 440 individuals. The family Cyprinidae with 339 individuals contributed 77 per cent of the total fish catch. The high value was due to the abundance of Salmostoma boopis (Day), Rasbora rasbora, Gara gotyla stenorhynhos, Puntius chola, Garra garra and Puntius amphibeus.The genus *Puntius* appeared to be more abundant compared to upstream zones with 93 individuals, which was estimated to be about 22 per cent of the total catch(Figure-9b) The family Belonidae with 49 individuals contributed 11 per cent of the total catch. The family Cichlidae with 23 individuals contributed 5 percent of the total catch, Ambassidae with 15 individuals contributed 4 percent, Gobiidae with 8 individuals contributed 2 percent of the total catch and Aplocheilidae with 6 individuals

contributed one per cent of the total catch. These are represented in table IXB and depicted in figure 7b.

The dominant family Cyprinidae with 9 species classified under 4 genera. The *Puntius* was the largest genus with 5species. The genus Gara with 2 species and all other genera, *Salmostoma,* and *Rasbora* recorded only one species. All other families listed only one species each (Table –VII).

4.5. (C) Study of fish fauna in downstream of Bedti River:

The downstream of Bedti River recorded 18 species under 10families (Table-VII). Among the families Cyprinidae dominated with 9 species. All other families listed only one species each. The downstream of Bedti documented a total of 765 individuals. The family Cyprinidae with 621 individuals contributed 81 per cent of the total fish catch. The high value was due to the abundance of Puntius amphibeus, Rasbora rasbora (Hamilton-Buchanan), Puntius filamentosus, Gara gotyla stenorhynhos, Salmostoma boopis (Day) and Puntius jerdoni (Day).The genus *Puntius* appeared to be more abundant compared to other two zones with 396 individuals, which was estimated to be about 55 per cent of the total catch. The Puntiius amphibeus was dominating among the Puntius genus which was estimated about 37 percent of the total catch (Figure-9c).The family Mugilidae with 84 individuals contributed 11 per cent of the total catch. The family Gobiidae with 18 individuals contributed 2 percent of the total catch, Balitridae with 9 individuals, Aplocheilida with 8 individuals, Syngnathidae with 8 individuals, Claridae with 5 individuals, Bagridae ,Belonidae with 4 individuals and Cichlidae with 4 individuals contributed one percent each of the total catch. These are represented in table IXC and depicted in figure 7c.

The dominant family Cyprinidae with 9 species classified under 4 genera. The *Puntius* was the largest genus with 5 species.The genus Gara with 2 species and all other genera, *Salmostoma,,* and *Rasbora* recorded only one species. All other families listed only one species each (Table – VII).

In summary the Bedti river, the upstream recorded a total 19 species classified under 6 families with 476 individuals, while in the middle stream of the same river was noted that 6

families with 14 species and 440 individuals. The downstream was documented 18 species under 10 families and 765 individuals. The middle stream is less diversified with less species richness, but abundance was very high. The upstream stream showed more species richness but the abundance was poor and diversity of families was at par with middle stream. The fish abundance was less in downstream, but more than middle stream and upstream. The diversity of family was more than up and middle stream.

The diversity of family Cyprinidae was same in middle stream and downstream, while it was slight more in upstream. Family Cyprinidae and aplocheilidae were represented in all the streams. Ambassidae species were not found in downstream.

Balitridae, Syngnathidae and Mugilidae families were exclusively found in downstream, while Siluridae family was unique to up stream. Claridae and Bagridae families were not found in middle stream. Gobidae, Belonidae and Cichlidae families were not recorded in upstream. There is slight variation in the number of families among the different streams of Bedti river, while species richness showed ascending order from middle stream to downstream to up stream. The upstream recorded the maximum species diversity with 19 species among the other two streams.

4.6. Species Richness in three streams of Bedti River:

The main streams of River Bedti of Uttara Kannada district recorded a total of 12 families and 28 species and 1681 individuals (Table-VIII, Figure 6a, 6b, 6d & 6e). Here also family Cyprinidae contributed major share to species richness and abundance with 15 species and 1246 individuals, which was almost 53 per cent of species richness and 74per cent of total individuals. The family Bagridae was the next major family with 2species and 47 individuals which accounted about 7 per cent of the species richness and 3 per cent of the abundance. In Bedti river the Siluridae family was also recorded 2 species and 51 individuals which was about 7 per cent of the species richness, but contributed only 3 per cent to the abundance.

The families Mugilidae, Claridae and Balitridae were recorded one species each with 84, 37, and 9 individuals respectively. The species richness of all families was 3 percent. But the

percentages of abundance of the above families were 5 percent, 2percent and 1 percent respectively.

The families Ambassidae, Belonidae, Cichlidae, Gobiidae, Aplocheilidae and Syngnathidae were recorded 77, 53, 27, 26, 16 and 8 individuals respectively. The species richness of all families was 4 percent. But the percentage of abundance of the above families was 5 percent, 3 percent, 2 percent, 2 percent, 1 percent and less than 1 percent respectively. All families except Cyprinidae, Bagridae and Siluridae were recorded only one species. Therefore the studies were reflected that the family Cyprinidae was dominating followed by the families Bagridae and Siluridae. (Table-V and Figure-5, Figure-6b and 6c).

4.7. Study of diversity indices of fishes:

It is necessary to mention in this context that Shannon and wiener's diversity value is high in upstream compared to middle and downstream streams. The middle and downstream have almost same value. The Simpson's diversity value is also high in upstream and middle stream as compared to the downstream where as the Simpson's dominance value is high in downstream than the up and middle streams.

4.8. Vegetation types:

The vegetations of different streams were also taken in to consideration during the research. The upstream had 45 trees in 100x10 meters area, and no shrubs and herbs. *Pongemia arjuna* and, *Terminalia* species were very common in upstream of Bedti Bridge. The middle stream generally showed 35 trees in 100x10 meters area, shrubs 12 in 10x100 meters area and herbs 116 in 1x1 meter area. The mango species were more common in addition to *Syzygium, Terminalia and Pongemia* species. The matured mango trees had 3 meters girth. The grass species were common in the river.

The downstream immediately after the ghat and all along the ghat has dense vegetation with naturally bamboo trees. At Gullapur and Kalleshwar herbs and shrubs diversity were more. The downstream had 60 trees in 100x10 meters area, shrubs 30 in 10x10 meters area and shrubs are 50 in 1x1 meters area during the study period.

4.9. Study of fish fauna in Tributaries of Bedti River:

The study area is mainly located in Uttara Kannada district shown in Figure-3**.** The river is the outcome of hundreds of tributary streams which merge and become limited number of tributaries. The streams have their catchments covered with various types of Landscape element types ranging from dense forest to agricultural areas, scrubs and wasteland. The major tributaries selected for the present studies are 1) Ganeshpal 2) Pattana hole 3) Sahasralinga 4) Sonda 5) Majjigehalla. The objective of the present work is to reveal the fish species diversity with respect to the river tributaries.

A total of 19 species belonging to 4 families of fishes were recorded during the study. Cyprinidae, Balitridae, Aplochaeilidiae and Ambassidae were the most abundant families. These are presented in Table- XI. The tributaries of river Bedti have different ecological characteristics, which have abundantly influenced the fish population. It has natural course of water without any dams and pollution. However in recent times Bedti River has been reported as polluted through urban sewage water flow. Moreover, the fishes have proved that they have the evolutionary flexibility to produce species to fill the spectrum of niches presented. They can be very big or very small, inhabit open waters or stay close to the bottom and they are present at every consumer trophic level in both the grazing and decomposer chains.

The predominant fish fauna in south Asia belongs to the carp family Cyprinidae. The carp family alone in the river was prominent with *Puntius* as major genus. Here also family Cyprinidae contributed major share to species richness and abundance with 16 species and 975 individuals, which was almost 84 per cent of species richness and 91 per cent of total individuals. The families Ambassidae, Balitridae and Aplocheilidae were recorded 66, 18, and 17 individuals respectively with one species each. The species richness of all families was almost 5 percent. But the percentage of abundance of the above families was 6 percent, 2 percent, and 1 percent less respectively. These are represented in Table -XII, XIII and graphically depicted in figure -10a, 10b and figure 11.

The river tributaries exhibited highest number of Cyprinidae followed Ambassidae, Balitridae and Aplochaeilidiae revealed that, the tributaries of river Bedti accounted 1076 individuals. These are presented in Table -XII. The significant finding of the present observation was that

the occurrence of Rasbora rasbora in all tributaries while Puntius arulius was found only in Pattanahole. Tor tor, Aplocheilus lineatus, Pseudoambasis ranga and Labeo fimbratus were found only in Sahasralinga while Puntius filamentous was found only in Ganeshpal. Nemacheilus guentheri was recorded only in Majjigehalla. It was observed that the species abundance was in the order Pattanahole 354, Sonda 269, Sahasralinga 245, Ganeshpal 114 and Majjigehalla 96. It has been further argued that the increase in the number of species indicates less anthropogenic pressure on that particular tributary. Contrary to these observations, it is noted that both in Ganeshpal and Majjigehalla river tributaries of the present study exhibited less species abundance. The most interesting observation of the present study was that though species Rasbora rasbora (edible fish) are more they are not very much liked by the local community because they are less tasty to eat. Diversity of fish species is determined generally by several physical factors, size, depth, quality of stream and biotic conditions such as food, vegetation and substratum. Habitat destruction due to deforestation results in increased erosion and suspended matter and deposition of fine sediments resulting in habitat loss and destruction of spawning grounds and species extermination. Different river systems are known to harbor some species exclusive to the system. As per the present study family richness was more in Sahasralinga as compared to other tributaries. This is presented in Table XIV and depicted graphically in Fig. 12.

The Cyprinidae family was dominating in all the tributaries. Tributaries such as Sahasralinga and Ganeshpal (T1 and T4) was contributed 10 species each with 24 percent species richness. Pattanahalla, Sonda and Majjigehalla tributaries (T3, T2 and T5) were contributed 9, 8 and 5 individuals with 21percent, 19 percent and 12 percent species richness respectively. The family Balitridae was found to confine to the tributary Majjigehalla(T5) only with one species while the families Aplochelidae and Ambasside were recorded only at the Sahasralinga tributary (T1) with one species each. This is presented in Table XV and depicted graphically in Fig. 13.

As per the Simpsons Diversity Index most diverse fish community was recorded in Pattanahole and Majjigehalla accommodated least diversity. These are depicted graphically in figure14.

According earlier reports from Daniels & Sreekantha species richness or diversity depends less on the characteristics of a single ecosystem than on the interactions between ecosystems, e.g. transport of living animals across the different gradient zones in the water body. Fish is captured in natural lakes, reservoirs, streams, tributaries, rivers and oceans. However, few species in spite of their great commercial interest have been comprehensively less studied to establish the importance of their distribution for their successful management. It is in this context, this study enlightens the fish species diversity in tributaries of the river ecosystem.

It has been revealed that fish diversity and abundance have shown variation in the tributaries based on the human interference. Overfishing and habitat degradation might be the significant factors affecting the fish diversity and richness.

4.10. Endemic fishes of Western Ghats:

The Western Ghats is a mega diversity place rich in flora and fauna as well as soil organisms. Mayer (1988, 1990) identified 18 regions or 'Hot Spots' which sheltered high concentration of endemic species. This region is the home of many important organisms.

Information utilized for this exercise was based on two sources.

1. **Field survey**- The field notes recorded during our survey twice in a year in all the 11 locations. Bedti formed the source data.
2. **Data from literature**: Literature was the second source of data where most of check lists, identification keys, and scientific papers provided information on distribution of fish species.

   The Bedti River registered 17 species of Western Ghats endemics. Here also family Cyprinidae was the domonant family with 11 species. The family Bagridae listed 3 species. The families Balitoridae and Claridae listed 2 and one species each respectively. The Bedti River in total recorded about 33 per cent of Western Ghats endemism out of the total species richness. .

   Our survey also yielded some data.

They were

1. Habitat loss.
2. Logging activities and encroachments.
3. Addition of urban sewage.
4. Accumulation of silt.

From the above reasons it was evident that

Fish diversity and abundance, including endemic fishes are declining at a faster rate. It is of at most importance to conserve those fishes, which face the danger of overexploitation and habitat loss. Proper management strategies are to be undertaken in the river of Bedti of Uttara Kannada district so as to protect the endemic fishes.

Maintenance of forest: Forests on sides of the river and in and around middle stream and also some parts of down streams have landscape heterogeneity and it should be protected to promote wild life. They need to be maintained as such without bringing under aforestation schemes.

Management of water sources: Perennial water sources flanked by swamps in many places are unique to this river. But as such there is no appreciation of these vital arteries of the river that has resulted in drastic reduction in summer time water flow. The fauna including critically endangered fish species are facing problem of survival.

Prevention of encroachment: Periodically attempts have been made in the past to clear the patches of forest especially near the river, for apparently for raising areca nut gardens and other agricultural purposes These encroachments have created indelible marks especially in the development of fish population as fishes are dependent on the fruits of plants as their food developing on the river bank. If vigilance was strong such damages could have been prevented. Therefore, it is suggested that monitoring by the forest department staff should be carried out on regular basis.

4.11. Chemical Parameters:

Abiotic and biotic factors have an important role in supporting fish diversity in riverine ecosystems. The relationship between abiotic factors and living organisms in fish diversity and abundances is far from being unidirectional because fish population will dramatically affect the trophic status of other organisms and alter the water conditions in various ways. Physico-chemical parameters like pH, temperature, dissolved oxygen; biochemical oxygen demand, dissolved solids have a greater influence on survivability of the fishes. Conditions of water can also cause mass mortalities of fish eggs and larvae apart from causing various abnormalities in the fish stocks. The average range of some of physico-chemical parameters of the river are shown in the table and graphically depicted in figure.

Chapter –V

Discussion

The Bedti river of Uttara Kannada district has different ecological characteristics, which have abundantly influenced the fish population. Bedti has natural course of water without any dams and pollution .However in recent times Bedti River has been reported to be polluted through urban sewage water flow. For mobile animals such as fishes can control their own distribution in the water, a rich mosaic of environmental possibilities become available. Moreover, the fishes have proved that they have the evolutionary flexibility to produce species to fill the spectrum of niches presented. They can be very big or very small, inhabit open waters or stay close to the bottom and they are present at every consumer trophic level in both the grazing and decomposer chains. For example *Garra species* is very well adapted to torrential water flow which has a suction cup on the ventral region, just below the mouth, can adhere to rocks, thus protects itself from torrential flow of water.

The predominant fish fauna in south Asia belongs to the carp family (Cyprinidae). The carp family alone in the river was prominent with *Puntius* as major genus. The carps alone constituted half of the total catch, of the known species, while together with catfishes (Bagridae family) they contributed almost 60 per cent. In the river both carps and catfishes are important while, in addition a further group of Osteophysians, the loaches (Family Balitoridae) also play a significant contribution to the Uttara Kannada Ichthyofauna.

The river Bedti exhibited highest number of carps. Bedti begin in moist deciduous forest and then enters evergreen forest. The data (Table -VII) revealed that, the main streams of the river Bedti accounted 1681 individuals. The significant finding of the present observation was that the occurrence of Glass fish (Family Ambassidae). Bedti River was also being polluted because the Euphorbia species were also observed on the bank of the Bedti river bridge during the study. . This is considered as a pollution indicator. Positive correlations between production and species abundance have been recognized in various earlier studies (Elton, 1927). The species diversity of an ecosystem is often related to the amount of living and non living organic matter in it. However apparently, species diversity depends, less on

characteristics of single ecosystem than on the interaction between ecosystems, e.g. transport of living animals across the different gradient zones in water body. The effect of such transport is important in enhancing the genetic diversity (Hammer et al, 1973).

It is well recognized that rivers present a series of habitat along their length although they do fall into two major categories, the generally eroding upper rhithron reaches and the more depositional stretch potamon downstream. The current in one direction affects life and determines the kind of plant and animals that can live in such a habitat. Most of the organisms found here have adaptations to cope with the current. It provides diverse environments and microhabitats, ranging from swift riffles over stones and cobbles to relatively stagnant pools. Body flattening, presence of adhesive devices and the use of dead zone are the chief adaptations in the torrential waters. Severe though the conditions in hill-streams, they have their compensation through plentiful oxygen supply and more even temperatures. In spite of various mechanisms for maintaining positions, there is a continuous drift of organisms downstream. Drift may be a means of regulating population size to the carrying capacity of the habitat. As the water course slows down over flat land, suspended matter is deposited, permitting a wealth of plants to take roots which in turn influence fantastic population.

Fishes are more mobile than the benthic invertebrates and are therefore able to move up or down stream; however, many are restricted to specific parts of the river system. The downstream of river together contained 18 species under 10 families and 765 individuals, whereas 14 species classified under 6 families and 440 individuals of middle stream. In upstream there were 19 species under 6 families and 476 individuals. It was observed that the family richness was more in downstream than the middle and upstream where as the family richness of middle and upstream were same. The family richness in the downstream may be attributed to the fact that many of the estuarine fishes invade to the fresh water bodies and contribute to the family richness of that zone. This was true in case of Hosakambi location which comes in downstream. In respect of species richness, upstream was exhibited higher value than that of downstream. In tributaries species abundance was found to be more than the main stream. It has been argued that, generally the number of species tend to increase

as the stream lowers down. The gradient itself may also influence the types of fish found closest to the source. For e.g. , the streams descending from the mountains, there is a distinct difference between the steeper slopes where only *Barbus liberiensis* is found in the upper most reaches and the less steep although still rapidly flowing streams where cichlid *Hemichromis bimaculatus* and the Cyprinodont *Epiplatys fasciolatus* are always found (Pyne, 1986). It has been further argued that the increase in species down a stream represent an increase in the nature and availability of resources including food, shelter and breeding ground. (Pyne, 1986; Zaret and Rand, 1971).

Contrary to these observations, it is noted that upper and to some extent middle zones of the river of the present study exhibited higher species richness than that of the lower zone. It is suggested that this increased species richness is due to

1) As good number of hill streams join the river in middle and upper zones, the number of niches available increases,

2) It is known that amount of dissolved oxygen is higher in upper and middle zones compared to the lower zone. It has been suggested that the Cyprinoids are found in abundance, in oxygen rich water. Interestingly both upper and middle zones of the river show highest species of cyprinoids.

3) It is also possible that the microhabitats are available more in the upper and middle zones, as the riverbed of these zones show heterogeneous substratum. Accumulation of silt in the downstream zone decreases the diversity of microhabitats. During our studies we have observed the accumulation of silt not only in the downstream but also on the upstream all along the length of the Bedti River Bridge (location selected for the study as it was easily accessible).

The most interesting observation of the present study was that species richness need not necessarily reflect species abundance. For example, the downstream zone was rich in fish abundance but low in diversity, whereas both middle and upper zones exhibited less abundance and high diversity particularly the upstream. The abundance in fish population in downstream zone may be due to the invasion of brackish water fishes to the fresh water

body. It is necessary to mention in this context that Shannon and Wiener's diversity value is high in upstream compared to middle and downstream streams. The middle and downstream have almost same value. The Simpson's diversity value is also high in upstream and middle stream as compared to the downstream where as the Simpson's dominance value is high in downstream than the up and middle streams. These are represented in table XVIII and graphically depicted in fig.17.

Diversity of fish species is determined generally by several physical factors, size, depth, quality of stream and biotic conditions such as food, vegetation and substratum. It is suggested that fish diversity increases from upstream to downstream with the upper reaches harboring highly specializes species adapted to rapid current, while the lower reaches harbor great many species occupying varied niches and ranges of food available. Habitat destruction due to deforestation results in increased erosion and suspended matter and deposition of fine sediments resulting in habitat loss and destruction of spawning grounds and species extermination. Different river systems are known to har'bour some species exclusive to the system.

Species richness or diversity depends less on the characteristics of a single ecosystem than on the interactions between ecosystems, e.g. transport of living animals across the different gradient zones in the water body. Fish is captured in natural lakes, reservoirs, streams, rivers and oceans. The worlds estimated total catches of fish is about seven million metric tons per annum. In many Asian countries inland catch make up 40 – 70 % of the total fish production (FAO, 1986). However, few species in spite of their great commercial interest have been comprehensively less studied to establish the importance of their distribution for their successful management (Ludwing and Raynolds, 1988). It is in this context, this study assumes importance reflecting the fish species diversity in river ecosystem.

Species richness or diversity is a property at the population level, while the functional diversity concept is more strongly related to ecosystem stability and stresses physical and chemical factors, for determining population dynamics in the river ecosystems, in spite of its tremendous significance in determining productivity and calculating species diversity.

It is evident from the present investigation that the river exhibited species richness at different levels due to both physical and hydro biological factors. It is of considerable significance to note that, in spite of human influence the river systems of the present study, demonstrated rich Ichthyologic diversity. The main streams of river Bedti, was accounted 12 families and 28 species. The river flows through evergreen forest with good riparian vegetation and it is less subjected to fragmentation. The river has rich flora of *Callophyllum, Eugenea* and *Ficus*. The fruits of these plants are good source of food for carps. Indeed the seeds of the plants are used as fish bait. The river has provided an ideal habitat by the presence of ponds and pools all along the river constructed by the local people for the purpose of irrigation. The river Bedti has the moderate pollution by the discharge of sewage water.

Our studies were also reflected the type of vegetation and landscape of the Bedti River and its vicinity. The middle stream generally shows 35 trees in 100x10 meters area, shrubs 12 in 10x100 meters area and herbs 116 in 1x1 meter area. The mango species are more common in addition to *Syzygium, Terminalia and Pongemia* species. The matured mango trees have 3 meters girth. The grass species were common in the river. The grass species and other species are responsible for reducing the flow of water. Dams were not constructed to the Bedti River. But Proposal was before the government for the construction of mini dam at Pattanahoe near Ganeshpal and Kelase near Yellapur Taluk. But the local people were against the scheme. Due to the agitation made by them and local environmentalist the proposal is withdrawn. If the proposal of the construction of mini dam is being implemented the enriched fauna and flora of the region would be destructed.

The upstream has 45 trees in 100x10 meters area, and no shrubs and herbs. The upstream is in context to the location at Bedti Bridge. At this location natural flow of water is obstructed and diverted to Yellapur town for drinking purpose. As a result entire trees are submerged partially and shrubs and herbs are fully. The river is covered by the accumulation of silt which might have led to the decrease of fish abundance. It is generally known that the obstruction in natural flow of river water, produce shallowness in the out flow water after the obstruction site. This possibly causes loss of microhabitats and also increases the water temperature.

