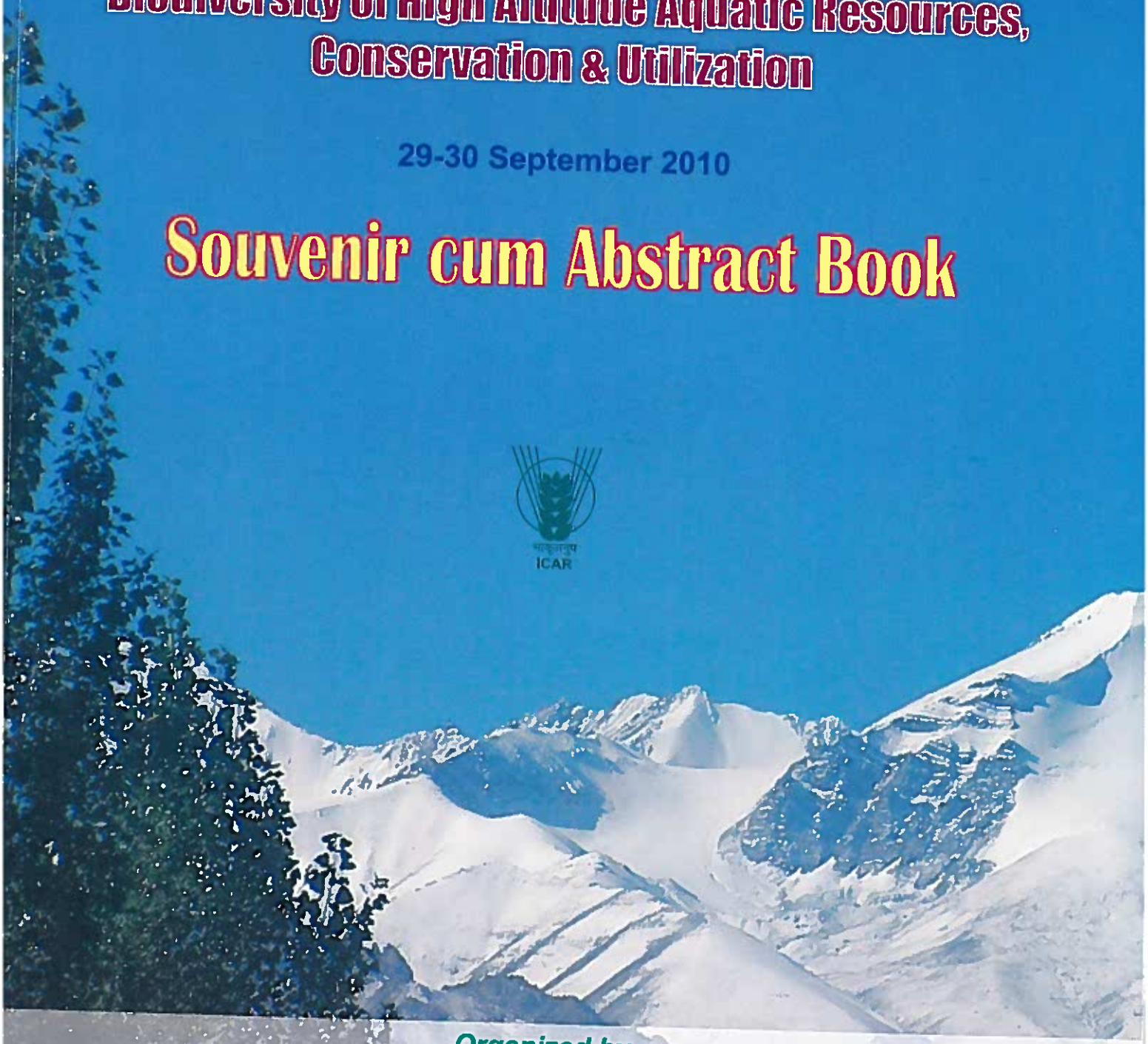
National Consultation On Biodiversity of High Altitude Aquatic Resources, Conservation & Utilization

29-30 September 2010

Souvenir cum Abstract Book



Organized by

Directorate of Coldwater Fisheries Research
(Indian Council of Agricultural Research)
Bhimtal-263 136, Nainital, Uttarakhand
&
Academy of Environmental Biology, Lucknow

National Fisheries Development Board (NFDB) Hyderabad

NFDB's AIMS

- Enhance Production
- Introduction of New Technologies
- Modernize Markets
- Promote Consumption
- Achieve Sustainability

NFDB Schemes

Name	Unit Cost in Rs.	Pattern of assistance
Construction of new fish / prawn ponds	(a)Rs. 3.00 lakhs/ ha for plain areas	1. 20% subsidy for all farmers/ entrepreneurs 2. 25% subsidy to SC & STs
	(b) Rs. 4.00 lakhs/ ha in hill state/ Districts & NE region	-do-
New species Pangasius Sutchi	Rs. 3.00 lakhs/ ha	-do-
Running Water Fish Culture Construction	Rs. 0.45 Lakhs/Unit	1. 20% subsidy for all farmers/ entrepreneurs 2. 25% subsidy to SC & STs
First year Input	Rs. 0.15 Lakhs/Unit	1. 20% subsidy for all farmers/ entrepreneurs 2. 25% subsidy to SC & STs
Establishment of freshwater prawn seed hatchery i) Capacity: 25 million PL / year	Rs. 30.00 lakhs/unit	one time grant
ii) Capacity: 5-8 million PL / year	Rs. 12.00 lakhs/unit	20% subsidy to Entrepreneurs / Farmers
Establishment of fish seed hatchery (7-8 million (fry) capacity / year)	Rs. 16.00 lakhs/ Unit in hill state/N.E. Region	20% subsidy to entrepreneurs/ farmers
Construction of fish seed rearing units for rearing fry to large fingerlings	Rs. 4.00 lakhs/ Ha in hill state/N.E. Region	1. 20% subsidy for all farmers/ entrepreneurs 2. 25% subsidy to SC & STs
Trout culture in race ways i) unit size: 45 m^3 water area	Rs.1.00 lakh/ Unit	1. 20% subsidy for all farmers/ entrepreneurs 2. 25% subsidy to SC & STs
ii) Inputs for trout farming unit size: 45 m^3 water area	Rs.1.30 lakhs/ unit	-do-
Trout hatchery Capacity 0.2 -0.3 million fry/year	Rs. 12.00 lakhs/unit	20% back ended subsidy
Trout fish feed mill 3 tons/hour	Rs 500.00 lakhs	100% one time grant on machinery and equipment to State Fisheries dept's.
New wholesale markets	Unit cost has to be decided and appraised on case to case basis.	Soft loan of 40% at 5% interest rate to Entrepreneurs through Commercial banks
Establishment of modern fish retail outlet by NFDB	Upto Rs. 10.00 lakhs excluding the building cost.	NFDB will establish the retail outlets and will be leased/ rented to eligible entrepreneurs / self help groups / ex-service men to manage the unit under PPP mode
Setting up of Fish Retail outlets	Up to Rs. 10.00 lakhs	25% subsidy to entrepreneurs and 30% subsidy to beneficiaries belonging to SC/ST and NE states.

Achievements of NFDB:

- Rs. 82.92 crores for stocking fingerlings in 2567 reservoirs covering 13.50 lakh hectares.
- An extent of 7000 hectares is developed with subsidy of Rs. 57.62 crores.
- Modernization of fishing harbours worth Rs.13.00 crores
- 25 wholesale and 48 Retail Fish Markets worth Rs.45.00 crores.
- Established an Aqua quarantine facility for vannamei culture.
- Promotion of open sea cage culture - Rs. 2.67 Crores.
- Trained 1,07,000 fisheries extension officers, fishermen, fish farmers.

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सत्यमेव जयते

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14 SEP. 2010

MESSAGE

It is a matter of immense pleasure that Directorate of Coldwater Fisheries Research, Bhimtal is releasing a Souvenir to commemorate the National Consultation on Biodiversity of High Altitude Aquatic Resources, Conservation & Utilization. In the present context, it is very important to adapt conservation practices through public participation & development of feasible fish farming techniques in cold water fishery sector to provide sustainable rural livelihood for the fish farmers and also to face the newer challenges like population upsurge and urbanization in hill & adjoining regions.

I wish the institute all success on the occasion and hope that the National Consultation would be helpful for the development of fisheries and welfare of fisher folk in the years to come.

(Prof. K. V. Thomas)

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SECRETARY & DIRECTOR-GENERAL

भारत सरकार
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MESSAGE

The country has significant coldwater genetic resources in the region extending from northwest to northeast Himalayan region and in some parts of Western Ghats spread to ten states. This diverse natural resource-base, wide climatic diversity vis-à-vis altitude are conducive to conserve and rear different fish species, developing domestic market for high value fish and growing interest of people in eco-tourism. The important coldwater species mainly trouts, mahseer and carps are important for food as well as sport fishery. In recent years due to population explosion, climate and habitat changes, coldwater aquatic resources now have become threatened and need mitigation and management measures.

I am pleased that the Directorate of Coldwater Fisheries Research, Bhimatal is organizing two days symposium on **"National Consultation on Biodiversity of High Altitude Aquatic Resources, Conservation and Utilization"** from 29-30 September, 2010 in collaboration with Academy of Environmental Biology, Lucknow to address these issues. I extend my heartiest congratulations to the organizers and best wishes for the success of the Symposium.

Dated the 12th September, 2010
New Delhi

(S. Ayyappan)

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MESSAGE

Coldwater fisheries is an important sector having vast resources mainly in the form of upland streams, rivers, high and low altitudinal lakes and reservoirs located in different hill states of India. Large population of indigenous and exotic coldwater fish species in these mountain water bodies forms an immense potential for mountain aquaculture practices and sports fishing. The Himalayan aquatic resources, once considered inexhaustible are now showing the effects of indiscriminate exploitation of fishery resources in terms of unavailability of catches in many parts of the streams. In order to conserve the valuable gene pool as well as to enhance the fish production from the mountainous region of the country location, situation and need specific technologies are to be developed. In the present scenario of climate change with dwindling fishery resources there is an urgent need of R&D initiatives to overcome these threats. The mappings of hill fishery resources, rational utilization and their conservation have now become a national concern.