These factors appeared to affecting the fish population considerably in river Bedti bridge location. The *Pongemia arjuna and, Terminalia* species were very common.

The downstream immediately after the ghat and all along the ghat has dense vegetation with naturally *Bambusa arundinacea* (bamboo trees) species. At Gullapur and Kalleshwar herbs and shrubs diversity were more. The downstream had 60 trees in 100x10 meters area, shrubs 30 in 10x10 meters area and shrubs were 50 in 1x1 meters area.

Another factor which also has contributed to the lesser fish diversity is the origin of the river in moist deciduous forest which has poor food plants. No dams have been erected across the river Bedti. If constructed which would have been imposed dramatic effect on hydro biological qualities of the entire river. Endemics are the species with restricted range. Endemic species are confined to a particular area and the confinement may be due to historical reasons, ecological and / or physiological (Subhas Chandran, 2000). In our study river Bedti revealed high endemism (33%) inspite of its pollution through urban sewage as per the studies were carried out in other rivers.

In the final analysis, the present preliminary studies have established a correlation between river ecosystem and species richness and abundance. The studies on fish diversity may be used as an index to the extent of understanding population level in a river system. This study provided the list of fish species in the river Bedti which are of great commercial interest and requires further comprehensive study to establish importance of their distribution for their successful management and finally the conservation in river ecosystem.

Abiotic and biotic factors have an important role in supporting fish diversity in riverine ecosystems. The relationship between abiotic factors and living organisms in fish diversity and abundances is far from being unidirectional because fish population will dramatically affect the trophic status of other organisms and alter the water conditions in various ways. Physico-chemical parameters like pH, temperature, dissolved oxygen; ammonia-nitrogen, phosphorus and chlorides have a greater influence on survivability of the fishes. Conditions of water can also cause mass mortalities of fish eggs and larvae apart from causing various abnormalities in the fish stocks.

Water temperature ranged between a minimum of 19-23^0 C during winter to maximum of 22.4 - 32^{o}C during summer is suitable for the fish growth. Sharmaand Gupta (1994) had reported that fish growth was better at temperature range of 14.5 to 38.6^{o}C. Though water temperature in this river was little bit high during the study period found ideal for fish growth and fish productivity The fish abundance was little bit less as compared to the earlier studies.. pH of the water was found to be neutral, and ranged between 7.2-8.4(Post monsoon), 7.6-9.1(Pre monsoon). These are presented in Table XVI and graphically depicted in fig-15. Fishes have their own tolerable limits for pH fluctuation, beyond which they cannot survive (Alikunhi, 1957). Though the pH was slightly high during summer, it was good enough for normal fish growth. Dissolved oxygen concentration is another parameter used in judging the suitability of a water body to support fish community (Banerjee, 1967). Some fluctuation in dissolved oxygen was noticed during monsoon which was as a result of higher photosynthetic activity.

The water samples were tested for DO and BOD. Tamboor of Bedti upstream was found very less BOD where as Hulgol tributary of Bedti had shown more. The middle stream was more BOD than the upper region of the downstream. From these studies it is evident that why fish species are abundant at tributaries than the other part of the stream. These are presented in Table-XVII and Figure 16.

The biochemical oxygen demand (BOD) is a way of expressing the amount of organic compounds in sewage as measured by the volume of oxygen required by bacteria to metabolize it under aerobic conditions. It is a good index of the organic pollution. If the amount of organic matter in sewage is more, the more oxygen will be utilized by bacteria to degrade it. Dumping sewage that contains high BOD increases the concentration of soluble organic compounds in the aquatic body where it is discharged. Digestion of these organic compounds in natural ecosystems such as lakes, river, can deplete available oxygen and result in asphyxiation of fish.

At Tamboor of Bedti upstream water was polluted by the Hubli-Dharwar urban sewage. That was the reason why BOD was less as compare to other regions of the river. The bacteria were also found more at this region than the other regions. It was proved from the bacteriological experiments. The bacteria were normal in all the samples of water except Tamboor.

Water, the universal solvent has a larger number of salts dissolved in it which largely govern the physic-chemical properties of water and in turn have an indirect effect on the flora and fauna. The dissolved solids were comparatively nil in all the places of water sample except at Tamboor water sample which was found to be polluted. The concentrations of dissolved solids were found decreasing from the upstream to downstream. The tributaries water on the contrary was all extremely pure and devoid of dissolved solids.

Threats to Freshwater Biodiversity to Bedti Region

The Western Ghats region, like other parts of the tropics, is undergoing rapid transformation. The deforestation rate is high and forests are being transformed into agriculture and monoculture plantations. Hydroelectric projects were not constructed in Bedti River. But government is planning to construct mini hydral projects at Kelase and some selected sites. The local people have strong opposition for the construction of mini dams. The mining and extraction of forest products are also altering the landscape. **Adjacent to the Gullapura and Kelase land sliding has occurred at Tadakebail of Yellapura taluk. This is the alarming threat to the Biodiversity of this region.** Major human induced ecological changes in the Western Ghats begin with the arrival of agriculture. A climatic change towards the middle of fourth millennium BP, which induced widespread human migrations within the Indian sub-continent, is correlated to decline of forests and mangroves in Western Ghats. The ecosystems in the Western Ghats do bear the imprints of human actions through history (Chandran, 1997).

Fragmentation of Habitat

One of the greatest threats to regional and global biodiversity is the fragmentation, the loss and isolation of natural habitats. Habitat fragmentation takes place when the continuity is broken. This may be mainly through the construction of dams across the rivers, conversion of wetlands into other forms of land uses, destruction of riparian vegetation, etc. In Western Ghats particularly, the rivers are extensively harvested for hydroelectric power through the construction of dams resulting in the fragmentation of the rivers. The government of Karnataka is showing more inclination for the construction of mini dams at Ganeshpal and kelase in spite of strong opposition of the local people. The mini dam construction across the

river should be banned. Anadromous fishes begin their life in freshwater, move to the marine environment to grow and mature, and then return to freshwater to reproduce. In Western Ghats decline in the population of *Anguilla bengalensis* has been attributed to fragmented rivers.

Pattern of Land use in the catchment area

The cumulative geographical, hydrological, and ecological impacts of deforestation, timber harvesting, and destruction of riparian vegetation, agricultural development, urbanization, land drainage, and flood protection on rivers have been documented worldwide. Deforestation of the catchment area usually results in soil erosion and nutrient input into the rivers. Destruction of riparian vegetation damages the coarse stream substrate where several fishes find their shelter. High suspended sediment concentrations in rivers and sediment deposition on the riverbed can affect the health, habitat and particularly damage the gills. The Western Ghats region is prone to large-scale mining activities. These activities contribute huge quantities of silt into the aquatic systems. The rapid transformation of habitats in the form of silt deposition may result in the decline fish population. The silt deposition has taken place particularly in middle stream and the part of upstream of Bedti.

Flow regulation

Flow regulation is mainly due to the construction of dams across the rivers. It can be estimated that more than 60 % of the worlds is and many rivers have reduced to cascades of manmade lakes. This clearly reveals the magnitude of flow regulations all over the world. The flow regulations remove the lotic habitats and give rise to lentic habitats. Also, the homogenization of the habitats and within which it forms the temperature gradients.

The flow of water was very slow in upper part of the downstream i.e. at Kalleshwar and also at the beginning of the upstream i.e. at Tamboor because their water flow was obstructed and was directed to irrigation purposes.

Over harvesting destructive fishing methods

Fishes are regarded as the rich sources of protein. Throughout the world, fishing has offered employment to thousands of families. Subsistence fishing in streams, rivers and tanks has been a source of living for weaker section of the society. This has brought to our notice at Kalleshwar, Gullapura, Tamboor and even at Hosakambi. All these aspects have resulted in commercialization of fishery. The annual commercial catch from the fisheries of the world is approaching 100 million ton. Such a tremendous rate of extraction from the aquatic ecosystem has adversely affected the fish base of the world. Human uses of freshwater resources have threatened the sustainability of these resources. Increase in the fishing population and the demand for fish has intensified the fishing activities. Fishermen are using the destructive methods of fishing to get higher yields. Illegal usage of small meshed fishing gears that damage the juveniles, is still in use. Fishing using chemical and herbal poisons like copper sulphate, bleaching powder, tree extracts damage the entire fish population of the aquatic body. Dynamiting is another destructive method by which fishermen easily collect huge quantity of fishes. Use of dragnets which sweep away the entire fish resource of a particular area including juveniles can be disastrous to both target and non-target fishes of the area.

Culture of alien species

A number of species get introduced into the waters, most of which are to the reservoir areas of dams with a view to increase the net fish yield of the reservoir. Of these introduced fishes, many have naturalized in the streams, ponds and tanks of the region. Species like *Oreochromis mossambica*, *Gambusia offinis*, *Poecilia reticulata,* etc. are exotic species, which are originally from Africa and South America and introduced extensively in India. Species like *Labeo rohita, Catla catla, Cirhinus mrigala* have been introduced recently in to the reservoirs. Importantly *Cyprinus carpio* has been widely introduced into the reservoirs of Western Ghats. This kind of haphazard introduction not only jeopardized the reservoirs but also threatened the freshwater biodiversity.

Changes in Water quality

Changes in water quality due to discharge of effluents from various industrial, domestic and agricultural sources have deteriorated water quality. The toxic elements in pollutants may be total, killing all the fish species present, or selective, destroying a few sensitive species or so altering the environment that some species are favored and others not. This kind of situation was seen at Tamboor where Hubli-Dharwar urban sewage was deteriorating the quality of water and also the life of aquatic fish population.

During the research we have focused on the fish species distribution, diversity, abundance in different streams and tributaries of Bedti River. We have tried to know how the different physico-chemical factors play a significant role in the distribution, growth and development of fish population. How the abiotic and biotic factors interact in order to trigger the population of fish fauna were also studied to some extent. The research was based on the field study, laboratory work and the extensive review of literature.

Chapter –VI

Summary

- Bedti, constitute one of the major river systems in Uttara Kannada**.** The river has different ecological and hydro biological characteristics, which have influenced the fish population.
- Abiotic and biotic factors have an important role in supporting fish diversity in the river ecosystems. The relationship between abiotic factors and living organisms in fish diversity and abundances is far from being unidirectional because fish population will dramatically affect the trophic status of other organisms and alter the water conditions in various ways. It is true in the case of the river studied.
- Another important observation of the present study was that of Physico-chemical parameters like pH, temperature, dissolved oxygen etc. These have a greater influence on survivability of the fishes. Conditions of water can also cause mass mortalities of fish eggs and larvae apart from causing various abnormalities in the fish stocks.
- The carp family (Cyprinidae) was the prominent group in the river. Hence the carp family provided a species richness in the river. The loaches (family Balitoridae) also contributed significantly to species richness of Bedti.
- The interesting observation of the present study was that of occurrence of Ambassidae family (Glass fish) in highest number in Bedti River though it was polluted.
- The study revealed that the family richness was more in the Downstream than the Middle stream and Upstream. The family richness in downstream is attributed to the fact that many of the estuarine fishes invade to fresh water body.
- It is observed that both upper and downstream zones of the river exhibited higher species richness than that of middle stream.
- The most interesting observation of this study was that, species richness need not necessarily reflect in species abundance.

- The application of diversity indices revealed that, the river enjoys high Ichthyofaunal diversity.
- Water temperature ranged between a minimum of 22-27^0 C during post-monsoon to maximum of 26 - 37^{o}C during pre-monsoon is suitable for the fish growth. Sharma and Gupta (1994) had reported that fish growth was better at a temperature range of 14.5 to 38.6^{o}C. The water temperature in this river was found ideal for fish growth and fish productivity.
- pH of the water was found to be neutral, and ranged between 7.2-8.4(Post monsoon), 7.6.-9.1 (Pre monsoon). Fishes have their own tolerable limits for pH fluctuation, beyond which they cannot survive .Though the pH was slightly high during summer; it was good enough for normal fish growth.
- Dissolved oxygen concentration is another parameter used in judging the suitability of a water body to support fish community. Some fluctuation in dissolved oxygen was noticed during monsoon which was as a result of higher photosynthetic activity.
- Studies on Western Ghats endemic fishes revealed that, endemism was also high in Bedti.
- It has been observed that species richness or diversity depends less on characteristics of a single ecosystem, than on the interactions between the ecosystems.

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APPENDIX-A

Tables showing the altitude (elevation) , latitude and longitude at different locations of Bedthi and its tributaries with respect to the distance covered within each location.

(Graph showing the elevation of each table is presented in appendix-B)

(Table 1 -11)

Table-1

Upstream location -1. Tamboor			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	479 m	20-11-2013 17:24:04	N15 05.814 E74 57.031
2	494 m	20-11-2013 17:24:30	N15 05.815 E74 57.031
3	500 m	20-11-2013 17:25:10	N15 05.812 E74 57.031
4	494 m	20-11-2013 17:25:41	N15 05.813 E74 57.031

Table-2

Upstream location -2. Bedthi Bridge			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	434 m	06-11-2013 11:58:48	N14 53.446 E74 47.150
2	428 m	06-11-2013 11:59:16	N14 53.447 E74 47.152
3	430 m	06-11-2013 11:59:51	N14 53.447 E74 47.149
4	428 m	06-11-2013 12:00:36	N14 53.450 E74 47.149
5	427 m	06-11-2013 12:01:06	N14 53.449 E74 47.150
6	427 m	06-11-2013 12:01:38	N14 53.448 E74 47.150
7	**426 m**	**06-11-2013 12:02:02**	**N14 53.448 E74 47.150**

Table-3

Middle stream location -1. Gullapura(Ramanagar)			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	60 m	06-11-2013 16:00:18	N14 49.195 E74 37.452
2	62 m	06-11-2013 16:00:54	N14 49.194 E74 37.453
3	**56 m**	**06-11-2013 16:01:30**	**N14 49.194 E74 37.453**
4	55 m	06-11-2013 16:02:05	N14 49.194 E74 37.453
5	56 m	06-11-2013 16:02:45	N14 49.195 E74 37.452
6	56 m	06-11-2013 16:03:16	N14 49.195 E74 37.451
7	57 m	06-11-2013 16:03:25	N14 49.195 E74 37.450

Table-4

Middle stream location -2. Kelase			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	68 m	06-11-2013 15:34:22	N14 50.472 E74 38.735
2	69 m	06-11-2013 15:34:43	N14 50.472 E74 38.735
3	69 m	06-11-2013 15:35:08	N14 50.471 E74 38.735
4	68 m	06-11-2013 15:35:34	N14 50.471 E74 38.735
5	67 m	06-11-2013 15:35:54	N14 50.471 E74 38.735
6	**66 m**	**06-11-2013 15:36:22**	**N14 50.471 E74 38.735**

Table-5

Downstream location -1 Hosakambi			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	29 m	20-11-2013 09:27:34	N14 40.821 E74 29.402
2	13 m	20-11-2013 09:28:00	N14 40.823 E74 29.401
3	10 m	20-11-2013 09:28:36	N14 40.824 E74 29.400

Table-6

Downstream location -2. Kalleshwar(Ramanaguli)			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	44 m	06-11-2013 17:45:24	N14 47.703 E74 35.165
2	46 m	06-11-2013 17:45:43	N14 47.703 E74 35.166
3	48 m	06-11-2013 17:46:05	N14 47.701 E74 35.168
4	**52 m**	**06-11-2013 17:46:37**	**N14 47.701 E74 35.170**
5	54 m	06-11-2013 17:47:03	N14 47.701 E74 35.170
6	54 m	06-11-2013 17:47:41	N14 47.702 E74 35.169
7	53 m	06-11-2013 17:48:09	N14 47.702 E74 35.168

Table-7

Tributary -1. Hulgol (Sahasralinga)			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	463 m	06-11-2013 08:43:36	N14 43.270 E74 48.455
2	**456 m**	**06-11-2013 08:44:12**	**N14 43.268 E74 48.457**
3	446 m	06-11-2013 08:44:48	N14 43.266 E74 48.458
4	451 m	06-11-2013 08:45:21	N14 43.269 E74 48.460
5	452 m	06-11-2013 08:45:53	N14 43.267 E74 48.460
6	453 m	06-11-2013 08:46:20	N14 43.267 E74 48.460
7	452 m	06-11-2013 08:46:28	N14 43.267 E74 48.460

Table-8

Tributary -2.Shalmala (Sonda)			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	451 m	06-11-2013 10:43:25	N14 44.415 E74 48.592
2	453 m	06-11-2013 10:43:43	N14 44.415 E74 48.589
3	456 m	06-11-2013 10:44:07	N14 44.414 E74 48.589
4	457 m	06-11-2013 10:44:27	N14 44.416 E74 48.589
5	456 m	06-11-2013 10:45:02	N14 44.417 E74 48.587
6	**453 m**	**06-11-2013 10:45:39**	**N14 44.416 E74 48.588**
7	455 m	06-11-2013 10:46:13	N14 44.416 E74 48.589
8	457 m	06-11-2013 10:46:46	N14 44.416 E74 48.589
9	457 m	06-11-2013 10:47:17	N14 44.416 E74 48.588
10	458 m	06-11-2013 10:47:45	N14 44.416 E74 48.589

Table-9

Tributary -3.Pattana Hole			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	443 m	21-11-2013 09:12:18	N14 42.950 E74 42.294
2	452 m	21-11-2013 09:12:53	N14 42.943 E74 42.290
3	454 m	21-11-2013 09:13:27	N14 42.943 E74 42.290
4	448 m	21-11-2013 09:13:50	N14 42.943 E74 42.289

Table-10

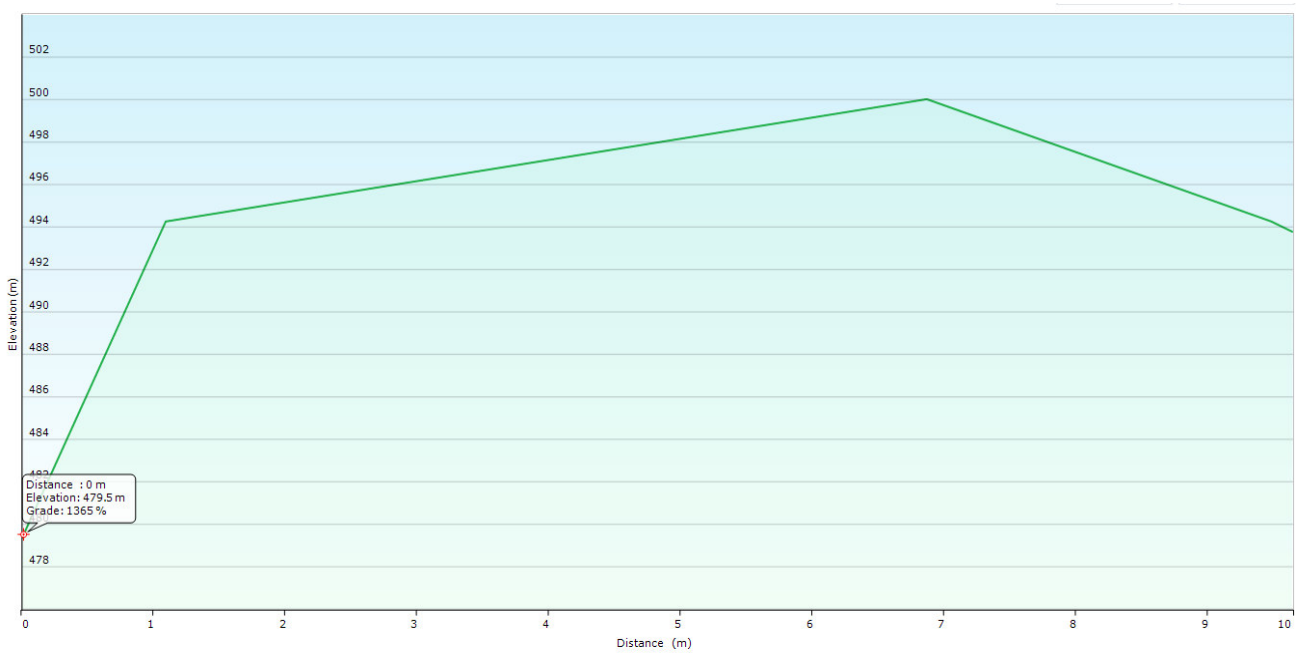
Tributary -4.Ganeshpal			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	450 m	21-11-2013 12:13:51	N14 46.984 E74 45.521
2	449 m	21-11-2013 12:14:14	N14 46.982 E74 45.520
3	396 m	21-11-2013 12:14:57	N14 46.982 E74 45.519

Table-11

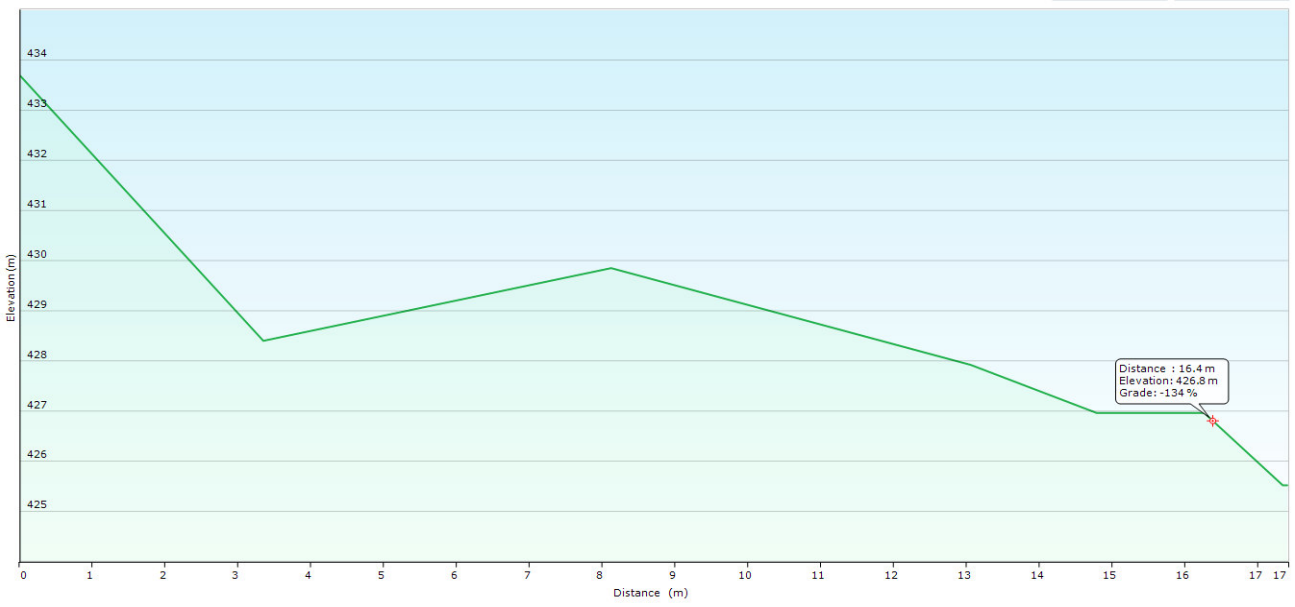
Tributary -5.Majjige Halla			
S.No.	**Altitude**	**Date and time**	**Latitude and longitude**
1	517 m	21-11-2013 17:20:07	N14 50.326 E74 56.548
2	522 m	21-11-2013 17:20:36	N14 50.332 E74 56.547
3	530 m	21-11-2013 17:21:06	N14 50.332 E74 56.547

APPENDIX-B

Graph showing the altitude at different locations with respect to the distance covered.