I am indeed happy to know that the Directorate of Coldwater Fisheries Research, Bhimtal is organizing *"National Consultation on Biodiversity of High Altitude Aquatic Resources, conservation and Utilization"* from 29-30th September 2010 along with Academy of Environmental Biology, Lucknow. This will provide the platform to discuss the important issues related to coldwater fisheries sector and their possible solution. I extend my heartiest congratulations to the organizers and my best wishes for the grand success.

(B. Meenakumari)

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PREFACE

The availability of fishery resources in hill regions in terms of gene pool is diverse which include large population of indigenous and exotic, cultivable and non-cultivable fish species. These available species are mainly used as food, while few of them as sport and ornamental purposes. On account of population upsurge and urbanization in the hill and adjoining regions, demand for fish has significantly increased over last decades. The coming decades are expected to pose newer and greater challenge to coldwater fishery sector both in the development of aquaculture and conservation practices in the hill regions of the country. The Directorate of Coldwater Fisheries Research, Bhimtal has played a pivotal role in development of feasible fish farming techniques for hill region.

In this context the National Consultation on **"Biodiversity of High Altitude Aquatic Resources, Conservation & Utilization"** being organized at this Directorate from 29 to 30 September 2010, would provide a suitable platform to all the stakeholders to discuss the various relevant issues of the sector.

I hope the conclusions emerged out of this consultation will pave the way for over all development of the coldwater fishery sector.

(P.C. Mahanta)

Content

Souvenir

Abstracts

PART–I
SOUVENIR

Issues related to development of coldwater fisheries in India

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Abstract

Mountains are always on the new front of civilization and have been by far the most exploited geographical unit on earth. Its easy access and resourcefulness have always attracted human activities, but its complexity in understanding has led to misuse and abuse. The risk face of all the facts just mentioned is that if the fish stocks dwindle, there would be a grave threat to food security; anything that transforms the uplands would affect inhabitants by virtue of their habitation. While it is practical to think that coldwater fisheries management should benefit the contemporary society, it is more ethical and wise to think about the tomorrow's' of life. An active consciousness about risks would allow an optimal integration of consumerism and conservation, which are the decisive factors of sustainable development. At the core of understanding the subtle issues of coldwater fisheries is the need to diagnose the hidden risks and evolve wise practices to counter their possible ill effects.

1. Introduction

The uplands of the country are a kaleidoscope of diverse topography, climate, race, language and culture, live together and share common problems. Agriculture development has its own limits such as non-availability of the flat land and infrastructure facilities for intensive farming. Most of the population is fish eater but the region is not self sufficient. The coldwater fisheries may play an important role in the socio-economics life of the people dwelling in the mountainous zones of the country. The majority of dependents on fish as means of livelihood are now facing problems to meet their both ends owing to sharp decline in fish catch in the upland areas. Keeping in view the squeezing land and burgeoning human ratio, mountain fish resource base is of great relevance and development of such areas becomes matter of national concern, which needs different technological approach and support services. Such regions have to be tapped for increased fish production for national basket and rural development in hills. In Indian sub-continent, coldwater fishes are generally the denizens in the Himalayan and sub-Himalayan zones in the north and watersheds draining the southern slopes of Deccan plateau (Western Ghats). Vast water resources present diversified and queer type of fish fauna in different hill regions comprise about 258 fish species from Indian uplands of which 203 are recorded from the Himalayas while 91 form Deccan plateau.

2. Subtle Issues and Hazards in Coldwater Fisheries

2.1 Infrastructural Issue

In the coldwater sector, most of the hill states are at different levels of development with regard to

fishery development. The States like Jammu & Kashmir and Himachal Pradesh have during the last two decades made significant progress in capture fisheries such as sport fishery, aquaculture especially of trout, and fishermen welfare and support services to the sector. Inspite of these efforts the production is still very low as compared to the all India average. On the other, is the newly created State of Uttaranchal, where till two years back hill fishery did not receive adequate attention and most of the facilities are still not in place. Then there is a selective region of Northeast where the potential for coldwater fishery exists but development is at very low level. The primary reason for this situation in the country has been the lack of support at planning level and thinking with authorities that hill fishery is mainly a game activity and does not require R&D support. But of late it is being realized and demonstrated that coldwater fishery can contribute to food and nutrition security in hills and remote regions. Therefore, in the planning process the fishery in hills needs to be given due importance in terms of financial, infrastructure and modern institutional back-up facilities. In hills the fishery development through aquaculture, sport and conservation should be promoted and supported, in order to introduce crop-fish diversification, so that natural resource management becomes economically sustainable activity. This will result in profitable utilization of small resource base available in hills for any farming activity.

2.2 Conservation Related Issues

Initially, the hill streams harbored a rich population of mahseer, snow trout and minor carps, though the introduced exotic trout was only limited to a few streams. Sport fisheries, especially of mahseer and Schizothoracid was well known but with the rapid overall development of the country and owing to ever-increasing demand of fish as food, the aquatic ecosystems are under constant pressure of man-induced stresses to the detriment of the aquatic flora and fauna. Though the decline of individual fish species is very often related to more than one proximate factor, the various causes of imperilment of fishes in the aquatic ecosystems have been identified by Mahanta et.al. (1998) and Das and Pandey (1998).

2.2.1 Habitat destruction

Siltation from the catchment areas, besides changing the ecology due to construction of dams, has destructed the feeding and breeding grounds of many fishes (Sehgal, 1994). It is estimated that about 5,334 million tons of soil is eroded annually from the cultivable land and forests of India. Our rivers carry nearly 2,050 million tons of silt, depositing approximately 480 million tons to the reservoirs causing eutrophication and reduction in the productivity of the water bodies. Habitat alterations in Himalayan waters have affected distribution and abundance of native fishes in mountain streams of India (Sehgal, 1994; Raina, 1996). Power dams and reservoirs have dramatically changed the fish habitats and local fish communities. The migration routes of important native fishes like mahseer (*Tor putitora and T. tor*) and snow-trouts (*Schizothorax richardsonii, S. plagiostomus*) have been blocked (Sehgal, 1994). Excessive withdraw of water from the river courses for agriculture, domestic and industrial uses leaving inadequate water for comfortable fish life is also a major factor responsible for the depletion of fisheries resources.

2.2.2 Wanton destruction

Wanton killing by the use of dynamites, electric shocks and poisoning of brood fishes in spawning

season and juveniles during post-monsoon periods have affected a number of food and game fishes of upland waters, especially in rivers and streams originating in Assam, Nepal, Bhutan, Garhwal, Kumaun and Himachal Pradesh (Joshi, 1994; Chauhan et al., 1994 and Nautiyal, 1994). Mass killing of fishes of all the sizes during summer months in pools formed in river courses is an alarming situation, particularly in Ganga which does not retain many waters during summer now-a- days. Anthropogenic pressure such as increase water abstractions, wanton methods of fishing and pollution in the upland fisheries resources altered the systems. The coldwater fishes such as *Tor tor, Tor khudree, T. putitora, Schizothorax richardsonii, Schizothoraichthys progastus* have been included in the threatened/vulnerable list.

2.2.3 Aquatic pollution

Pollution is probably the single most significant factor causing major decline in the population of many fish species. Chemical pollution from factories and plants situated in the Nilgiris, Mysore and Croog have exterminated certain groups of hill stream fishes available in local aquatic habitats. Certain Noemacheiline loaches recorded by Day from Bhawani river at Mettupalayam, Coimbatore district are no longer available.

2.2.4 Introduction of Exotic Species

Brown trout *(Salmo trutta fario)* and rainbow trout *(Onchorhynchus mykiss)* are the two species, which constitutes trout fishery in the streams, lakes and reservoirs in the Indian uplands. In the Himalayan region, *Salmo trutta fario* is the only trout which supports sport fishing, while in the Southern region rainbow is the principal one. Common carp mainly includes two phenotype *viz.*, scale carp, *Cyprinus carpio (communis)* and mirror carp, *Cyprinus carpio (specularis)* which constitutes the bulk of the commercial fishery of certain lakes and reservoirs of J&K, Himachal Pradesh, Uttaranchal, North-Bengal, Arunachal Pradesh, Nagaland, Meghalya, Tamilnadu and Kerala. A third phenotype, leather carp, *Cyprinus carpio (nudus)* is of very rare occurrence. A good amount of data has been generated reflecting that introduction of *Cyprinus* has been responsible for decline in local snow-trout fishery in some of the upland lakes. Now the commercial catches of *Cyprinus* have nearly increased to 70-80% in most of the upland lakes and reducing the contribution of local variety to nearly 1 0%. Except in the lakes of Kashmir, the lakes/reservoirs in many other upland states have been stocked with silver and grass carp in order to increase the per hectare yield from the system. This practice in some has increased the per unit productivity but has resulted in sharp decline in indigenous fishery (Vass, 2005). Majority of fish production from the upland regions is fundamentally based on the contribution made by these exotic carps. On this issue one would argue about the conflict between increased fish productivity and preservation/ conservation of indigenous biodiversity, both issues is equally important (Vass and Gopakumar, 2002).

2.3 Management Issues

Coldwater Fisheries management was more of resource management till recently. Moreover, it was more or less uni-sectoral in approach. Even today, pollution abatement, geomorphological changes, resource harvest and developmental activities are not addressed in an integrated single table. But with the changing

times and in the face of availability of modern information, management has been becoming highly integrated. The subtle or not so subtle lapses between integrated methods and non integrated methods are many. In view of these, plans of integrated approach have emerged and are being practiced.

Capacity building is a cherished activity in this century and has been made easier by both the technology and the availability of funds. Although it is impossible to precisely estimate the needed quantified capacity by the society, qualitative approaches of defining the components of capacity are in vogue. So there are ideals on what should be the capacity. These ideals depend on country context social expectations, global parameters and a context specific vision of the future. But more often than not, there is a gap between ideal and reality and the gap could subtly enlarge and seal the fate of development. Realities emerge from rapid changing technology, systematic inertia, transfer loss in knowledge, speed of capacity building lack of appreciation of vision and/or irrelevant follow up of programmes. Examples in the world are not too few in this matter. One of the foremost risks in capacity building is that there are subtle areas of capacity leaks, which do not attract as much attention.