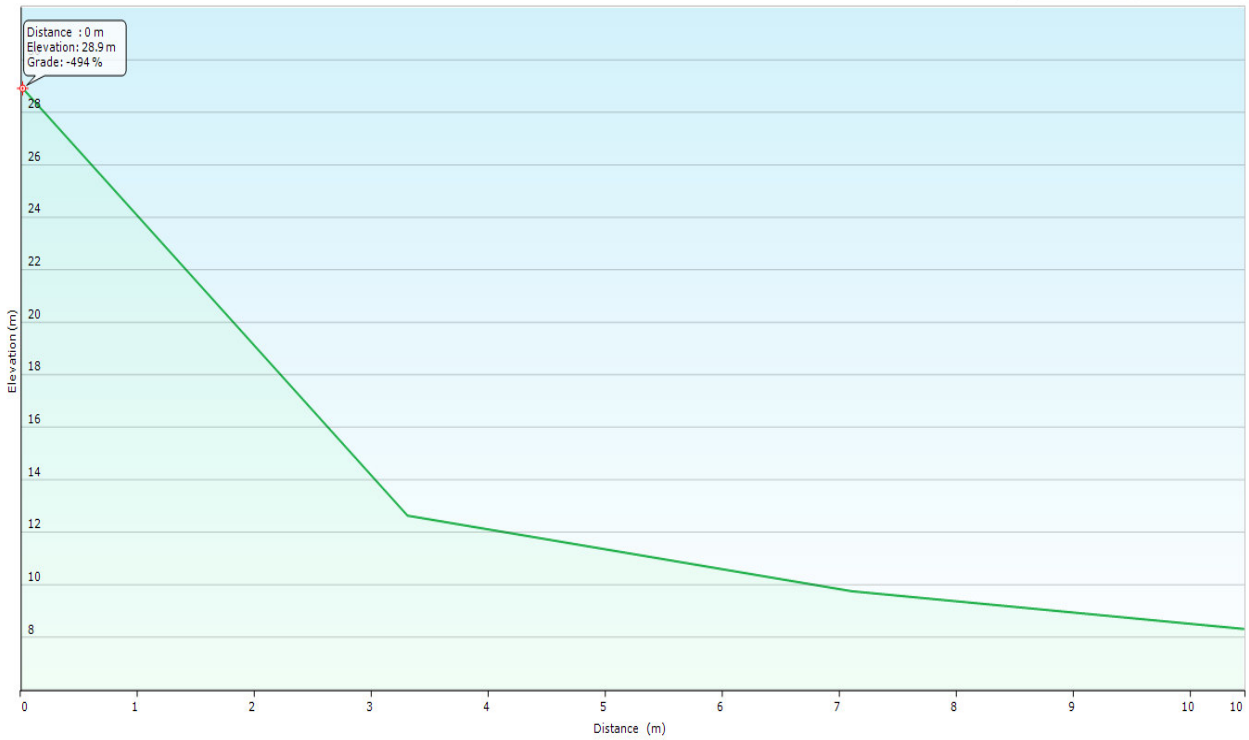
Graph1. Upstream location (Tamboor)



Graph2. Upstream location (Bedti Bridge)

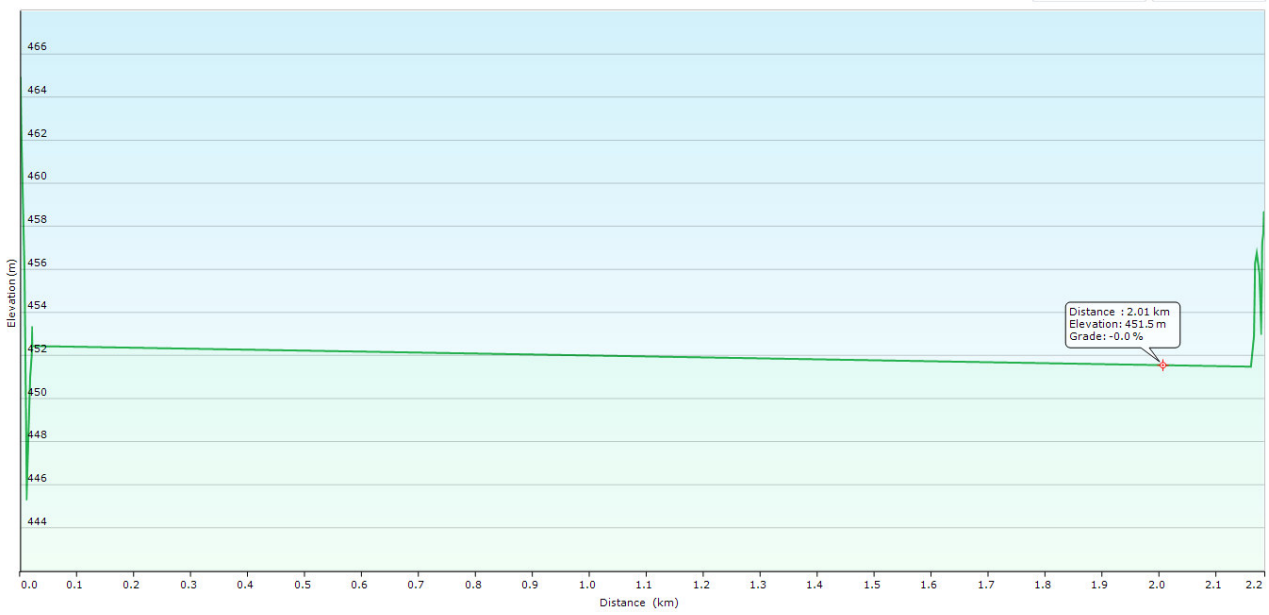
Graph3. Middle stream location (Gullapura)

Graph4. Middle stream location (Kelase)

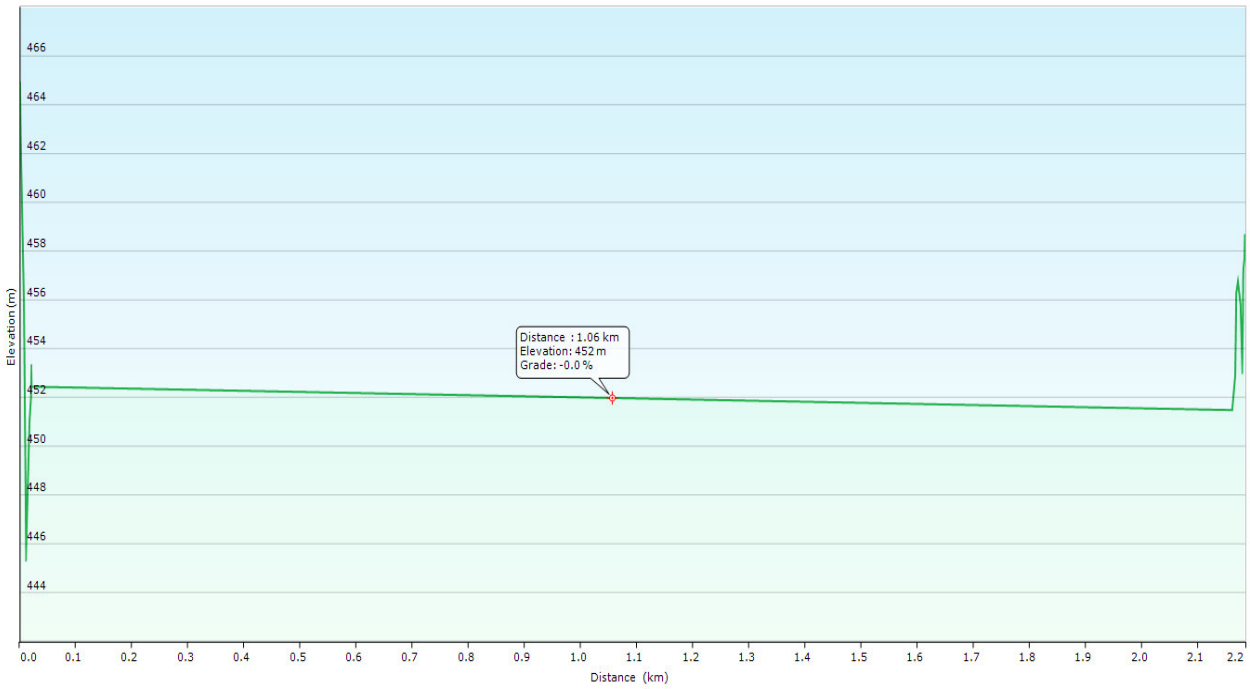


Graph5. Down Stream location (Hosakambi)

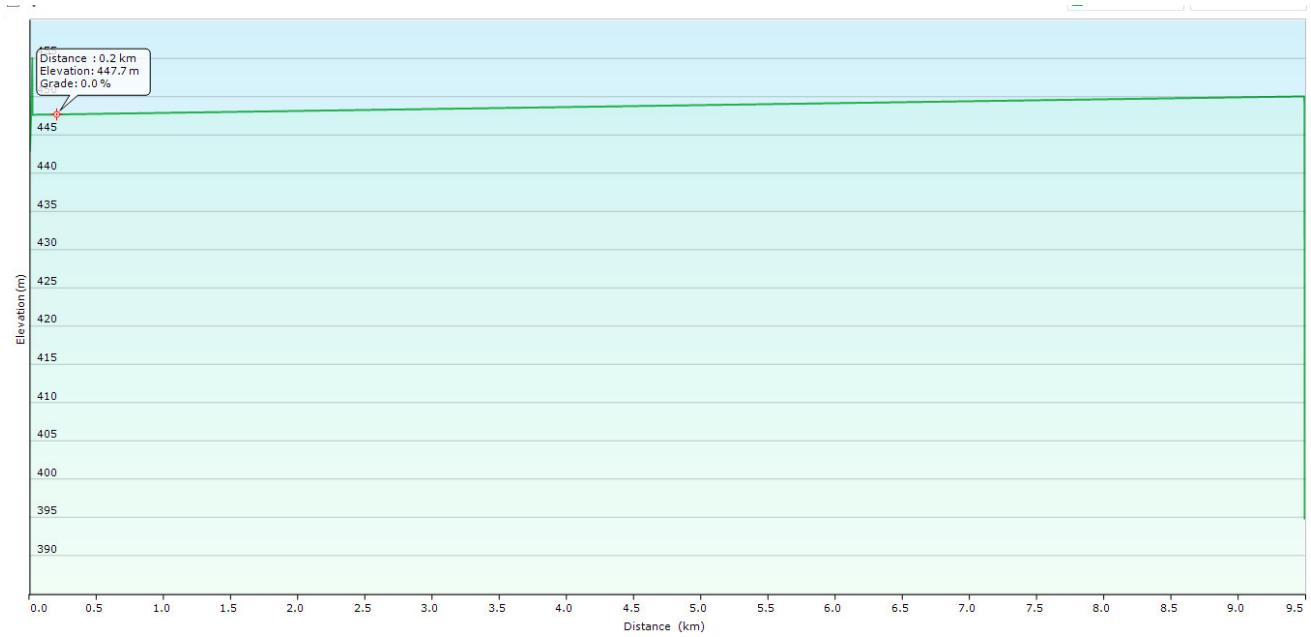
Graph6. Downstream location (Kalleshwar)



Graph7. Tributary 1.Hulgol (Sahasralinga)

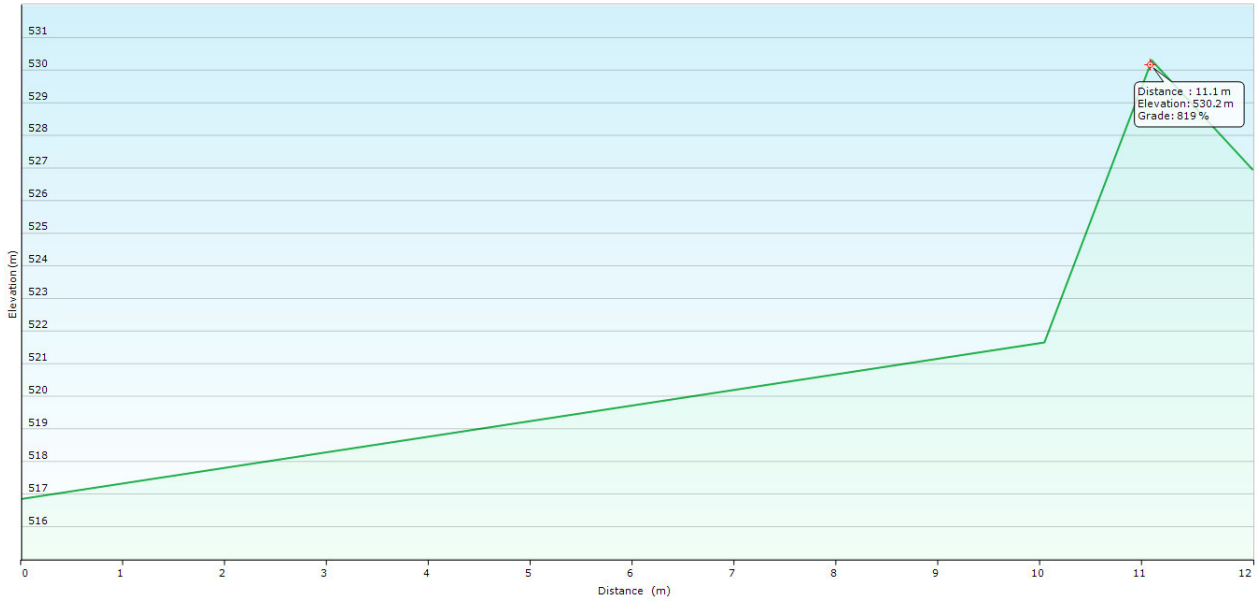


Graph8. Tributary 2.Shalmala (Sonda)



Graph9.Tributary 3.Pattana Hole

Graph10. Tributary4. Ganeshpal



Graph11. Tributary5. Majjige Halla

Period	Rain fall (in mm)	Percentage
From 1st January 2013 to 31st December 2013	2957.3mm	9% Normal (N= -19 to + 19 %)
Pre-monsoon 1st January to 31st May 2014	150mm	13% Normal (N= -19 to + 19 %)
June 2014	384mm	-40% Deficient (D= - 59 to -20 %)

Table III- Cumulative rain fall pattern (in mm) of Uttara Kannada District

Streams	Seasons	Locations	Air temperature in ^{O}C	Water temperature in ^{O}C
Up stream	Post monsoon	Tamboor	24.6(at5.10pm)	25.5(at 5.15pm)
		Bedti bridge	29.4(at 12.40pm)	27.1(at 12.45pm)
	Pre monsoon	Tamboor	34.6(at4.30pm)	33.9(at4.35pm)
		Bedti bridge	36.2(at12.45am)	35.7(at12.50am)
Middle stream	Post monsoon	Gullapura	31.2(at 4.20pm)	27.2(at 4.25pm)
		Kelase	32.3(at 4 pm)	28.2 at 4.5 pm)
	Pre monsoon	Gullapura	36.9(at12.45pm)	35.1(at12.50pm)
		Kelase	39.8(at 2.10pm)	37.6(at 2.15pm)
Down stream	Post monsoon	Hosakambi	27.6(at9.30am)	26.7(at9.35am)
		Kalleshwar	29.6(at 5.30pm)	27.1(at 5.36pm)
	Pre monsoon	Hosakambi	32.7(at 10.45am)	32.9(10.50am)
		Kalleshwar	37.8(at12.00pm)	35.6(at12.10pm)

Table IVA – Variations of temperature of air and water at selected locations of Bedti.

Tributary	Season	Air temperature in ^{O}C	Water temperature in ^{O}C
Hulgol	Post monsoon	25.1(at8.45am)	24.3(at8.50am)
	Pre monsoon	37.8(at12.00pm)	34.5 (at 12.10pm)
Shalmala	Post monsoon	28.6(at10.45am)	26.6(at10.50am)
	Pre monsoon	34.2(11.20am)	31.8(11.25am)
Pattana hole	Post monsoon	22.8(at 9.15am)	22.7(at9.20am)
	Pre monsoon	29.8 (at9.00am)	26.3(at9.10am)
Ganeshpal	Post monsoon	30.4(at12.15pm)	25.4(at12.20pm)
	Pre monsoon	36.4(at11.00am)	31.6(at11.10am)
Majjige Halla	Post monsoon	24.2(at5.20pm)	24.5(at5.25pm)
	Pre monsoon	37.5(at 1.00pm)	35.2(at1.15pm)

Table- IVB--Variations of temperature of air and water at selected tributaries of Bedti.

Locations	Latitude	Longitude	Altitude	Flow rate in secs/5mtrs	Depth in meters	Width in meters
Upstream of Bedti						
1.Tamboor	15^{0} 05.814'N	74^{0} 57.031'E	479	90	1.5-2.0	85
2.Bedthi Bridge	14^{0} 53.448'N	74^{0} 47.150'E	426	85	O5	150
Middle stream of Bedti						
1.Gullapura (Ramnagar)	14^{0}49.194'N	74^{0}37.453'E	56	95	05	110
2.Dabguli	14^{0}50.471'N	74^{0}38.735'E	66	62	01	50
Downstream of Bedti						
1.Hosakumbi	14^{0}40.821'N	74^{0}29.402'E	29	75	1.8-4.0	50
2.Kalleshwar (Ramanaguli)	14^{0}47.701'N	74^{0}35.170'E	52	105	5.0-15.0	150
Tributaries of Bedti						
1.Hulgol	14^{0}43.268'N	74^{0}48.457'E	456	32	01	100
2.Sonda (Shalmala)	14^{0}44.416'N	74^{0}48.588'E	453	64	03	60
3.Pattanahole	14^{0}42.950'N	74^{0}42.294'E	443	40	0.18-2.0	22
4.Ganeshpal	14^{0}46.984'N	74^{0}45.521'E	450	34	0.30-2.5	120
5.MajjigeHalla	14^{0}50.332'N	74^{0}56.547'E	530	31	0.16-1.5	11

Table -V-Different natural parameters of specified regions of the River Bedti.

Table VII. Distribution of fishes in three streams of Bedti River

Sl.No.	Order and Family	Species	Upstream	Middle stream	Down stream	T0tal
	ORD-CYPRINIFORMES					
I	**Family-Cyprinidae**					
1		Rasbora rasbora (Hamilton-Buchanan)	15	68	140	**223**
2		Puntius jerdoni (Day)	26	8	14	**48**
3		Puntius chola	0	41	9	**50**
4		Puntius filamentosus(Valenciennnes)	0	0	90	**90**
5		Puntius amphibeus	22	30	280	**332**
6		Puntius narayani (Hora)	1	7	3	**11**
7		Puntius ticto ticto (Hamilton-Buchanan)	16	8	0	**24**
8		Salmostoma boopis (Day)	29	95	28	**152**
9		Danio aequipinnatus	8	0	0	**8**
10		Tor tor (Hamilton-Buchanan)	4	0	0	**4**
11		Garra mulya	7	0	8	**15**
12		Labeo fimbratus	12	0	0	**12**
13		Garra garra	0	28	0	**28**
14		Gara gotyla stenorhynhos	132	54	49	**235**
15		Devario regina (Fowler)	14	0	0	**14**
II	**Family- Balitoridae**					
16		Nemacheilus semiarmatus (Day)	0	0	9	**9**
	ORD-MUGILIFORMES					
III	**Family-Mugilidae**					
17		Mugil cephalus	0	0	84	**84**
	ORD-SILURIFORMES					
IV	**Family-Bagridae**					
18		Mystus cavasius (Hamilton-Buchanan)	18	0	0	
19		Mystus malabaricus (Jerdon)	25	0	4	
						47
V	**Family-Claridae**					
20		Clarias dussumieri (Valenciennnes)	32	0	5	**37**
VI	**Family- Siluridae**					
21		Wallago attu	14	0	0	
22		Ompok bimaculatus (Bloch)	37	0	0	

Table VII. Distribution of fishes in three streams of Bedti River

						51
	ORD- BELONIFORMES					
VII	**Family- Belonidae**					
23		Xenentodon cancila (Hamilton-Buchanan)	0	49	4	**53**
	ORD- CYPRINODONTIFORMES					
VIII	**Family- Aplocheilidiae**					
24		Aplocheilus lineatus (Valenciennnes)	2	6	8	**16**
	ORD-PERCIFORMES					
IX	**Family- Ambassidae**					
25		Pseudoambasis ranga(Hamilton-Buchanan)	62	15	0	**77**
X	**Family- Gobiidae**					
26		Glossogobius giuris giuris (Hamilton-Buchanan)	0	8	18	**26**
XI	**Family- Cichlidae**					
27		Etroplus suratensis (Bloch)	0	23	4	**27**
	ORD- GASTEROSTEIFORMES					
XII	**Family- Syngnathidae**					
28		Ichthyocampus carce	0	0	8	**8**
			476	**440**	**765**	**1681**

Table VIII. **Table showing the distribution of the abundance of family and species of upstream, middle stream and downstream of Bedti.**

Family	Total Species
Cyprinidae	1246
Balitoridae	9
Mugilidae	84
Bagridae	47
Claridae	37
Siluridae	51
Belonidae	53
Aplocheilidiae	16
Ambassidae	77
Gobiidae	26
Cichlidae	27
Syngnathidae	**8**
Grand Total	**1681**

Table- IX A Family wise species abundance in upstream of Bedti river

Family	Upstream
Cyprinidae	286
Bagridae	43
Claridae	32
Siluridae	51
Aplocheilidae	2
Ambassidae	62
	476

Table-IXB. Family wise species abundance in middle streams of Bedti River	
Family	**Middle stream**
Cyprinidae	339
Belonidae	49
Aplocheilidae	6
Ambassidae	15
Gobiidae	8
Cichlidae	23
	440

Table-IXC Family wise species abundance in downstream of Bedti River.	
Family	**Down stream**
Cyprinidae	621
Balitridae	9
Mugilidae	84
Bagridae	4
Claridae	5
Belonidae	4
Aplocheilidae	8
Gobiidae	18
Cichlidae	4
Syngnathidae	8
	765

Table-X Family wise Species Richness in three different streams of Bedti River	
Family	**No. of Species**
Cyprinidae	15
Balitridae	1
Mugilidae	1
Bagridae	2
Claridae	1
Siluridae	2
Belonidae	1
Aplocheilidae	1
Ambassidae	1
Gobiidae	1
Cichlidae	1
Syngnathidae	1

Table- XII Distribution of the abundance of family and their species in five tributaries studied.