2.4 Policy Issues

The aquatic resources in hills are quite valuable for the development of fishery both for food and sport, but scientific management of these resources is necessary to achieve the objectives. In order to manage these ecosystems, so that they can contribute to fishery development in remote hilly regions on a sustainable basis, the following issues need attention.

a) Practically all the water resources suitable for hill fishery in the state are owned by the forest/irrigation department. For implementation of fishery development programme there is a need to place them under the management of fishery department.

b) Construction/renovation of existing fish farms and hatcheries on a priority to promote aquaculture activities.

c) A balanced strategy for lakes, for tourism and fishery development is required.

d) Hill fisheries conservation: In steams vis-à-vis other users of the resource.

e) Development of sport fishery: In linkage with tourism department involving creation of angling facilities and ranching of mahseer and trout in streams.

f) In natural ecosystems need enforcement of protective legislation and adopting aquaculture practices on a large scale.

g) Breeding grounds should be declared as sanctuaries at least during the breeding season.

Conclusion

Uplands have been a source of resource and service to the mankind for long. They have been used for procuring food, energy and minerals. While we look at the uplands as a supporter of our lifeline, we also have to be conscious of the abuse and misuse. While uplands provide light for life, we should not cast an abusive shadow. Sometimes, the shadows are so subtle that we fail to recognize them or we ignore them. For example,

mining, tourism etc. are activities, which may not have immediate effects but may be cumulatively harmful on a long run. Fragile upland environment draw the human attention in different ways. Human intervention is not only in view of resource exploitation, but also towards protection of the environment for future. However, it is a matter to consider that good intentions too could prove our lifeline; we also have to be conscious of the abuse and misuse ineffective if not supported and sustained by appropriate information and knowledge. The wise practice philosophy has a comprehensive vision of looking for details of risks: and risk mitigation concepts. It is only after recognition of details that a possibility of generating global prescriptions for wise management practices would emerge. It requires effort and time to analyze various activities in the uplands that are coordinated under diverse technological, social and cultural backgrounds. It is surely laborious and time consuming to unravel the hidden unwise components of plans and programmes and initiate ways of countering their effects. But, it is a necessity and an investment for a safe and wise future. The research on coldwater fisheries in the country was mainly initiated under ICAR system especially through Directorate but the Academic Universities located in hill states also did contribute in generation of various basic information on many aspects of coldwater fish species and aquatic ecosystems sustaining them. Now the Agriculture Universities are also getting involved in this activity. The governmental support even at national level to the hill fisheries research, started very late, in comparison to the warm-water sector. The individual level efforts in the Universities were undertaken to workout some basic problems with regard to important coldwater fishes in the upland states of India.

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Upland fisheries management in India with special reference to Arunachal Pradesh: A North Eastern Hill State

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Introduction

The coldwater rivers and hill-streams are known for their high velocity, waterfalls, rapids, cascades, deep pools and substratum comprising with bedrock-boulder-sand. These water resource harbors 258 fish species belonging to 21 families and 76 genera. Among these, some species are known for sports purpose, a few of them have potential ornamental value and majorities are recognized as food fishes.

In the Indian Himalaya, the cultivation of fish contributes little to the overall freshwater fish production. Virtually every facility created for fish cultivation in the Indian Himalaya produces fish for stocking into the streams and lakes primarily to meet the requirements of sport fishing. Commercial fishery is also dependent to some extent on the stocking of lakes and reservoirs with fry and fingerlings. While for a number of years fish hatcheries in the Himalaya have been raising eyed-eggs, fry and fingerlings of brown and rainbow trout, and fry and fingerlings of common carp for stocking, only recently have some hatcheries started producing seed for stocking the indigenous mahseers and schizothoracines. To meet the ever-increasing demands of angling, subsistence and commercial fisheries, there has been a need for modernization of some hatcheries, as past neglect has resulted in a decline in seed production. Some hatcheries have had to be abandoned. The degradation ofihatcheries took place especially where water quality deteriorated and the silt load in streams increased. This chapter discusses the farming of coldwater exotic and indigenous fish and the current developmental activities, which can be considered as a turning point in coldwater fisheries development of the Indian Himalaya.