S.No	Family	Total Species
1	Cyprinidae	975
2	Balitridae	18
3	Aplochaeilidiae	17
4	Ambassidae	66

Table -X1 Distribution of fishes in five different tributaries of river Bedti.

Sl.No.	ORDER- CYPRINIFORMES	Species	T-1	T-2	T-3	T-4	T-5	Grand Total
1	**1. Family- Cyprinidae**	Rasbora rasbora (Hamilton-Buchanan)	17	25	235	18	30	325
2		Puntius jerdoni (Day)	00	15	08	20	00	43
3		Puntius chola	13	00	28	06	00	47
4		Puntius filamentosus(Valenciennnes)	00	00	00	04	00	04
5		Puntius amphibeus	00	00	06	00	40	46
6		Puntius narayani (Hora)	02	07	28	00	01	38
7		**Puntius arulius**	00	00	12	00	00	12
8		Danio aequipinnatus	00	00	25	06	04	35
9		Tor tor (Hamilton-Buchanan)	15	00	00	00	00	15
10		Garra mulya	05	48	10	12	03	78
11		Gara gotyla stenorhynchos	04	18	00	10	00	32
12		Garra garra	00	140	00	00	00	140
13		Labeo fimbratus	40	00	00	00	00	40
14		**Labeo calabus**	14	00	00	21	00	35
15		**Labeo rohita**	24	08	00	07	00	39
16		**Hypselobarbus jerdoni (Day)**	26	08	02	10	00	46
		Total	**160**	**269**	**354**	**114**	**78**	**975**
	2. Family- Balitoridae							
17		**Nemacheilus guentheri**	00	00	00	00	18	**18**
	ORDER- CYPRINODONTIFORMES							
	3. Family- Aplocheilidiae							
18		Aplocheilus lineatus (Valenciennnes)	17	00	00	00	00	**17**
	ORD-PERCIFORMES							
	4. **Family- Ambassidae**							
19		Pseudoambasis ranga(Hamilton-Buchanan)	66	00	00	00	00	**66**
								1076
T-1-Sahasralinga T-2-Sonda T-3-Pattanahole T-4-Ganeshpal T-5-Majjige halla								

Table -XIII Family wise species richness in tributaries of Bedti River	
Family	**Total Species**
Cyprinidae	16
Balitridae	1
Aplochelidae	1
Ambassidae	1

Table – XIV Distribution of the abundance of family and their species in five different tributaries studied.

S.No	Family	Tributaries				
		T-1	**T-2**	**T-3**	**T-4**	**T-5**
1	Cyprinidae	160	269	354	114	78
2	Balitridae	00	00	00	00	18
3	Aplochaeilidiae	17	00	00	00	00
4	Ambassidae	66	00	00	00	00

Table XV Family wise species richness in different tributaries of Bedti .					
Family	**T1**	**T2**	**T3**	**T4**	**T5**
Cyprinidae	10	8	9	10	5
Balitridae	0	0	0	0	1
Aplochelidae	1	0	0	0	0
Ambassidae	1	0	0	0	0

Table XVI- pH of water samples of selected streams and tributaries of Bedti River			
Streams/ Tributary	Post monsoon		Pre monsoon
Upstream(Tamboor)	8.4		9.1
Middle stream(Gullapura)	8.2		8.6
Downstream (Ramanaguli)	7.2		7.6
Tributary (Hulgol)	7.86		8.1

Table XVII- BOD of water samples of selected streams and tributaries of Bedti River		
SlNo.	Location	mg/litre
1	Tamboor (Upstream)	0.75
2	Gullapura (Middle Stream)	1
3	Ramanaguli (Downstream)	0.9
4	Hulgol (Tributary)	1.2

Table-XVIII Diversity Indices and species richness of fshes of three different streams of Bedti.

Streams	Sp.rich	Shan.div	Sim.dom	Sim.div	tot.ind	t.sp
Upstream	2.92	2.48	0.12	0.88	476.00	19.00
Middlestream	2.14	1.97	0.12	0.88	440.00	14.00
Downstream	2.56	1.97	0.20	0.80	765.00	18.00

Fig.5a. Map Showing Cumulative Rainfall Pattern, January 2013 – December 2013

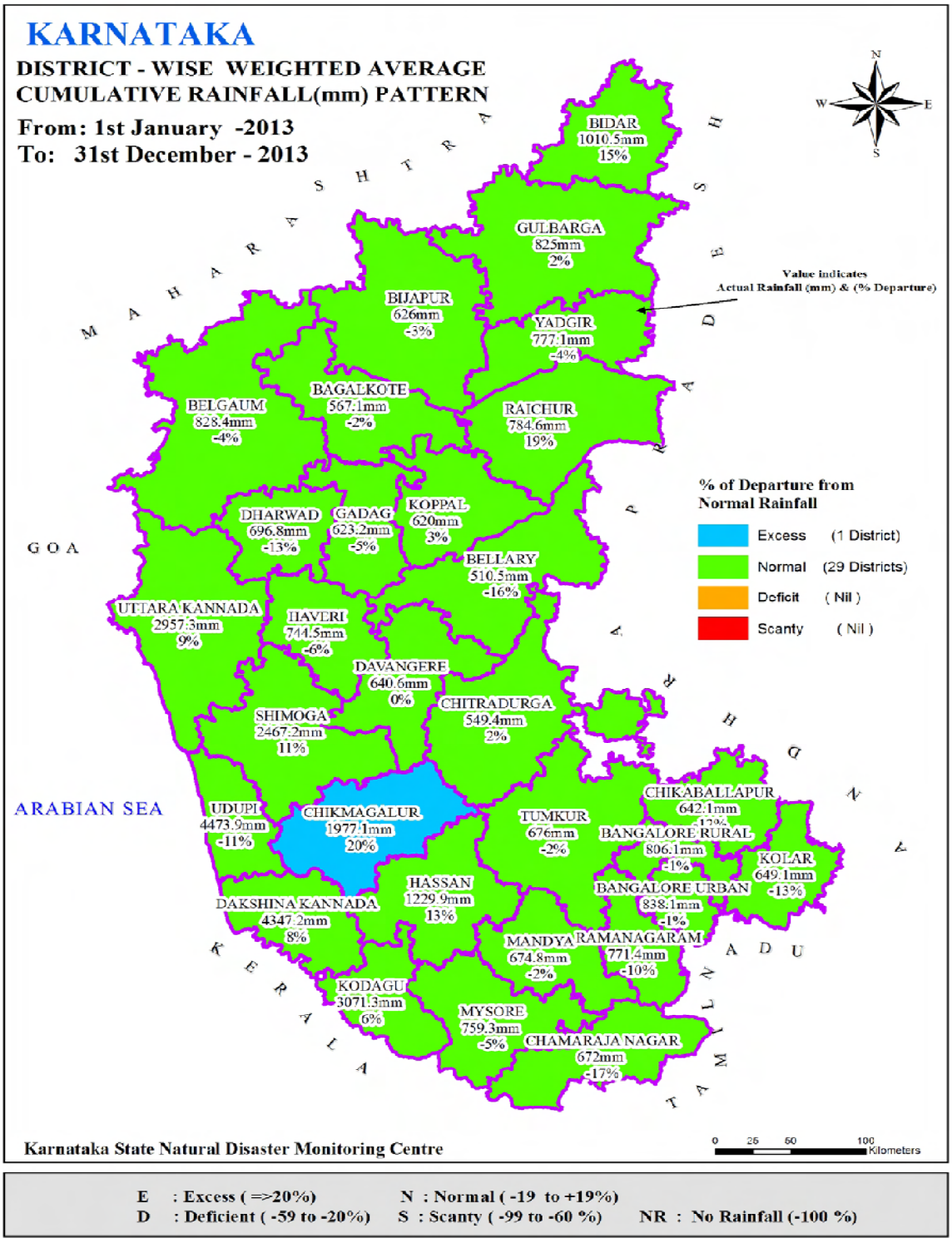


Fig.5b. Map Showing Cumulative Rainfall Pattern, January 2014 – May 2014

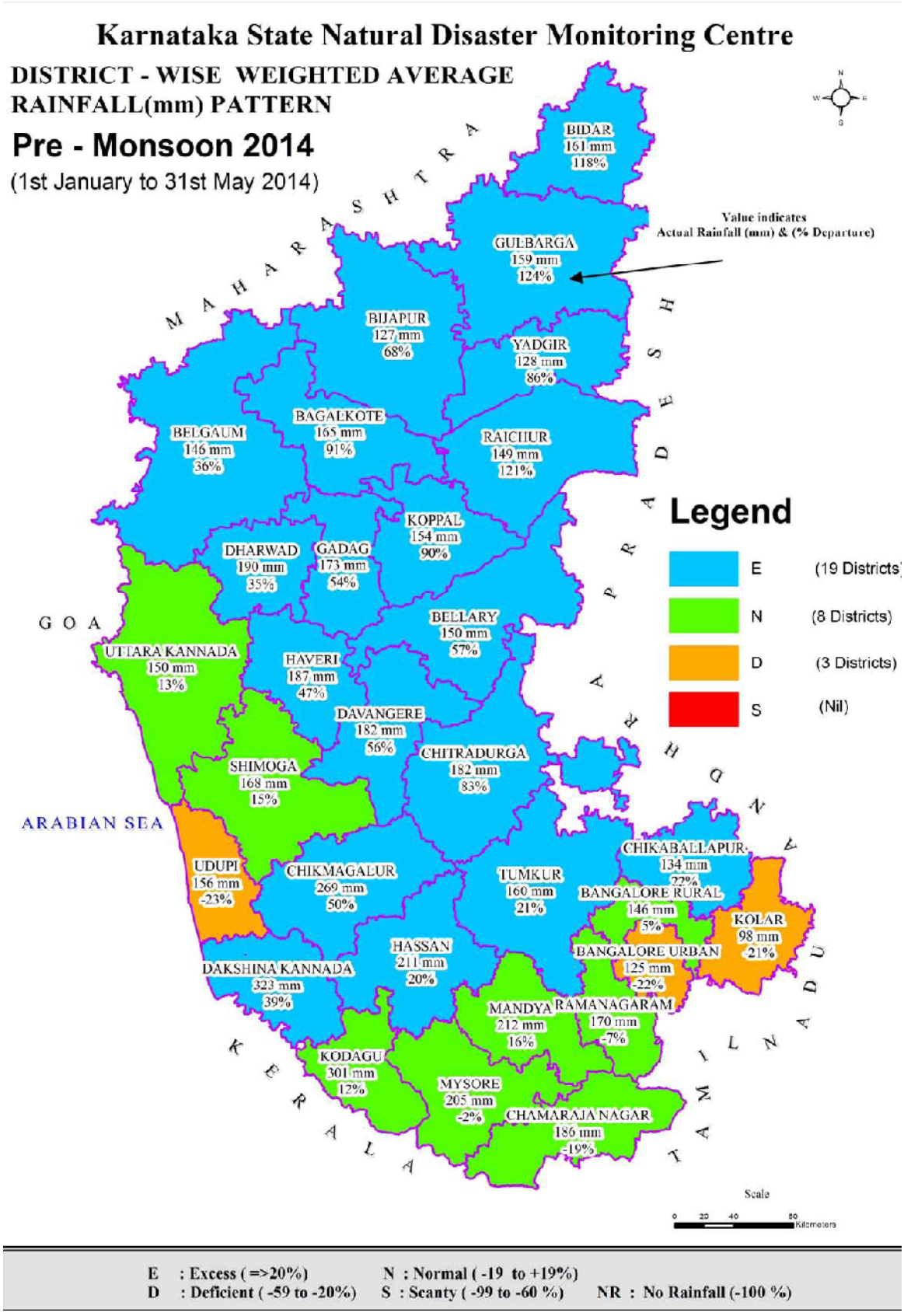
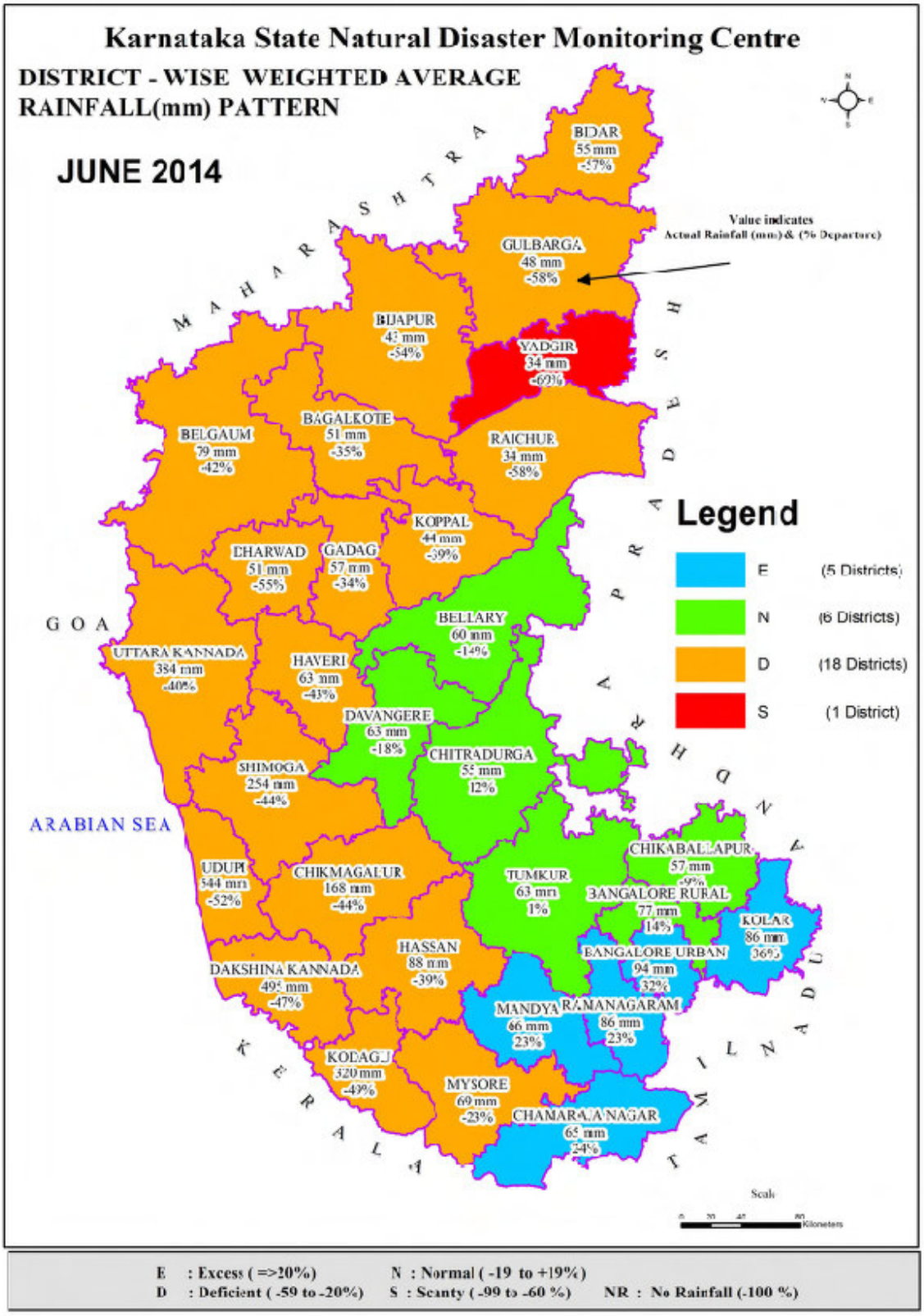


Fig.5c. Map Showing Cumulative Rainfall Pattern of June 2014



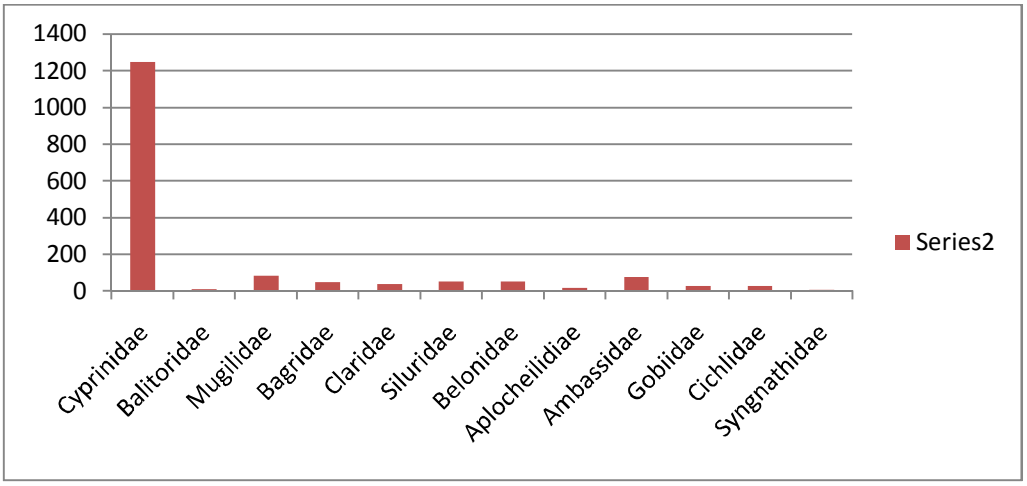


Figure 6a: Histogram showing abundance of various families of fishes and their species in three streams of Bedti.

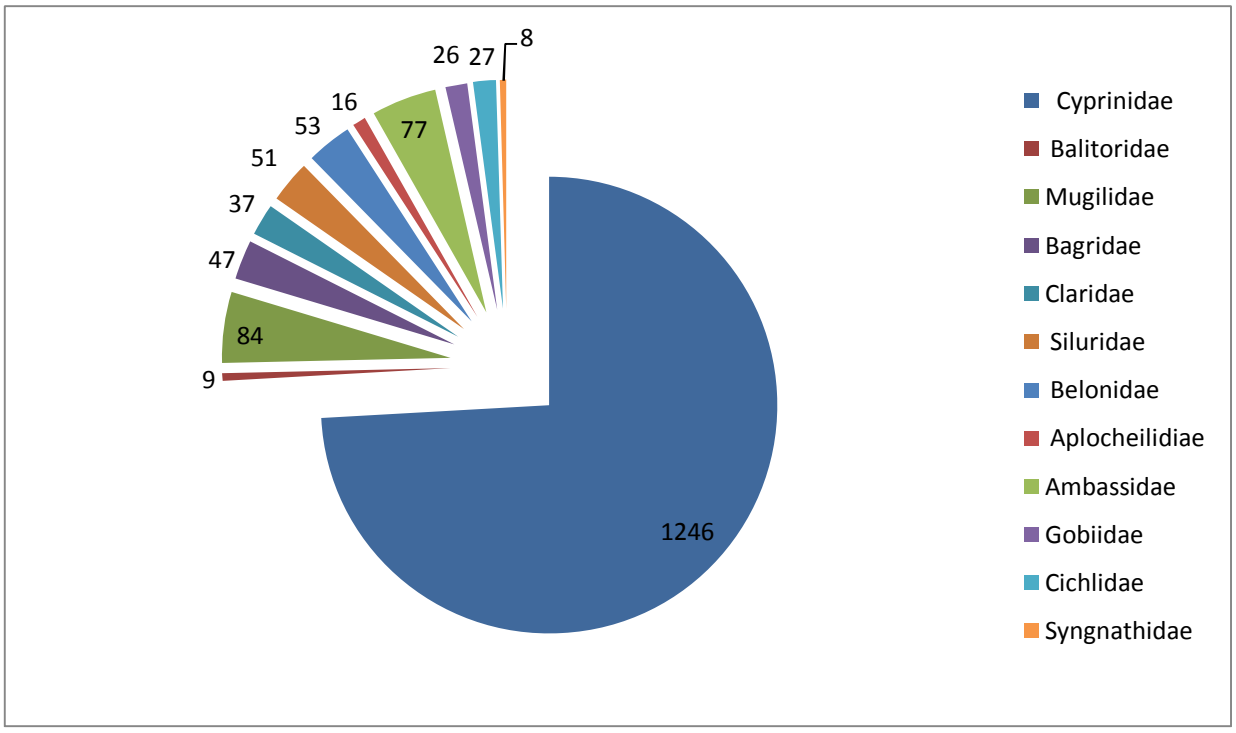


Figure6b- Distribution of abundance of various families of fish and their species in three streams of Bedti.

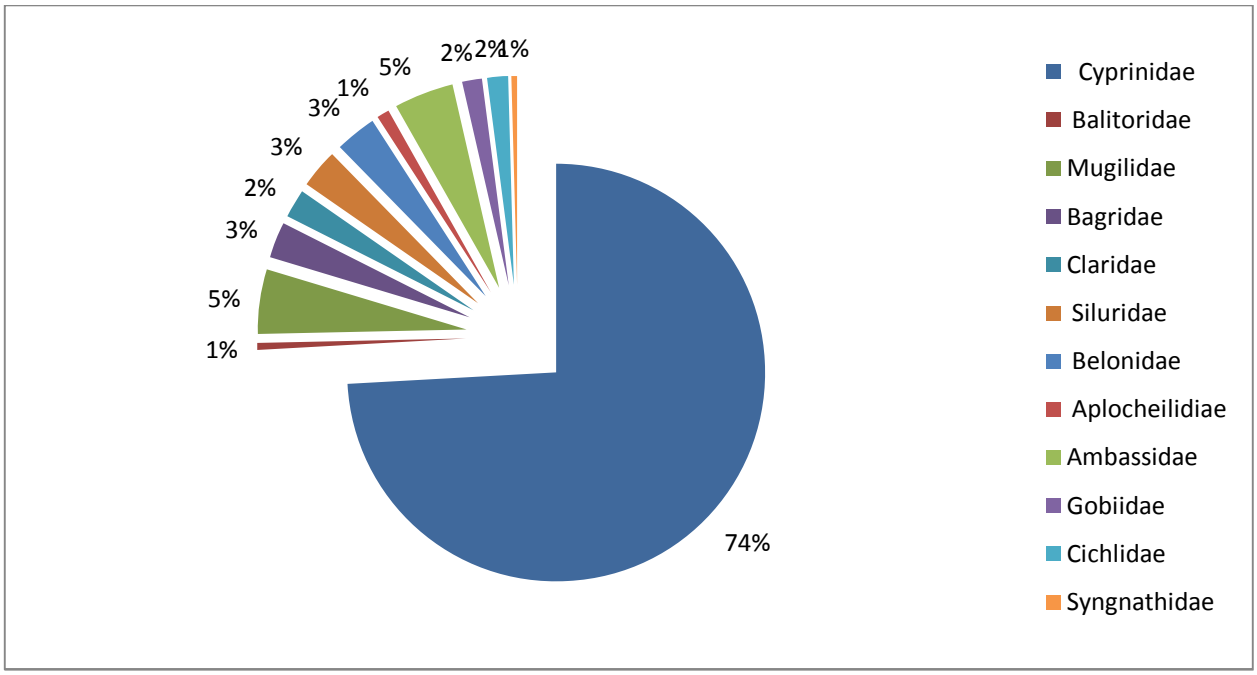


Figure 6c- Distribution of fish families Percent in three streams of Bedti.

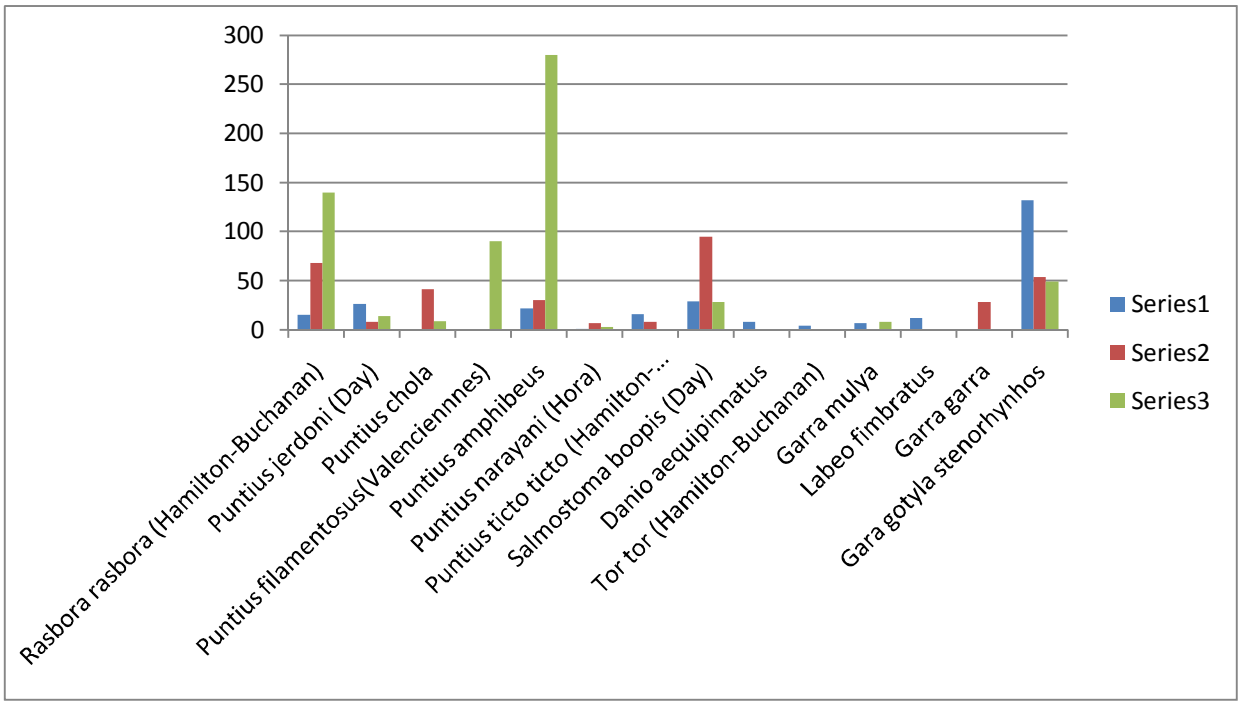


Figure 6d. Histogram showing the individual fish species richness in upstream (Series 1), Middle stream (Series 2) and downstream (Series 3) of Bedti.

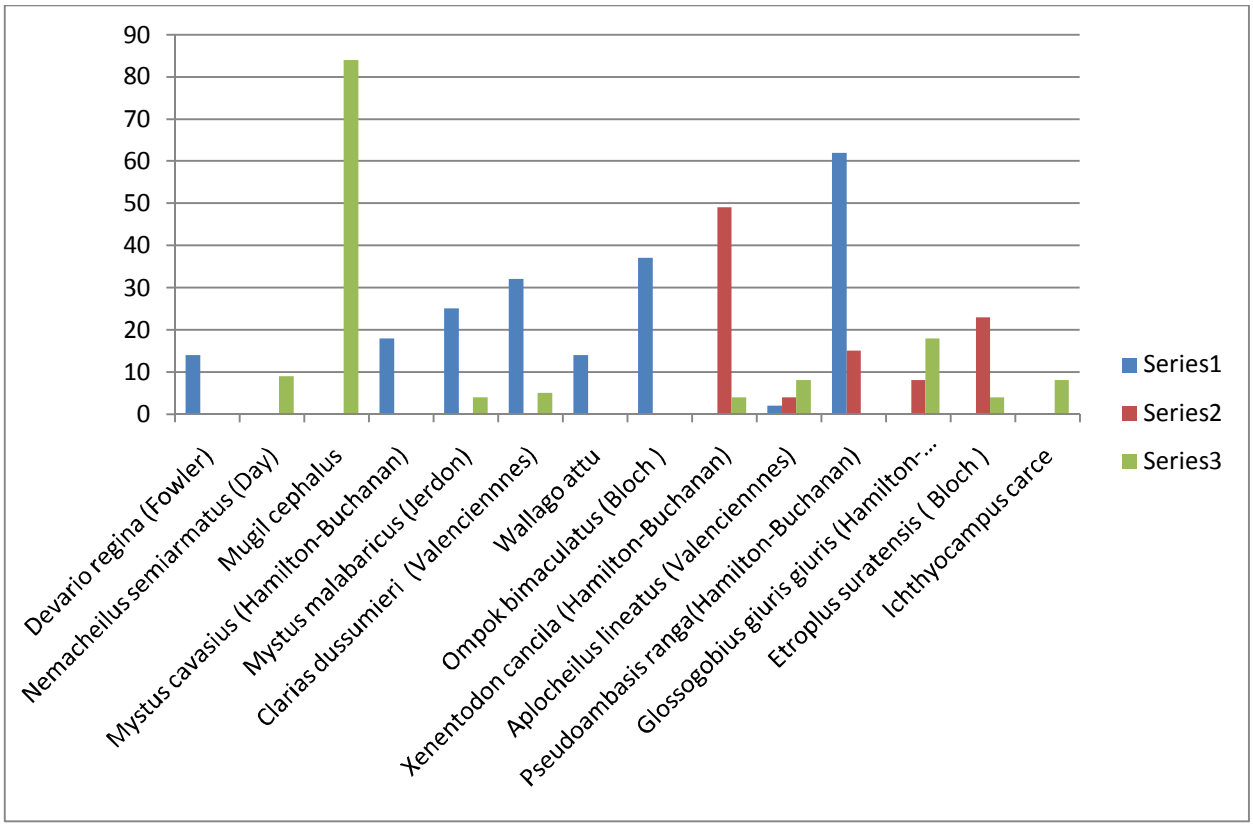


Figure 6e- Histogram showing the individual fish species richness in upstream (Series 1), Middle stream (Series 2) and downstream (Series 3) of Bedti.

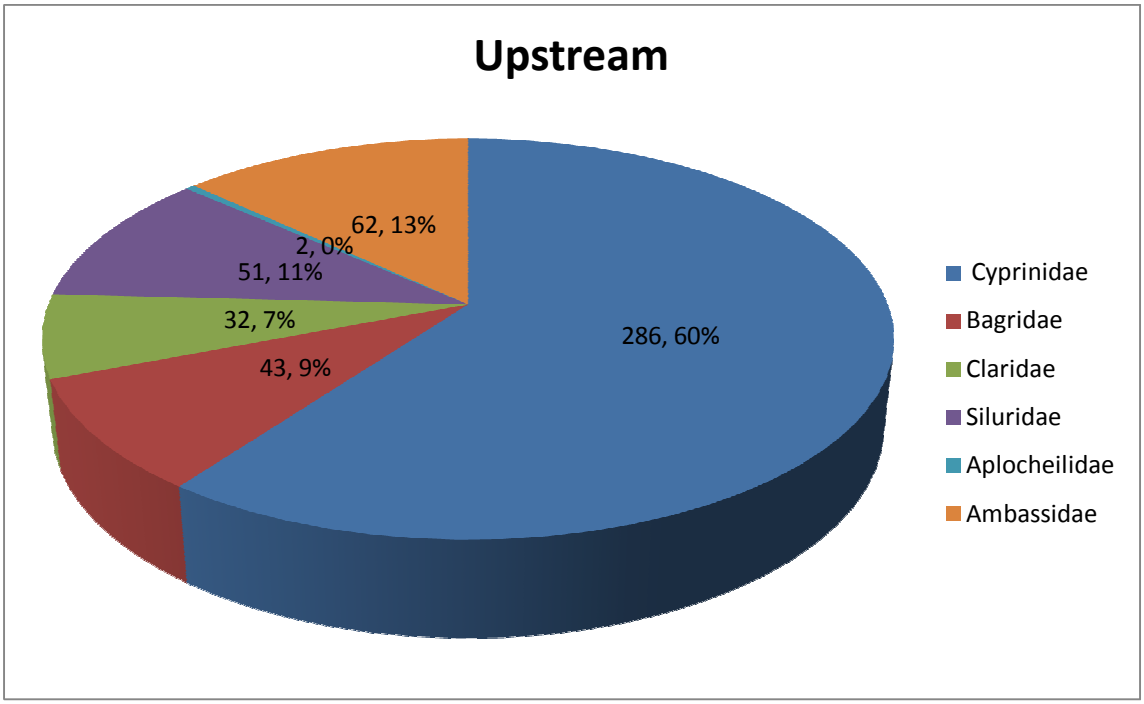


Figure 7a- Family wise species abundance and their percentage in up streams of Bedti River

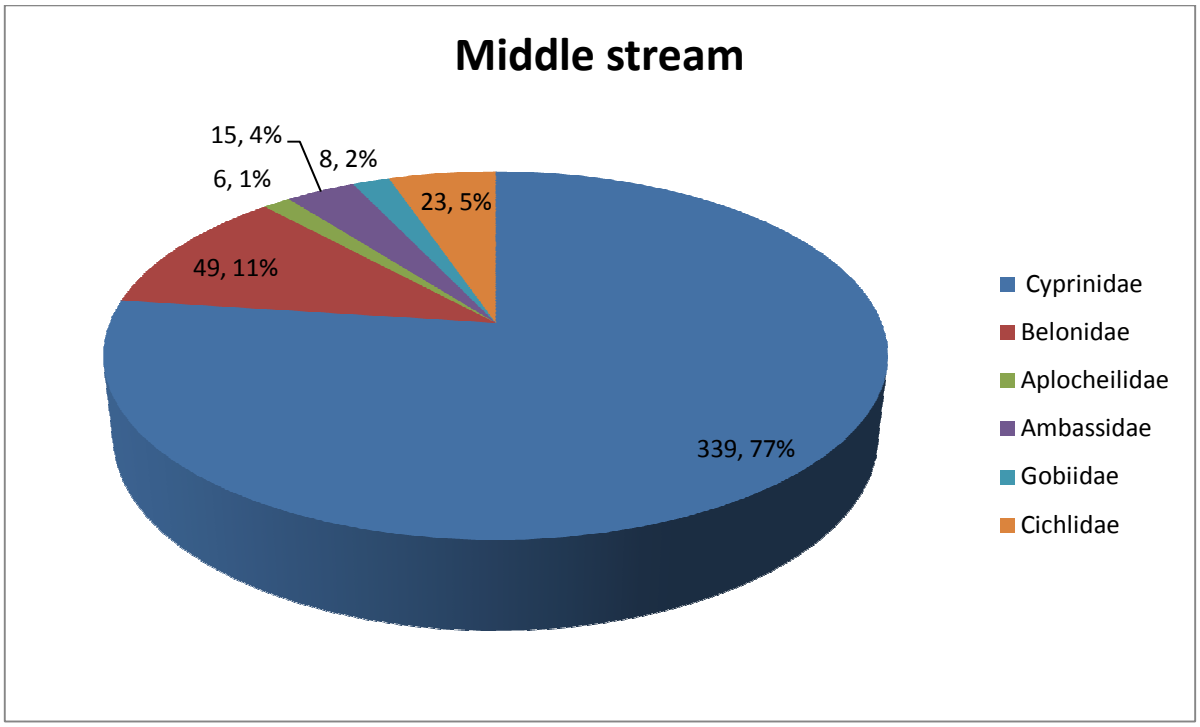


Figure 7b- Family wise species abundance and their percentage in middle streams of Bedti River

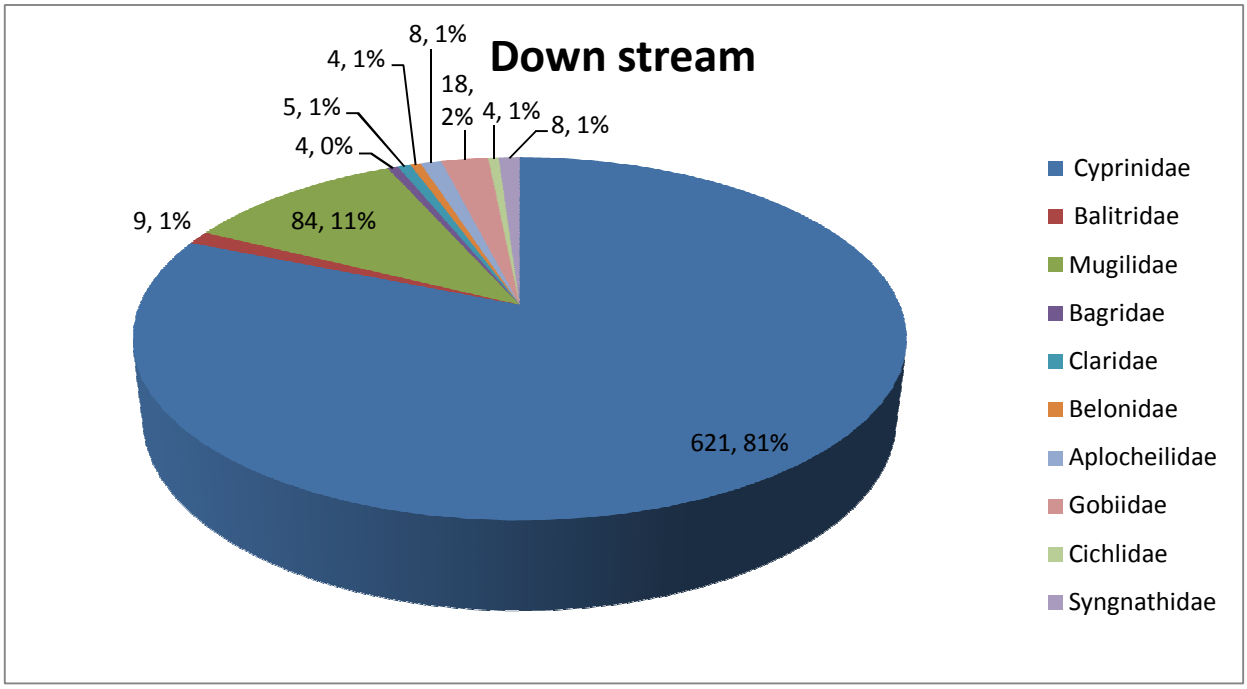


Figure 7c- Family wise species abundance and their percentage in down streams of Bedti River

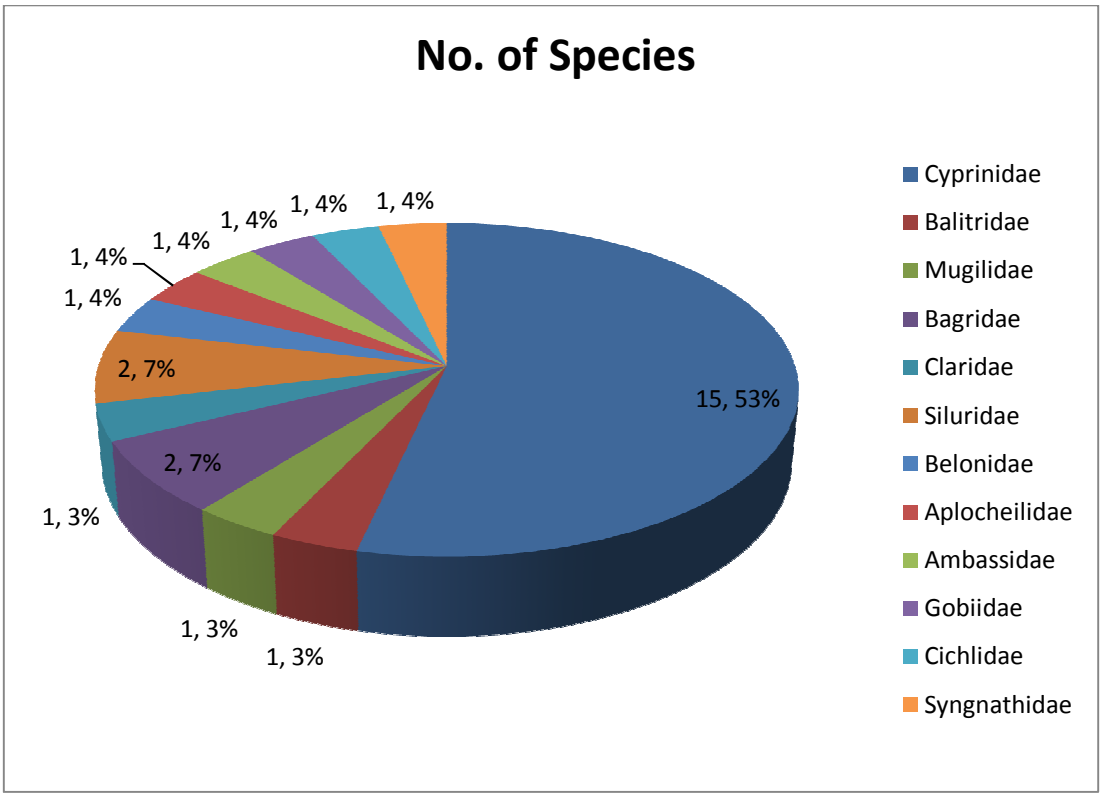


Figure 8 - Family wise species richness in three different streams of Bedti River.