The Himalaya and their water resources

The Himalaya, which cover 594 400 km^2, run for about 2 500 km from West to East, between Nanga Parbat (8126 m) in the West and Namcha Barwa (7 756 m) in the East. This mountain system is bordered in the West by the Karakoram Mountains and in the North by the high Plateau of Tibet. The width from the South to the North varies between 200 and 400 km. From South to North one can distinguish four parallel and longitudinal mountain belts of varying width, each having distinct physiographic features and its own geological history: the Siwaliks, the Lesser Himalaya, the Greater Himalaya and the Trans-Himalaya (Sehgal, 1999). The Himalaya are drained by 19 major rivers, of which the Indus and the Brahmaputra are the longest, each having a mountain catchment of about 160 000 km^2. Of the remaining 17 rivers five belong to the Indus system, of which the Beas and the Sutlej have a total catchment of 80 000 km^2, nine (Ganga, Yamuna, Ram

Ganga, Kali-Sharda, Karnali, Rapti, Gandak, Bhagmati, Kosi) belong to the Ganga system, draining nearly 150 000 km^2. The Ganga has five source rivers (Bhagirathi, Mandakini, Alaknanda, Dhauliganga, Pindar). A number of rivers enter from within India and from Bhutan. The Brahmaputra (known as Yarlung Zangbo Jiang or Tsangpo, in China) has a catchment of about 110 000 km^2. Most of these rivers flow in deep valleys until they exit the mountains.

The zones in the Himalayan region and the existing ichthyofauna

The fish species distribution in the Himalayan streams depends on the flow rate, nature and substratum, water temperature, and the availability of food. In the torrential streams, Sehgal (1988) identified several zones on the basis of the dominant fish species and the hydrographical features:

Headwater zone inhabited by rheophilic species of loaches and catfishes (*Nemacheilus gracilis, N. stoliczkae* and *Glyptosternum reticulatum*)

Large stream zone formed by the joining of headwater streams, inhabited by *Diptychus maculatus* and *Nemacheilus* spp. In the upper reaches of the most torrential section of this zone, the rheophilic species of snow trouts, *Schizothoraichthys esocinus*, *S. progastus, Schizothorax richardsonii* and *Schizopygopsis stoliczkae*, occur. The intermediate reaches of the large stream zone are frequented by *Schizothorax longipinnis, S. planifrons* and. *S. micropogon*. The least rapid reaches of this zone are occupied by *Garra gotyla, Crossocheilus diplochilus, Labeo dero* and *L. dyocheilus*;

Slow moving meandering zone inhabited by a large number of cold or eurythermal species such as *Barilius* spp, *Tor* spp, catfishes, homalopterid fish (*Homaloptera* spp) and snakeheads (*Channa* spp).

Fisheries of Himalayan Rivers

There are two basic types of fisheries in the Indian Himalayan rivers: subsistence fishery, and sport/ recreational fishery. Fish production in mountain streams is low and therefore, any commercial fishery is on a very limited scale. The low biological productivity results in the prevalence of small-sized fish, except in pools where fish have some shelter and resting place. Fish also reach a larger size in some coldwater reservoirs and lakes. Water temperature is always an important limiting factor influencing geographical distribution and local occurrence within one water system. Cold stenothermic species such as the endemic schizothoracines (*Schizothoraichthys esocinus* and *Diptychus maculatus*) and exotic brown trout have an upper tolerance of about 20°C. Carps, mahseers and lesser barils have a wider tolerance and even survive water temperatures over 25°C. Schizothoracines and brown trout remain active in the near-zero temperatures which prevail in streams of the lesser and greater Himalaya during December and January. Hailstorms and drought conditions in the Lesser Himalaya may cause adverse conditions, leading to fish kill.

In India, the subsistence and commercial fisheries exploit carps (*Labeo* and *Tor* spp.), lesser barils (*Barilius* spp.), schizothoracines (*Schizothorax* and *Schizothoraichthys* spp.), garrids (*Garra* spp.) and sisorids (*Glyptothorax* and *Glyptosternum* spp.). The other genera are of small size and of low economic value. The exotic brown trout (*Salmo trutta*) has established itself in some areas of the Himalayas (Sehgal, 1999).

In the North-Western Himalaya eight species of fish are considered to be of commercial importance (Sehgal, 1988). Experimental netting showed the following relative occurrence in catches: *Schizothorax richardsonii* (64.0 percent), *Schizothorax esocinus* (6.8 percent), *Garra gotyla* (5.7 percent), *Barilius bendelisis* (5.2 percent), *Tor putitora* (3.9 percent), *Labeo dero* (3.7 percent), *Crossocheilus diplochilus* (2.0 percent), *Labeo dyocheilus* (0.2 percent), other fish (8.5 percent). *S. esocinus* contributed 53.2 percent to the total catch in the cold water stretches of the Indus River, and 21.9 percent in the Jhelum River. The widely distributed *S. richardsonii* was caught in all 11 river systems as investigated by Sehgal (1988). This species also contributed to the fisheries in the lesser, and to some extent in the Greater Himalaya. In the lower reaches it is fished especially during the winter.

Tor putitora, called golden mahseer in India, is an important sport fish. It migrates from the lower to the middle reaches to spawn, mainly during the time when streams swell with the southwest monsoon precipitation. In snowmelt receiving tributaries of the Beas River it spawns twice a year. This fish has been heavily poached, and further damage has been inflicted by dams and weirs, which have stopped fish migrations. Increased soil erosion, resulting from the deforestation of mountains, has led to heavy siltation of rivers and streams, thus impairing the basic ecological requirements of this fish.