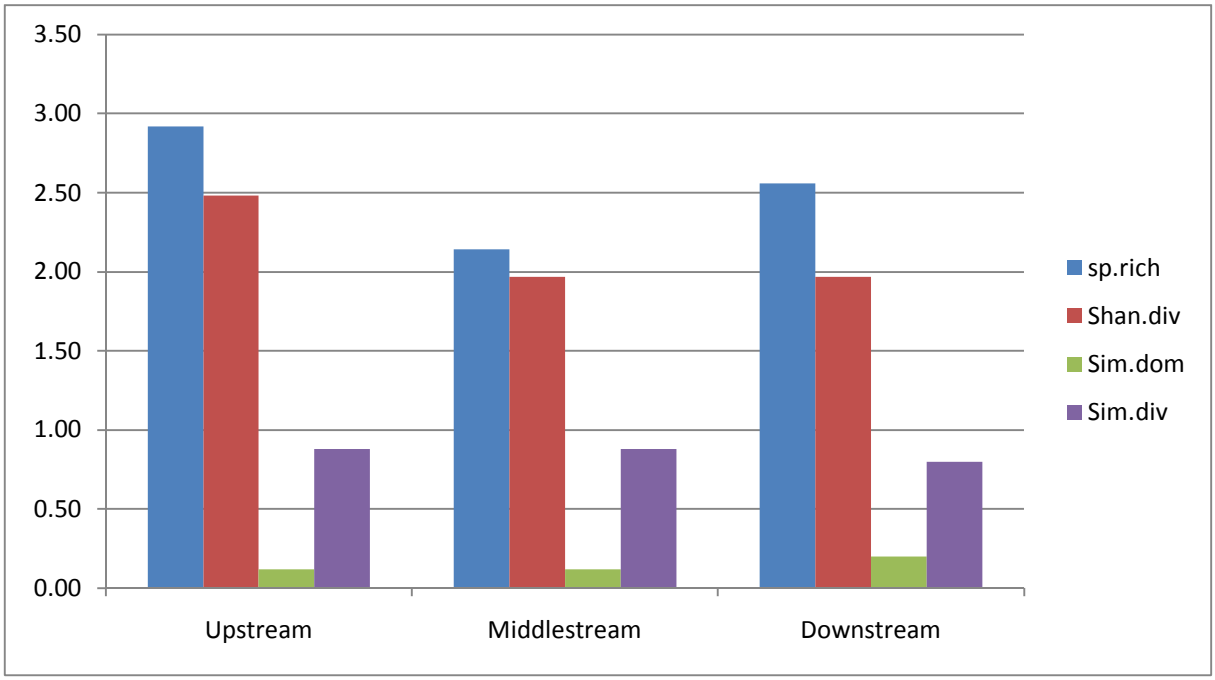
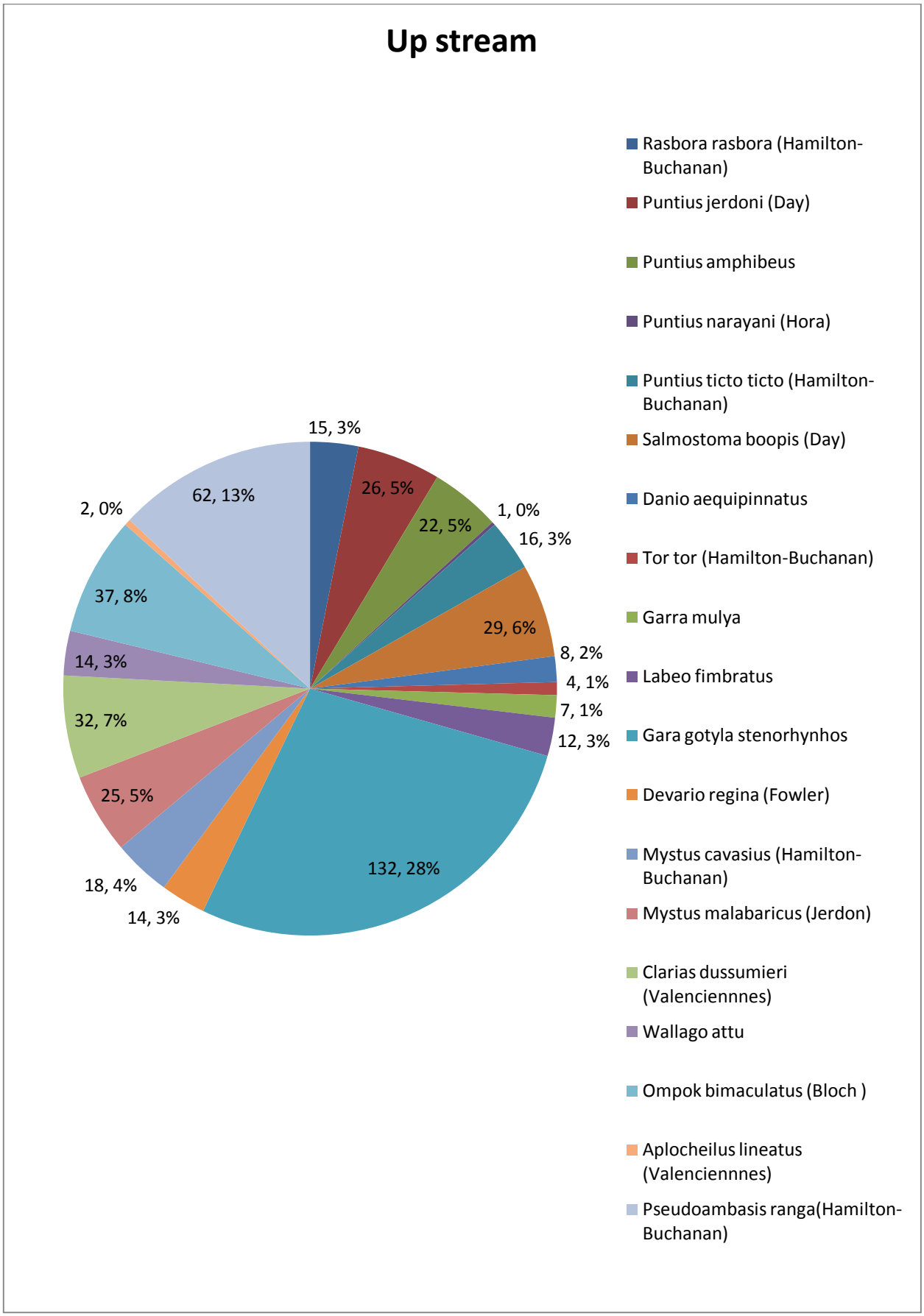


Figure 17- Histogram showing diversity indices and species richness of fishes of three different streams of Bedti River.


Up stream
15, 3%
26, 5%
22, 5%
1, 0%
16, 3%
29, 6%
8, 2%
4, 1%
7, 1%
12, 3%
132, 28%
14, 3%
18, 4%
25, 5%
32, 7%
14, 3%
37, 8%
2, 0%
62, 13%
Rasbora rasbora (Hamilton-Buchanan)
Puntius jerdoni (Day)
Puntius amphibeus
Puntius narayani (Hora)
Puntius ticto ticto (Hamilton-Buchanan)
Salmostoma boopis (Day)
Danio aequipinnatus
Tor tor (Hamilton-Buchanan)
Garra mulya
Labeo fimbratus
Gara gotyla stenorhynhos
Devario regina (Fowler)
Mystus cavasius (Hamilton-Buchanan)
Mystus malabaricus (Jerdon)
Clarias dussumieri (Valenciennnes)
Wallago attu
Ompok bimaculatus (Bloch)
Aplocheilus lineatus (Valenciennnes)
Pseudoambasis ranga(Hamilton-Buchanan)

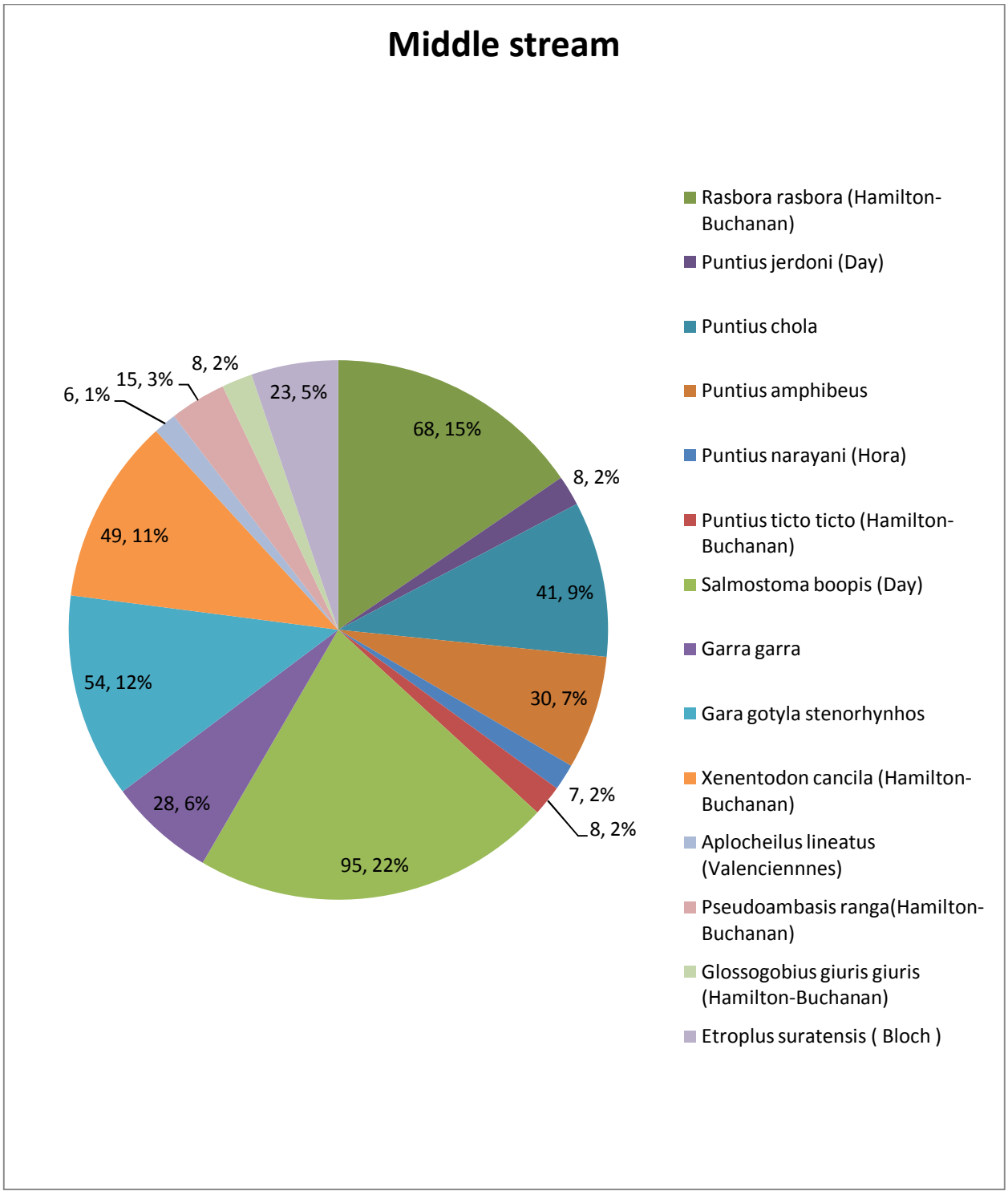


Figure 9b. Pie chart showing the abundance and percentage of individual species middle stream of Bedti.

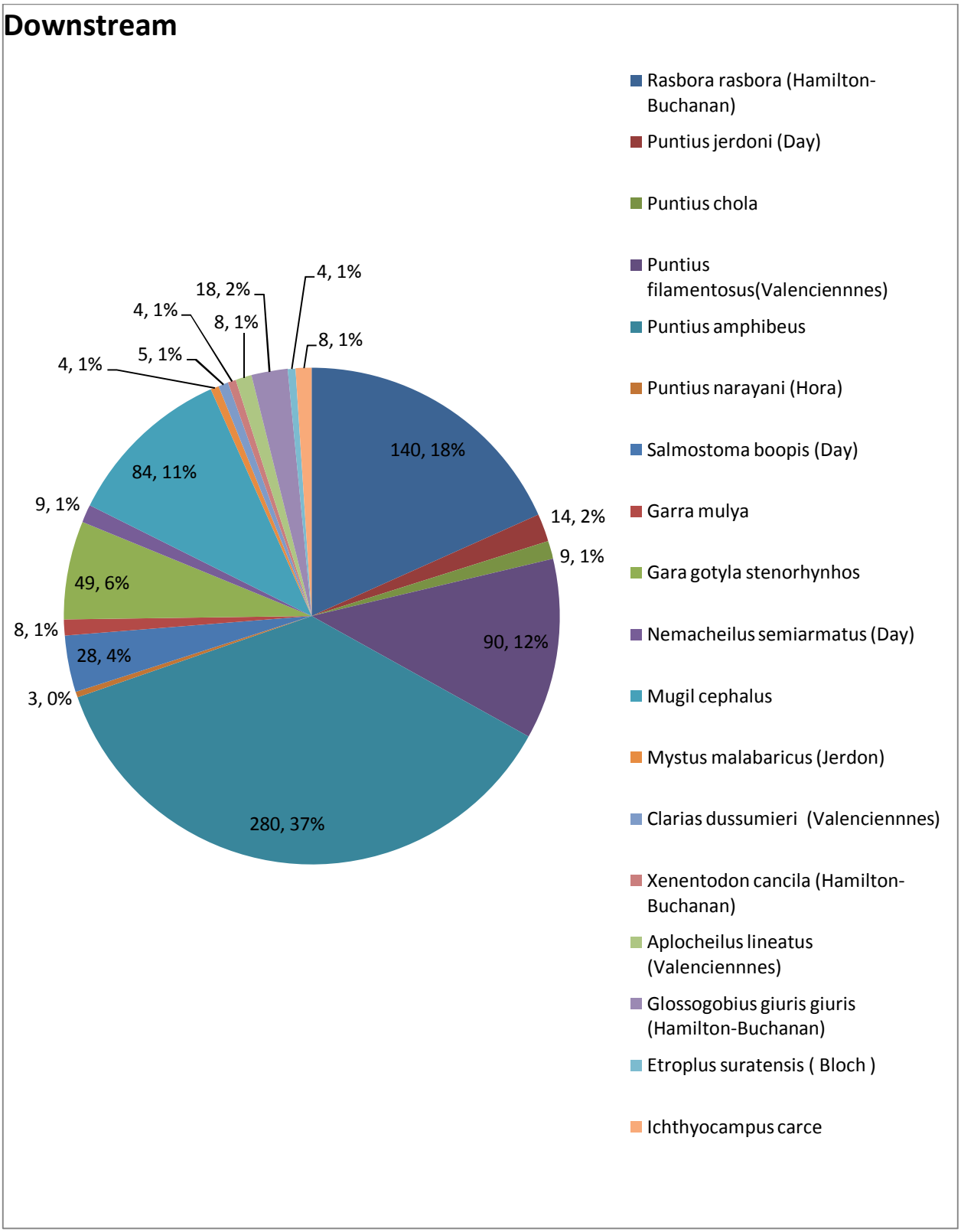


Figure9c. Pie chart showing the abundance and percentage of individual species in downstream

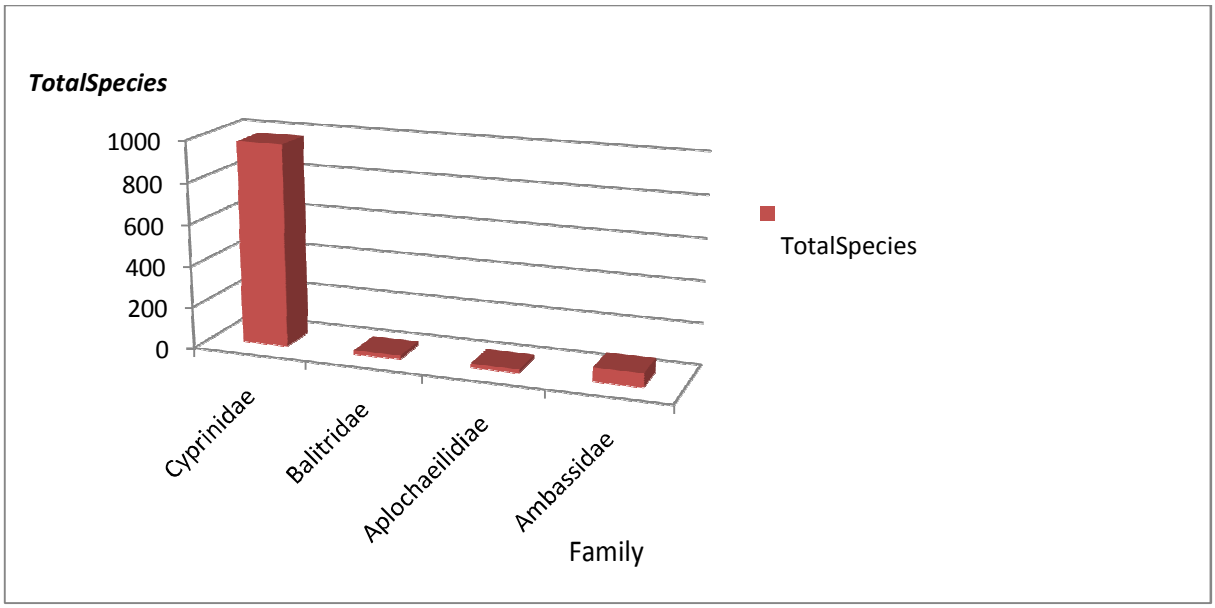


Figure-10a Histogram showing the distribution of the abundance of family and their species in five tributaries studied.

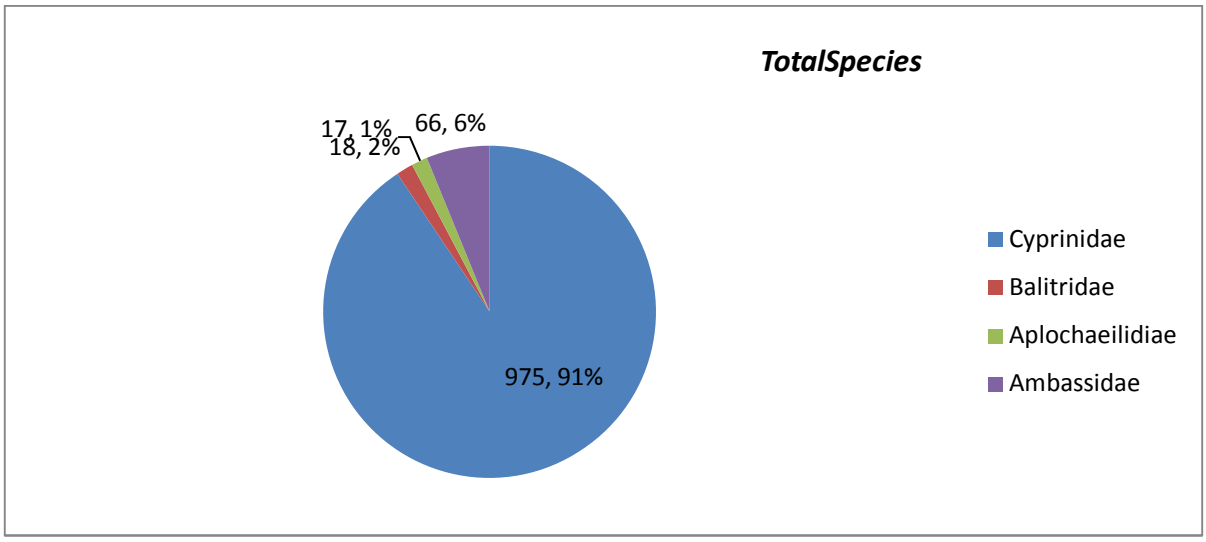


Figure- 10b Pie chart showing the distribution of various families of fish abundance in five tributaries studied.

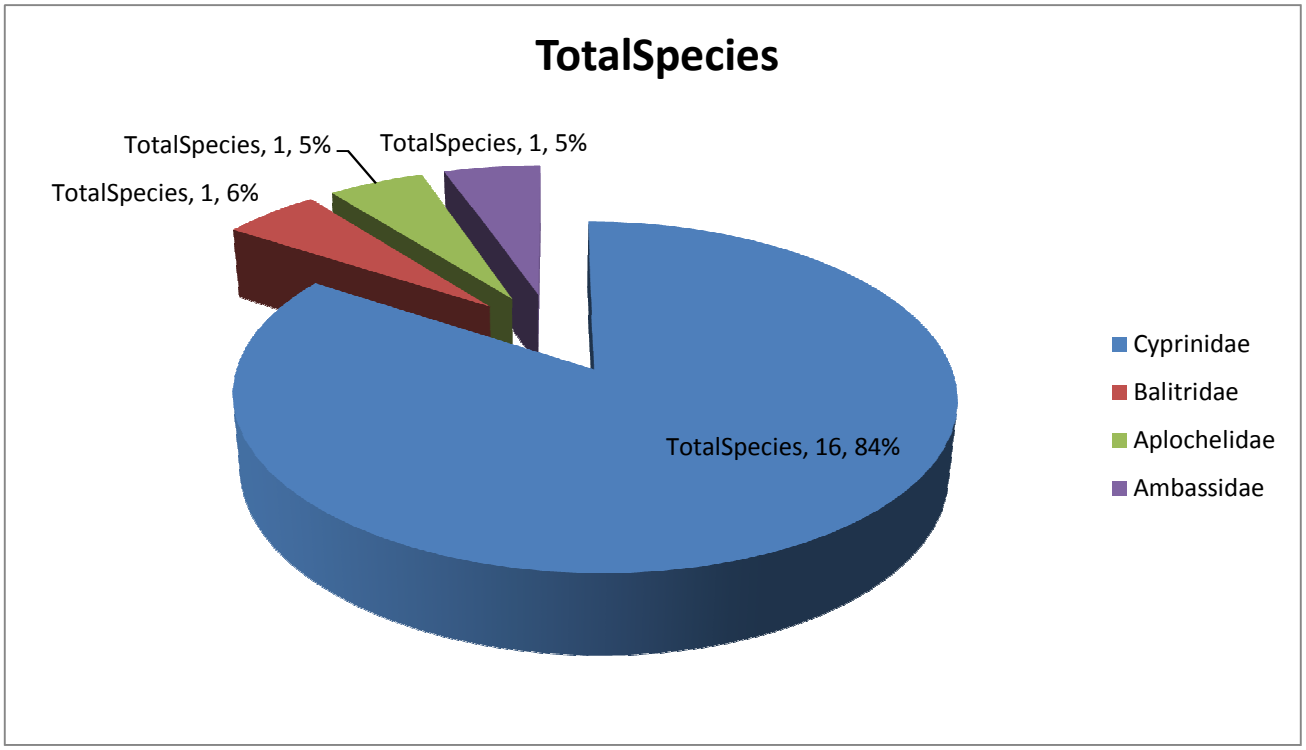


Figure 11- Pie chart showing the family wise species richness in tributaries of Bedti River

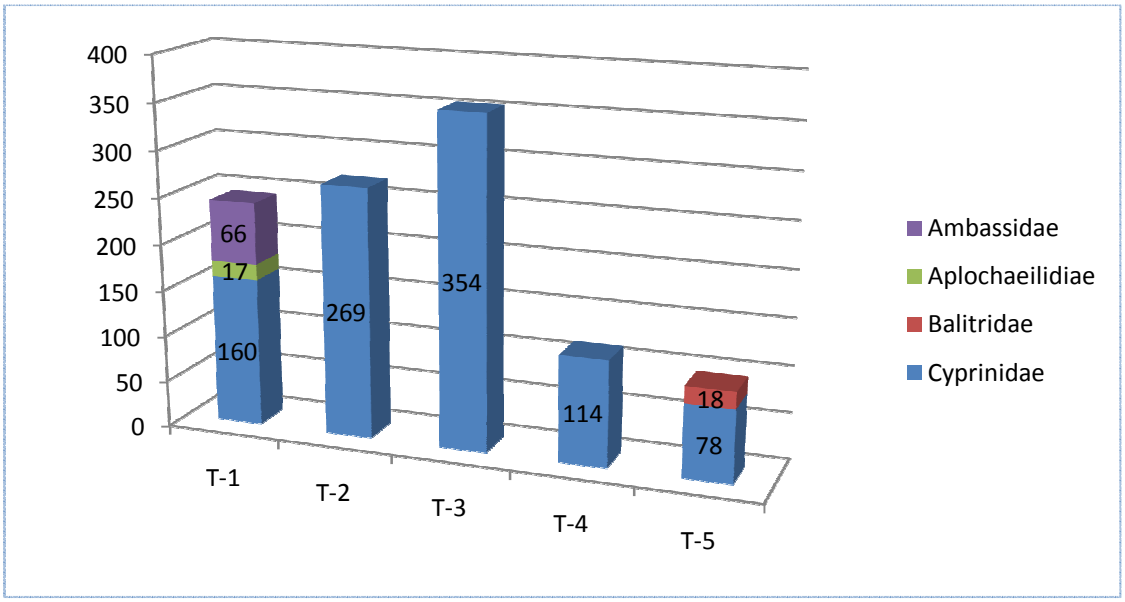


Figure- 12 Histogram showing the species abundance with respect to the five different tributaries of Bedti.

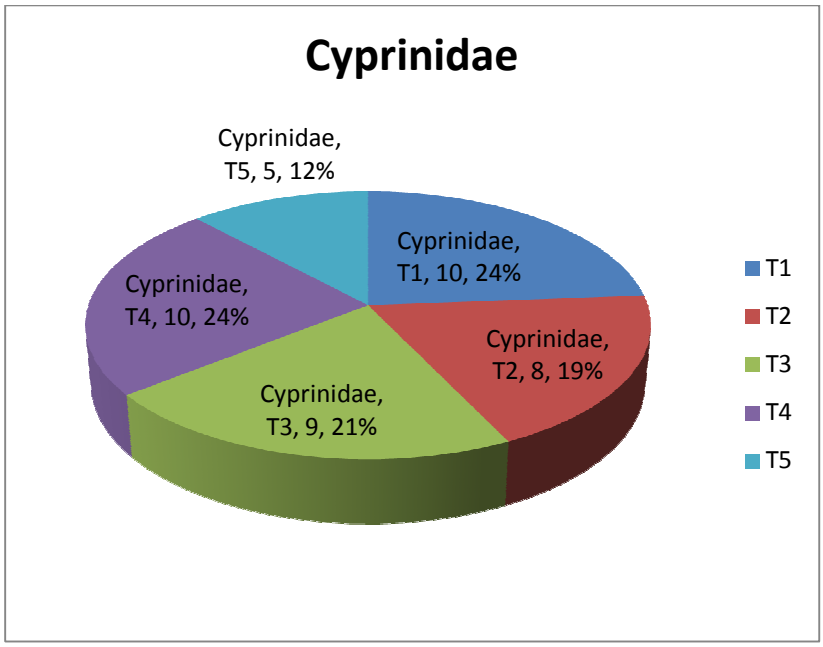


Figure-13 Pie chart showing the species richness of Cyprinidae family in 5 different Tributaries studied.

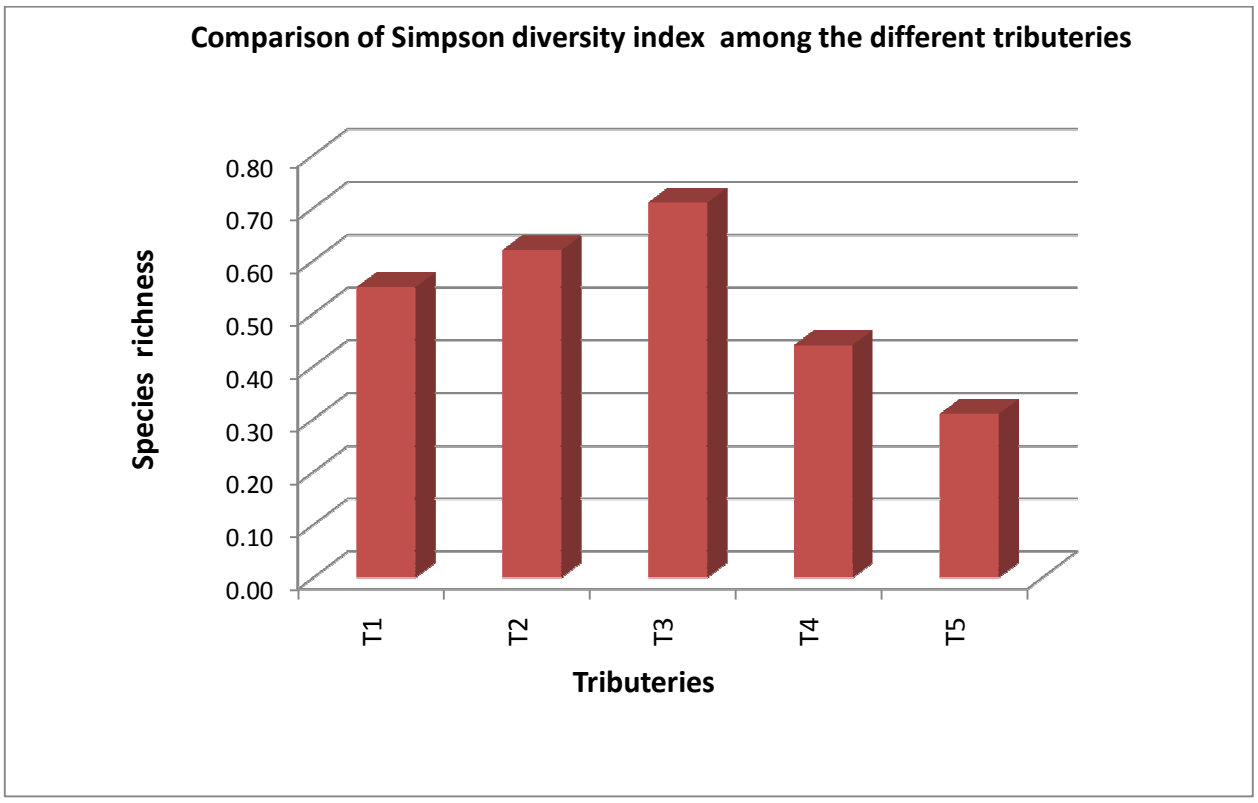


Figure- 14 Histogram showing the Simpson diversity index with respect to the five different tributaries of Bedti

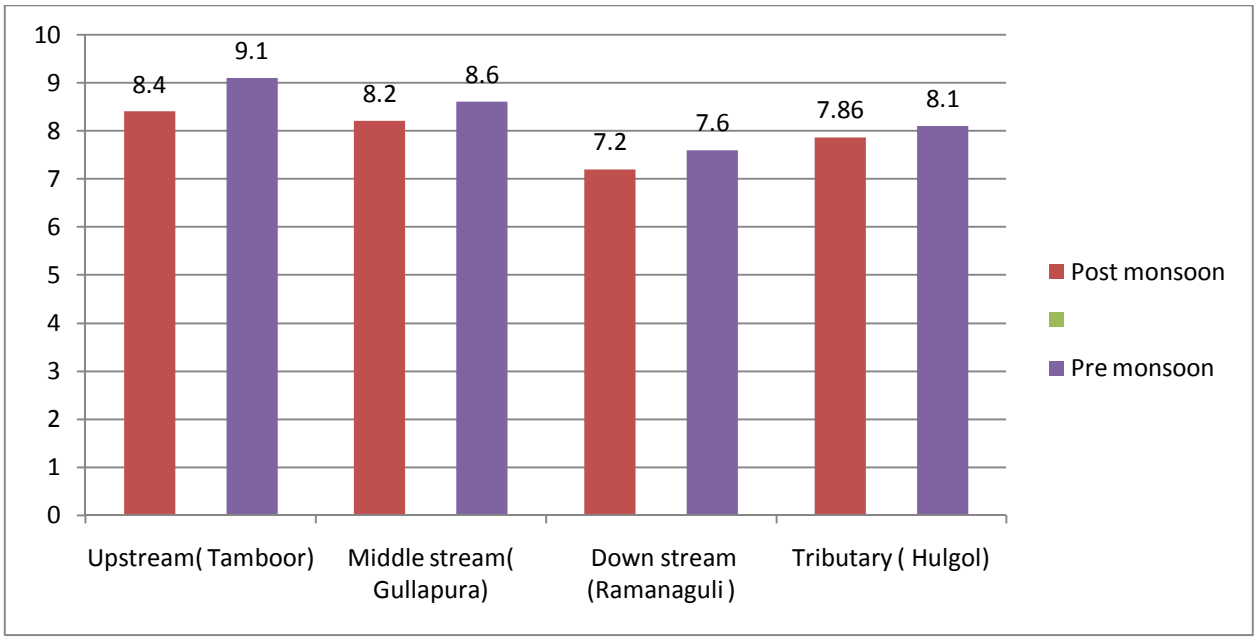


Figure 15- Graph of showing the pH of selected streams and tributaries of Bedti during post and pre monsoon Period.

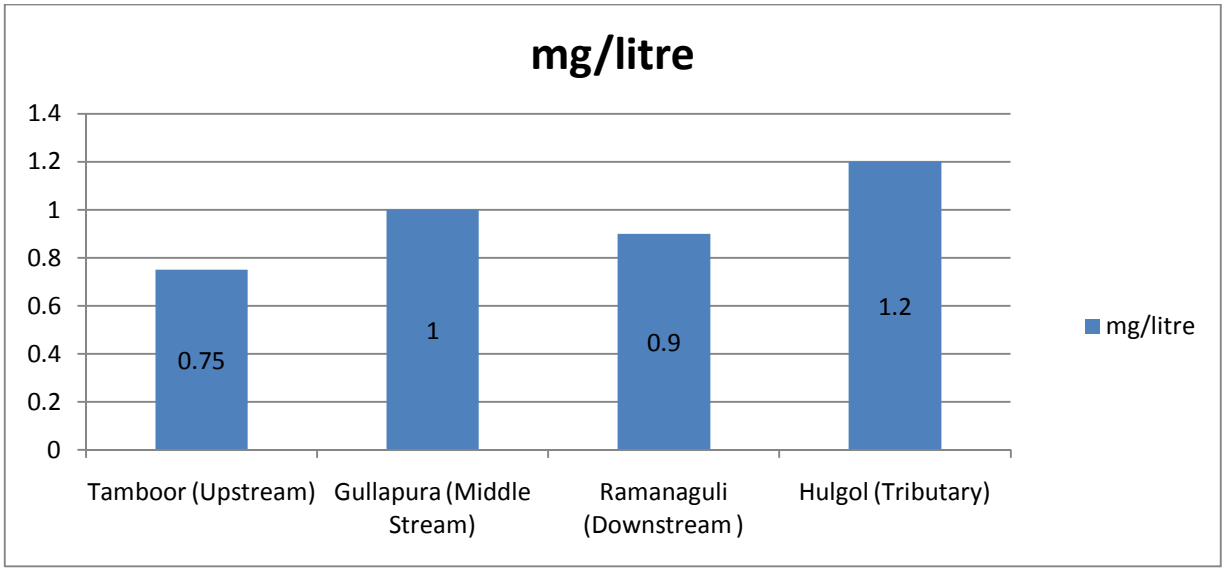


Figure 16- BOD of water samples of selected streams and tributaries of Bedti

Figure9a. Pie chart showing the abundance and percentage of individual species in upstream of Bedti.

Gmail

Sooryanarayana Bhat <ssbsirsi@gmail.com>

Identification of Fish specimens.

5 messages

Kosygin Laishram <lkzsi5@yahoo.com> Mon, Jan 13, 2014 at 11:38 AM
Reply-To: Kosygin Laishram <lkzsi5@yahoo.com>
To: "ssbsirsi@gmail.com" <ssbsirsi@gmail.com>
Cc: hegde67 <hegde67@yahoo.co.in>

To
Dr. S. S. Bhat
Assistant Professor
Department of Zoology, M.E.S.M.M. Arts & Science College
SIRSI-581402, Dist. Uttara Kannada, Karnataka

Dear Dr. Bhat,
With reference to your letter dated 07-11-2013, the undersigned received 10 specimens of Fishes for identification from you. The fishes are identified as detailed here under.

Jar No.	Species name	Order	Family	Ex.	Remarks
1	*Hypselobarbus jerdoni* (Day)	Cypriniformes	Cyprinidae	1 ex.	
2	*Parambassis ranga* (Hamilton)	Perciformes	Ambassidae	1 ex.	
3	*Rasbora rasbora* (Hamilton)	Cypriniformes	Cyprinidae	1 ex.	
4	*Garra* sp.1	Cypriniformes	Cyprinidae	1 ex.	It has weekly developed proboscis and resembles *Garra gotyla* (Grey). However, it needs further confirmation by examining more examples.
5	*Ompok bimaculatus* (Bloch)	Siluriformes	Siluridae	1 ex.	
6	*Mystus malabaricus* (Jerdon)	Siluriformes	Bagridae	1 ex.	
7	*Mystus cavasius* (Hamilton)	Siluriformes	Bagridae	1 ex.	
8	*Labeo fimbriatus* (Bloch)	Cypriniformes	Cyprinidae	1 ex.	
9	*Garra* sp. 2	Cypriniformes	Cyprinidae	1 ex.	It has weekly developed proboscis and resembles *Garra gotyla* (Grey). However, it needs further confirmation by examining more examples.
10	*Devario regina* (Fowler)	Cypriniformes	Cyprinidae	1 ex.	

The above information may be used exclusively for scientific purpose with due recognition and acknowledging the work of Zoological Survey of India, Kolkata. Thanks for keeping confidence and co-operation.

Please acknowledge the receipt of the same.
Yours sincerely,
(L. Kosygin Singh)
Officer-in-Charge
Freshwater Fish Section
Zoological Survey of India
Kolkata

Sooryanarayana Bhat <ssbsirsi@gmail.com> Mon, Jan 13, 2014 at 9:03 PM
To: Kosygin Laishram <lkzsi5@yahoo.com>

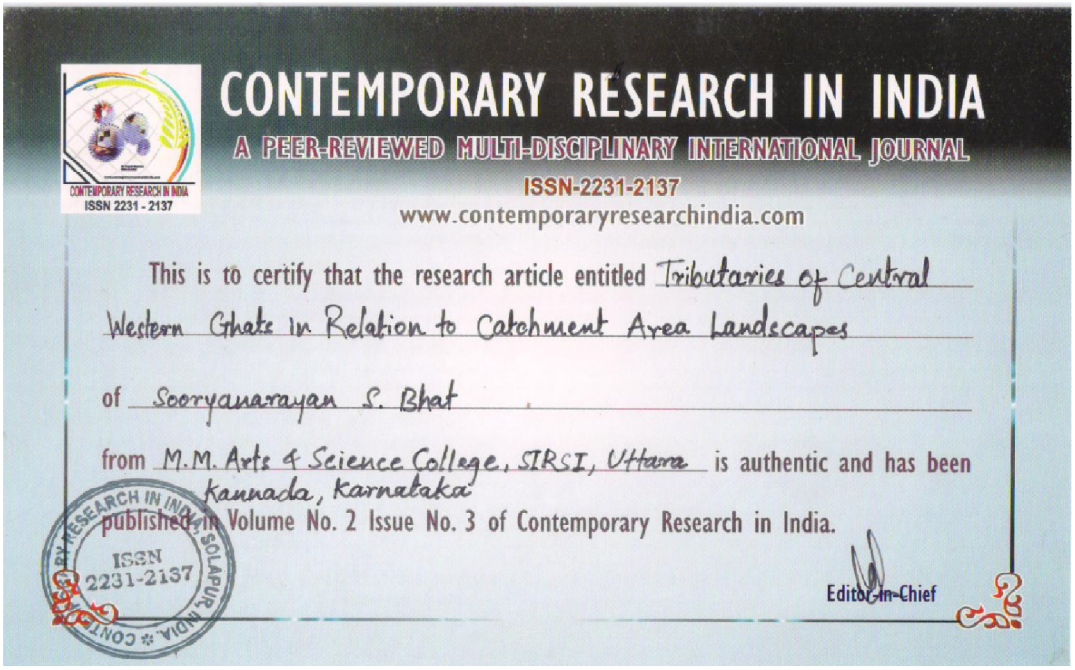
CONTEMPORARY RESEARCH IN INDIA (ISSN 2231-2137) : VOL. 2 : ISSUE : 4 218

DISTRIBUTION OF FRESHWATER FISHES OF BEDTI (GANGAVALI) RIVER AND ITS TRIBUTARIES OF CENTRAL WESTERN GHATS IN RELATION TO CATCHMENT AREA LANDSCAPES

Sooryanarayan S. Bhat, Assistant Professor in Zoology, M.M.Arts & Science College, SIRSI, Uttara Kannada,Karnataka

Abstract:

Particularly in relation to Landscape features and catchment area vegetation have not merited much attention from the ecologists. This can be considered a big setback in matters pertaining to conservation of the Freshwater stream and fishes of the Western Ghats. The efforts have been made to document fish diversity of Bedti River and its tributary streams of ***Central Western Ghats in Dharwad and Uttara Kannada District*** *of Karnataka State. Fresh water offers one of the more common and stable habitats of the Biosphere. It has its own physical and chemical characteristics and hosts a large communities which have adapted to dynamic environment, involving close interactions between organisms and physical and chemical constituents prevailing within the system. It has a well-defined food chain and food web through which energy is channelized and community develops through discrete successional stages. It involves such diverse system as lakes, pools, bogs, streams and rivers.* ***Bedti (Gangavali)*** *is one of the west flowing rivers that originate in the moist deciduous forest areas of Dharwad district. The river is the outcome of hundreds of tributary streams which merge and become limited number of tributaries. The streams have their catchments covered with various types of landscape element types ranging from dense forest to agricultural areas, scrubs and wasteland. Not much thought has ever been given for the quality of the stream and its catchment area landscape while considering conservation of the precious endemic species. Therefore catchment area landscape degradation has serious implication on the fish fauna. Final outcome of the study will be an inventory and conservation strategy after the holistic consideration of the fishes in relation to their Macro and Microhabitats and landscape features of the catchment.*



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This is to certify that the research article entitled Tributaries of Central Western Ghats in Relation to Catchment Area Landscapes

of Sooryanarayan S. Bhat

from M.M. Arts & Science College, SIRSI, Uttara Kannada, Karnataka is authentic and has been published in Volume No. 2 Issue No. 3 of Contemporary Research in India.

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Editor-in-Chief

"Distribution of freshwater fishes of Bedti (Gangavali) River and its tributaries of Central Western ghats in relation to catchment area landscapes"

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Vol. 2(8), 5-10, August (2014) *Res. J. Animal, Veterinary and Fishery Sci.*

A Note on Fresh water Fish diversity in major Tributaries of River Bedti of Western Ghats region of Karnataka, India

Sooryanarayan S. Bhat* and Anil kumar K. Hegde
M.M. Arts and Science College, SIRSI-581402, Uttara Kannada, Karnataka, INDIA

Available online at: www.isca.in, www.isca.me
Received 14th July 2014, revised 2nd August 2014, accepted 20th August 2014

Abstract

The present report describes the status of fish diversity in the major tributaries of river Bedti of Western Ghats region of Karnataka. Fresh water offers very common and suitable habitats of the Biosphere. It has characteristic features in chemical, physical properties and hosts a large biodiversity which have adapted to dynamic environment. It has a well-defined food chain and food web through which energy is channelized and community. The present work was carried from June 2013 to June 2014. Fishes were caught with the gill net, cast net and drag net of suitable dimensions. The fishes were soon preserved and sent to the ZSI Kokatta for identification. The identified fishes were classified up to families. Highest fish diversity was recorded in Pattanahole.

Keywords: Fresh water, fish diversity, major tributaries, taxonomy, puntius sp.

Full Paper Published in *Research Journal of Animal, Veterinary and Fishery Sciences* Vol. 2(8), 5-10, August (2014) *Res. J. Animal, Veterinary and Fishery Sci.* ISSN 2320 – 6535

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Paper presented on the subject entitled **"Fresh water Ichthyofaunal Biodiversity with special reference to the middle stream of River Bedti of Western Ghats Region of Karnataka, India"**

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A Note on Fresh water Fish diversity in major Tributaries of River Bedti of Western Ghats region of Karnataka, India

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Abstract

The present report describes the status of fish diversity in the major tributaries of river Bedti of Western Ghats region of Karnataka. Fresh water offers very common and suitable habitats of the Biosphere. It has characteristic features in chemical, physical properties and hosts a large biodiversity which have adapted to dynamic environment. It has a well-defined food chain and food web through which energy is channelized and community. The present work was carried from June 2013 to June 2014. Fishes were caught with the gill net, cast net and drag net of suitable dimensions. The fishes were soon preserved and sent to the ZSI Kokatta for identification. The identified fishes were classified up to families. Highest fish diversity was recorded in Pattanahole.

Keywords: Fresh water, fish diversity, major tributaries, taxonomy, puntius sp.

Introduction

The study area is mainly located in Uttara Kannada district depicted in figure-1. Uttara Kannada district of Karnataka state has a geographic area of 10,291sq^{2}m and situated strategically in the middle of the Western Ghats. It is located between 13^0 55' to 15^0 32' N latitude and 74^0 05' to 75^0 05' E longitude[1]. It has a typical tropical climate with well-defined seasons and receives rainfall on an average 2500mm annually. The entire district is enriched in varied varieties of flora and fauna. The abundance of flora and fauna is mainly because of the four major rivers flowing in the district. The major rivers are i. Bedti ii. Kali iii. Aghanashini and iv. Sharavati. Bedti is one of the west flowing rivers that originate in the Moist Deciduous forest areas of Dharwad district. The river is the outcome of hundreds of tributary streams which merge and become limited number of tributaries. The streams have their catchments covered with various types of Landscape element types ranging from dense forest to agricultural areas, scrubs and wasteland. The major tributaries selected for the present studies are i. Ganeshpal ii. Pattana hole iii. Sahasralinga iv. Sonda v. Majjigehalla. The objective of the present work is to reveal the fish species diversity with respect to the river tributaries.

Material and Methods

Fish sampling is the major fieldwork at all the specified locations. Fish sampling were made two times a year i.e. Pre monsoon and post monsoon. For collecting the fish Gill nets, Cast Nets and Dragnets of different mesh size were used. The net fishing is one of the most popular fishing methods. The fishes caught alive and preserved in 4% formaldehyde for the identification. The fishes caught in the net were immediately separated from the net and the numbers of fishes caught were counted and representative sample of every specimen were preserved in plastic jars using 4% formaldehyde solution. All colors, color patterns, spots blotches number and design of the fishes were carefully noted in the field note book.

For identification following morphological characters were considered: i. Total Length, Standard Length- Body depth, Head length, Head Width, Eye Diameter. ii. Position of mouth, supra terminal, terminal, sub terminal and Ventral. iii. Presence or absence of barbells, number of barbells, and location and length of barbells, iv. Height and length of Dorsal fin, length of pectoral and pelvic fins, length and height of caudal peduncle, length of longest fin ray and the number and position of spines and rays, lateral line scale count, v. Spots, blotches, bands and marks etc.