Coldwater fish farming in India

Traditional fish farming is not in regular practice in most of the hill states. Therefore, there is immense scope for the development of the farming to provide a source of employment to the hill people. Many suitable sites are available in different parts of the hill states, which could be utilized for fish production through aquaculture. The suitable sites are lying along the banks of the rivers, rivulets, streams and streamlets. Depending upon the micro-climatic conditions of the region, such suitable patches of water bodies should be identified throughout the region and be brought under anyone of the three-pronged fish farming practices.

Culture of indigenous and exotic coldwater fishes

Today, the available technologies allow the culture of a number of exotic and indigenous coldwater fish species in the Indian Himalaya. The most common exotic species are rainbow trout, brown trout, common carp, while the indigenous fish are: mahseers (*Tor putitora* and *Tor tor*), and schizothoracines (*Schizothoraichthys esocinus, S. progastus, Schizothorax richardsonii, S. niger and S. curvifrons*). Among these *Tor putitora, S. progastus* and *S. richardsonii* are preferred because of their wide range of distribution in the Himalaya.

The distribution of rainbow trout worldwide attests to its ability to adapt itself to a variety of aquatic environments under aquaculture conditions. Rainbow trout can be propagated artificially, which is important for its production as food fish. The fish can be fed artificial feed and withstand temperatures of up to 26.6°C for short periods. It also tolerates low dissolved oxygen content of water, resistant to some fish diseases and grow fast. In open waters, water temperature and precipitation are the primary factors affecting the survival and production of naturalized populations. The optimum thermal regime for the species lies in the range of 12-20°C and the annual precipitation and freshets are important.

The snow trout or mountain barbel (*Schizothorax richardsonii*) is widely distributed in the Indian Himalaya, from Ladakh in the North-West to Sadiya in the East. The species is an inhabitant of snow-melt and glacier-fed streams in the Greater and Lesser Himalaya. They undertake migration during winter months when the temperature in the Greater Himalayan waters reaches the near-freezing point. This induces them to migrate downstream and frequent the warmer spring-fed streams in search of suitable spawning grounds. The optimum temperature for spawning is 18-21.5^{0}C. The fish is a typical benthic feeder with a mouth well suited for rasping the microbiota growing over the bottom rocks, boulders, stones, etc. The early fry and fingerlings (15-65 mm in total length) consume mainly the larvae of Diptera, Nymphs of Mayflies and larvae of Caddis flies (66.4%, 23.2% and 9.5% respectively). Fish of 85 to 105 mm total length consume primarily Diatoms (66.6%), Blue-Green algae (11.9%), Insect larvae (6.7%) and Detritus (11.8%). Fish of 133 to 300 mm subsist mainly on Diatoms (60%), Blue-Green algae (9.6%), Green algae (8%), Insect larvae (10.2%) and Detritus (8.7%). Presence of gravel and sand in the gut is due to rasping the algal encrustations from stones and rocks.

Aquaculture

The aquaculture of coldwater fish in the Himalaya is limited, considering the total area of this region and the vast resources of water. At the end of the 1980s only 63 ha were under aquaculture in an area of 594,000 km^2. The present status of aquaculture of trout, common carp, mahseers and schizothoracines is described as follows.

Trout

Trout farming has immense scope in the Himalayan and some peninsular regions, where sufficient quantity of quality water is available. Trout need highly oxygenated (above 6 mg l^{-1}) cool water (5-20^{0}C) and high investment in the form of pond construction, procurement of seed, feed and maintenance of fish health. So, its expansion has limitations due to these barriers coupled with limited. At the beginning of the 1990s farming of trout was being carried out on several fish farms in Kashmir (4), Himachal Pradesh (3), Uttaranchal (2), Arunachal Pradesh (1) and Sikkim (1). The siting of these aquaculture facilities was based on the availability of water in required quantity and quality, i.e. from rheocrene springs and snow-melt/glacier-fed streams. Most farms receive water supply from snow-melt/glacier-fed streams. The old facilities at Laribal, Harwan and Achabal (the last receiving seepage water of the Bringhi stream and hence not a true spring-fed facility) in Kashmir, Katrain in Himachal Pradesh, and Kaldhayani in Uttarakhand might have been established when the stream water did not have the present level of silt load. At present a heavy load of silt reaches these farms from February to September. This is the result of soil erosion in their largely deforested catchments. Only from October to January is the silt load low. This has adversely affected the performance of these farms.

Trout hatcheries in the Himalayan region are of moderate size, having the capacity to incubate 64,000-480,000 green eggs. After the swim-up fry emerge they are fed initially on emulsified yolk of hen's egg followed by a mixture of yolk of hen's egg and bovine liver emulsion in 1:1 ratio. After having learnt the acceptance of initial artificial feeds, the fry are transferred to outdoor nurseries. In the northwest Himalayan

farms the emergence of fry of brown and rainbow trout coincides with spring rains and hailstorms. The hailstorms may chill the already cold water to a low temperature, which may lead to high mortality of the young fry. In March-April the snow /glacier-melt fed water containing fine silt is also detrimental to the survival of trout fry in trout farms. During the first three months the survival of fry fed on a diet of bovine liver and dry powdered silk-worm pupae, varies between 10.8-15.8%. Thus the principal factors responsible for fry losses are silt load, hailstorm-cooled water, diseases such as myxosporidiasis, octomiasis, ichthyophthiriasis, and nutritional deficiencies. Better quality feeds result in a survival from 50 to 61%, with maximum feed efficiency of 79.9% at 35% crude protein level. Yearlings and 1+ age group are raised in growing ponds and raceways. Trout is fed there on a conventional diet consisting of local raw fish, mutton, slaughter house waste, dry silk-worm pupae, etc. The most serious loss of growing trout is due to nutritional imbalance and non-observance of prophylactic measures.