Further, the some of the unidentified fishes were sent to Zoological Survey of India, Kolkata for identification and got identified. Simpsons Diversity Index was calculated to determine the fish diversity.

Results and Discussion

A total of 19 species belonging to 4 families of fishes were recorded during the study period 2013-2014. Cyprinidae, Balitridae, Aplochaeilidiae and Ambassidae were the most abundant families. These are presented in table-1. The tributaries of river Bedti have different ecological characteristics, which have abundantly influenced the fish population. It has natural course of water without any dams and pollution. However in recent times Bedti River has been reported as polluted through urban sewage water flow. Moreover, the fishes have proved that they have the evolutionary flexibility to produce species to fill the spectrum of

niches presented. They can be very big or very small, inhabit open waters or stay close to the bottom and they are present at every consumer trophic level in both the grazing and decomposer chains. For example *Garra species* is very well adapted to torrential water flow which has a suction cup on the ventral region, just below the mouth, can adhere to rocks, thus protects itself from torrential flow of water.

The predominant fish fauna in south Asia belongs to the carp family Cyprinidae[2,3]. The carp family alone in the river was prominent with *Puntius* as major genus. The Cyprinidae alone constituted 91% of the total catch of the known species, while Ambassidae 6%, Balitridae family contributed only 2% and Aplochaeilidiae 1%. These are graphically depicted in figure -2a and 2b.

The river tributaries exhibited highest number of Cyprinidae followed Ambassidae, Balitridae and Aplochaeilidiae revealed that, the tributaries of river Bedti accounted 1076 individuals. These are presented in table-2. The significant finding of the present observation was that the occurrence of Rasbora rasbora in all tributaries while Puntius arulius was found only in Pattanahole. It was observed that the species richness was in the order Pattanahole 354, Sonda 269, Sahasralinga 245, Ganeshpal 114 and Majjigehalla 96. It has been further argued that the increase in the number of species indicates less anthropogenic pressure on that particular tributaries[4-6]. Contrary to these observations, it is noted that both in Ganeshpal and Majjigehalla river tributaries of the present study exhibited less species richness. The most interesting observation of the present study was that though species Rasbora rasbora (edible fish) are more they are not very much liked by the local community because they are less tasty to eat. Diversity of fish species is determined generally by several physical factors, size, depth, quality of stream and biotic conditions such as food, vegetation and substratum[7-9]. Habitat destruction due to deforestation results in increased erosion and suspended matter and deposition of fine sediments resulting in habitat loss and destruction of spawning grounds and species extermination[10,11]. Different river systems are known to harbor some species exclusive to the system. As per the present study family richness was more in Sahasralinga as compared to other tributaries. This is presented in table 3 and depicted graphically in figure 3.

Table-1
Distribution of fishes in five different tributaries of river Bedti

Sl.No.	Order-Cypriniformes	Species	T-1	T-2	T-3	T-4	T-5	Grand Total
1		Rasbora rasbora (Hamilton-Buchanan)	17	25	235	18	30	325
2		Puntius jerdoni (Day)	00	15	08	20	00	43
3		Puntius chola	13	00	28	06	00	47
4		Puntius filamentosus(Valenciennnes)	00	00	00	04	00	04
5		Puntius amphibeus	00	00	06	00	40	46
6		Puntius narayani (Hora)	02	07	28	00	01	38
7		**Puntius arulius**	00	00	12	00	00	12
8		Danio aequipinnatus	00	00	25	06	04	35
9	**Family- Cyprinidae**	Tor tor (Hamilton-Buchanan)	15	00	00	00	00	15
10		Garra mulya	05	48	10	12	03	78
11		Gara gotyla stenorhynchos	04	18	00	10	00	32
12		Garra garra	00	140	00	00	00	140
13		Labeo fimbratus	40	00	00	00	00	40
14		**Labeo calabus**	14	00	00	21	00	35
15		**Labeo rohita**	24	08	00	07	00	39
16		**Hypselobarbus jerdoni (Day)**	26	08	02	10	00	46
		Total	**160**	**269**	**354**	**114**	**78**	**975**
	Family- Balitoridae							
17		**Nemacheilus guentheri**	00	00	00	00	18	**18**
	Order-Cyprinodontiformes							
	Family- Aplocheilidiae							
18		Aplocheilus lineatus (Valenciennnes)	17	00	00	00	00	**17**
	ORD-Perciformes							
	Family- Ambassidae							
19		Pseudoambasis ranga (Hamilton-Buchanan)	66	00	00	00	00	**66**
								1076
T-1-Sahasralinga T-2-Sonda T-3-Pattanahole T-4-Ganeshpal T-5-Majjige halla								

Table-2
Distribution of the abundance of family and their species in five tributaries studied

S.No	Family	Total Species
1	Cyprinidae	975
2	Balitridae	18
3	Aplochaeilidiae	17
4	Ambassidae	66

Table-3
Distribution of the abundance of family and their species in five different tributaries studied

S.No	Family	Tributaries				
		T-1	T-2	T-3	T-4	T-5
1	Cyprinidae	160	269	354	114	78
2	Balitridae	00	00	00	00	18
3	Aplochaeilidiae	17	00	00	00	00
4	Ambassidae	66	00	00	00	00

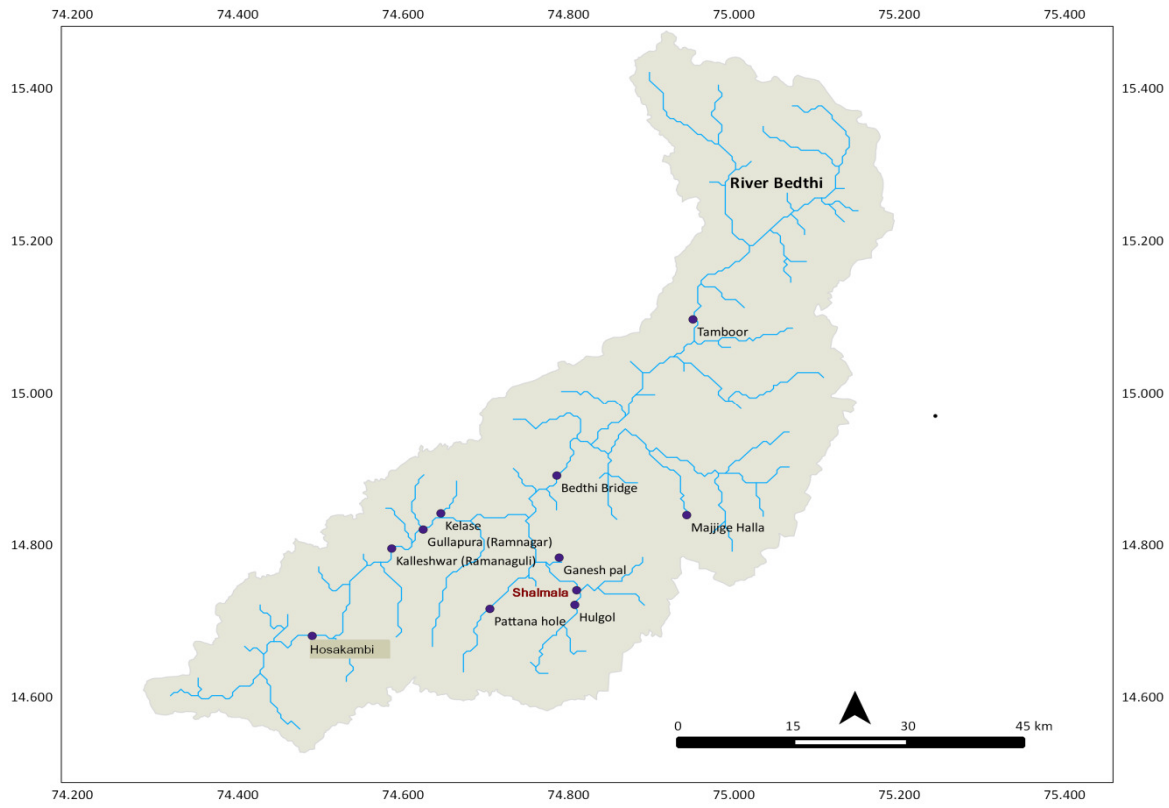

Figure-1
Major tributaries of river Bedti

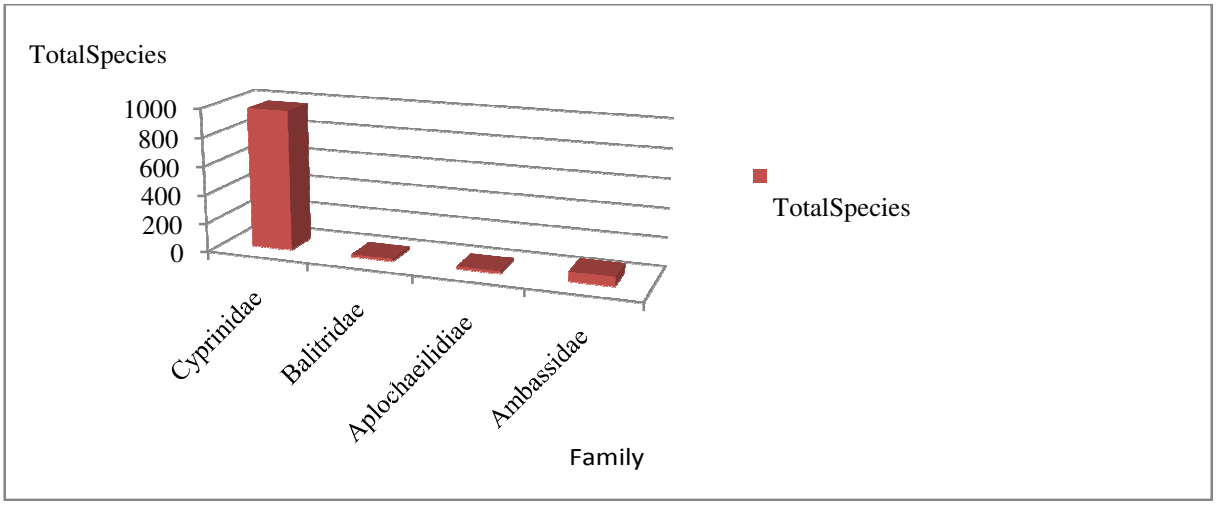

Figure-2a
Histogram showing the distribution of the abundance of family and their species in five tributaries studied

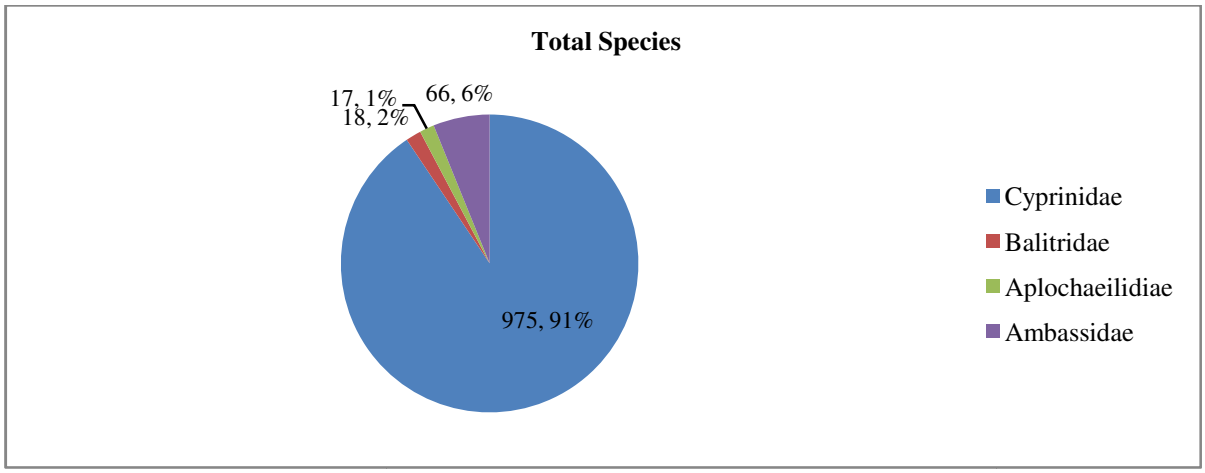

Figure-2b
Pie chart showing the distribution of various families of fish in five tributaries studied

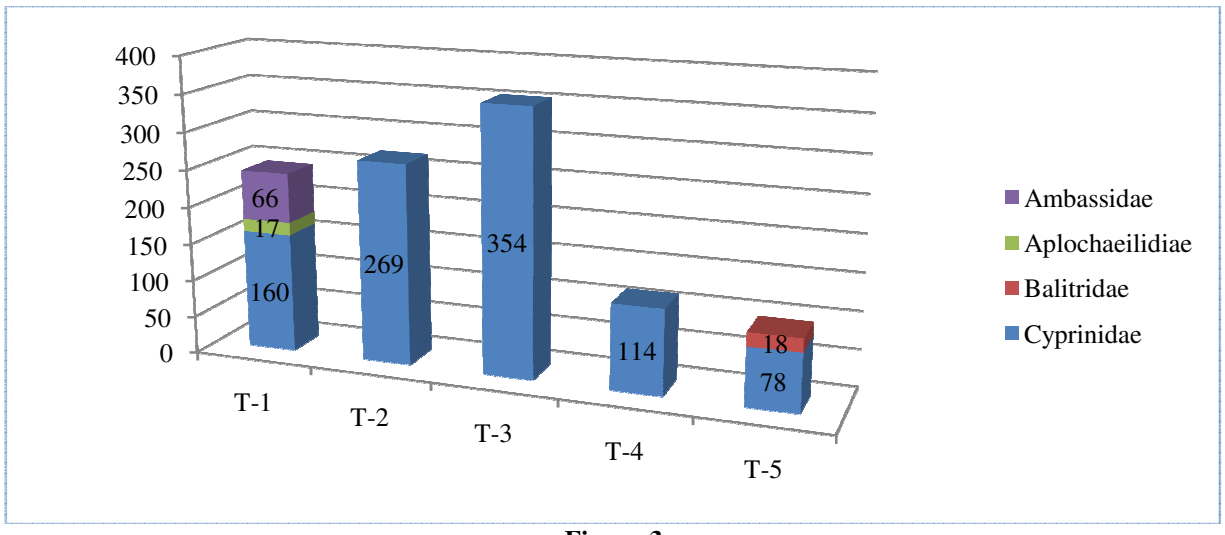

Figure-3
Histogram showing the species abundance with respect to the five different tributaries of Bedti

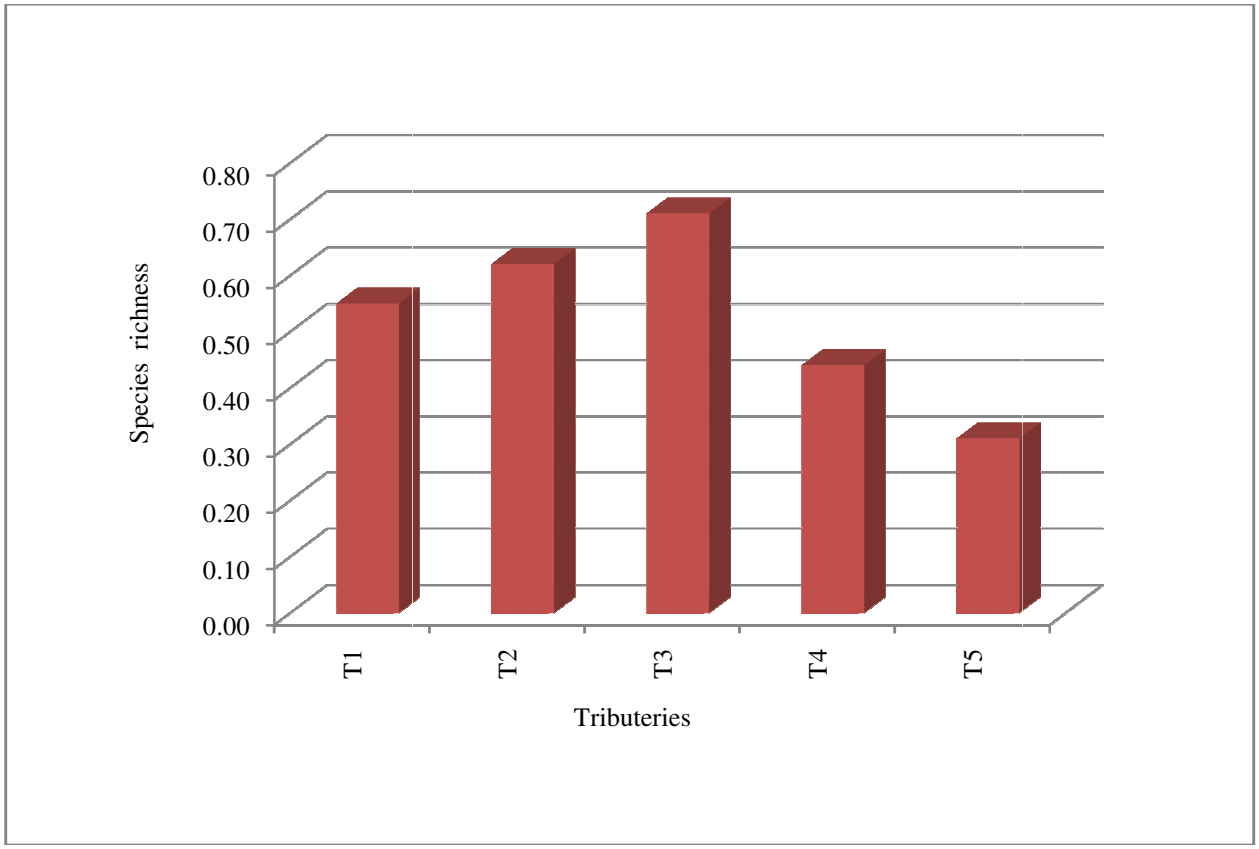

Figure-4
Histogram showing the Simpson diversity index with respect to the five different tributaries of Bedti

As per the Simpsons Diversity Index most diverse fish community was recorded in Pattanahole and Majjigehalla accommodated least diversity. These are depicted graphically in figure 4.

According earlier reports from Daniels and Sreekantha species richness or diversity depends less on the characteristics of a single ecosystem than on the interactions between ecosystems, e.g. transport of living animals across the different gradient zones in the water body[12]. Fish is captured in natural lakes, reservoirs, streams, tributaries, rivers and oceans. However, few species in spite of their great commercial interest have been comprehensively less studied to establish the importance of their distribution for their successful management. It is in this context, this study enlightens the fish species diversity in tributaries of the river ecosystem.

Conclusion

This report indicates fish diversity in the major tributaries of river Bedti of Western Ghats region of Karnataka. According to a study conducted during 2013-2014 it has been revealed that fish diversity and abundance have shown variation in the tributaries based on the human interference. Overfishing and habitat degradation might be the significant factors affecting the fish diversity and richness.

Acknowledgement

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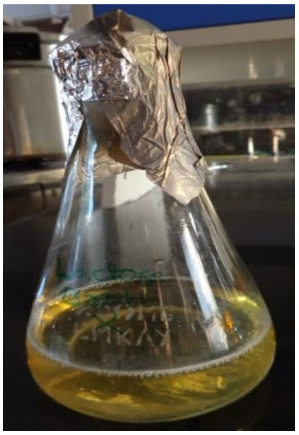
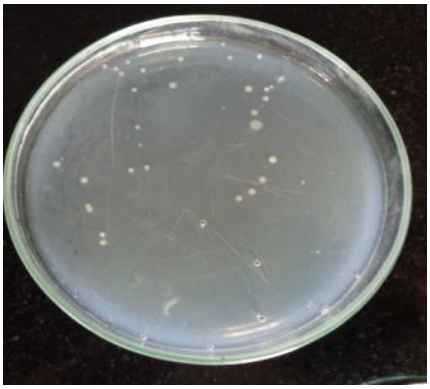
Appendix –C

Photographs showing MPN Bacteriological tests performed in the laboratory



NA Broth

Test tube containing NA Broth



Test tube showing positive for the presence of Bacteria

Principle investigator was carrying out the bacteriological test in the laboratory.

PLATES

Fig.1. Rasbora rasbora

Fig.2. Puntius jerdoni

Fig. 3. Puntius chola

Fig.4. Puntius filamentosus

Fig.5. Puntius amphibeus

Fig.6. Puntius narayani

Fig.7. Salmostoma boopis

Fig.10. Garra mulya

Fig.8. Danio aequipinnatus

Fig.11. Garra garra

Fig.9. Tor tor

Fig.12. Nemacheilus semiarmatus (Day)

Fig.13. Nemaecheilus guentheri

Fig.16.Clarias dussumieri

Fig.14. Mugil cephalus

Fig.17. Wallago attu

Fig.15. Mystus cavasius

Fig.18. Xenentodon cancilia

Fig.19. Aplocheilius lineatus

Fig.22. Labeo rohita

Fig.20.Pseudoambasis ranga

Fig.23. Labeo calabasu

Fig.21.Mugil cephalus

Fig.24. Mystus malabaricus

Fig.25. Etroplus suratensi

Fig.26. Puntius arulius

Fig.28. Gara gotyla stenorhynhos

Fig.27. Glossogobius giuris giuris

Photo gallery

Hulgol Tributary

Principal Investigator was recording water & air temperature

Pondanus unipillatus grass species at Hulgol Tributary

Co- Investigator at Sonda Tributary

A view of Bedti Bridge

Submurged Pongamia arjuna trees at Bedti Bridge

Gullapur (Middle stream)

Ramanaguli (Downstream)

A view of Hosakambi downstream

Fisherman was catching the fish at Hosakambi

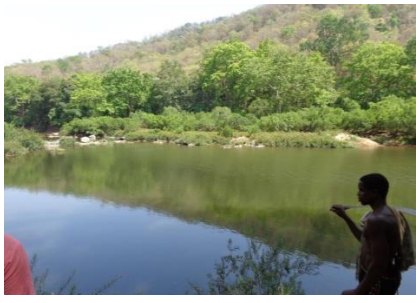
Tambur Upstream

Principal investigator along with helpers at Pattanahole tributary

Rasbora rasbora fishes were netted in large numbers at Pattanahole

Wild *Alium aquatica* at Ganeshpal tributary

Majjige halla tributary



A view at Kelase middle stream of Bedti River