Schizothoracines

The culture of schizothoracines is still in its experimental stage. Like the mahseers this group of cyprinids has shown a sharp decline in catches all along the Himalaya due to indiscriminate fishing and environmental degradation. It is believed that the introduction of exotic common carp has adversely affected the schizothoracine fishery in the lacustrine environment of the Kashmir valley lakes. While in the Jhelum River the presence of the common carp has had no impact on schizothoracines as reported by the some work. Sehgal (1974) started experiments with collection and artificial fertilization of eggs from *Schizothorax planifrons, S. curvifrons and S. plagiostomus*. These fish make spawning runs from Lake Wular into two inflowing streams. Subsequently, egg taking of *S. plagiostomus* and raising of post-larvae and fry was successfully carried out using mature specimens caught from several streams of Himachal Pradesh. Eggs of *S. niger* from Lake Dal were artificially fertilized and achieved a hatching rate of 10-40%. The result of induced breeding and artificial fertilization and incubation of *Schizothoraichthys esocinus* in a running water system gave cumulative hatching of 30-55%. Further rearing of *S. esocinus* upto fry and fingerling on artificial feeds met with some success. There is still work to be done on schizothoracine seed production to achieve a fully viable fingerling stage ready for release into rivers and lakes.

Common carp

In the Himalayan region two German phenotypes of common carp (mirror carp and scale carp) are commonly produced in aquaculture. These species are cultivated primarily to produce seed for extensive pond culture and for stocking of lakes and reservoirs. Common carp is produced in fish farms of the State Fisheries Departments of Himachal Pradesh, Uttaranchal, North Bengal, Arunachal Pradesh, Meghalaya, Manipur and Nagaland. The majority of the farms are located in the Lower Himalaya and the Himalayan foothills (Siwaliks). In the Indian Himalaya the common carp is successfully bred in cement tanks, in rectangular cloth containers fixed in ponds (hapas), and in earthen ponds. Since common carp eggs are adhesive and need a spawning bed, aquatic plants such as Hydrilla and Najas, palm leaves, dried pine and cedar needles and banana leaves are used as a substrate in different parts of the Himalayas.

The North- Eastern Himalayan region

The great Himalaya is divided into North-Western and North-Eastern Himalayan region. The North-East region with 21.57°-29.30° N latitude and 88°-97.30° E longitude comprise the state of Arunachal Pradesh, Assam, Manipur, Mizoram, Meghalaya, Nagaland, Sikkim and Tripura covering an area of 2.62 lakh sq. km. About 70% area is hilly and connected to mainland India through Siliguri/Chicken's neck having a width of 33 km on the eastern side and 21 km on the western side. The total population is 3.75% of the total population of the country and more than 60% are scheduled tribes. The North-East India is mostly hilly only about 30% area is plain on both sides of the river Brahmaputra and Barak. The topography of the region varies from few meters from sea level to Snow Line Mountains and has different kinds of agro climatic zone. This area receive highest rainfall during prolong rainy season from March to October. As a result aquatic resources in the form of rivers, stream, lakes, reservoirs, bheels, swamps and ponds are vast and varied. Commercially important group of fishes in coldwater sector are mahseer, *Schizothorax* spp., *Barils* and carps. As a result of a study of eleven rivers in the North -Western Himalaya, Sehgal (1999) noted the changes in the prevalent fish species. The Eastern Himalaya drained by the Brahmaputra has a greater diversity of coldwater fish than the Western Himalayan drainage.

The Arunachal Pradesh

Arunachal Pradesh lies between 26° 28' N to 29° 31' and 91° 30' to 97° 30' E having an area of 83747 Km^2. The total population is 10.91 lakh. Physiographically the state exhibit wide variations from 100-7000 m asl, therefore wide climatic variations. Majority of the land mass either under forest cover or inaccessible particularly the lower and greater Himalayan region. It has international boundary with China, Tibet and Bhutan.

The Arunachal Pradesh occupying the North-Eastern proximity of the country is characterized by the hilly terrain and criss-crossed by a number of rivers/streams along with a good number of beels in the lower belt and lakes in the middle and higher belts adding to the scenic beauty of its topography. The state has 7000 ha and 2000 Km of lentic and lotic water resources respectively. Of which, 30-40% is falling in the cold water zone of the state. The state is also the happy home for the rich fish fauna with more than 150 fish species. Out of which 20% represents the coldwater forms and the remaining 80% is contributed by the admixture of cold and warm water species.

Fisheries resources in Arunachal Pradesh

Riverine Resources

The state is bestowed with rivers and streams. The major rivers are Kameng, Subansiri, Dikrong, Kamla (Ranganadi), Siang, Siyom, Dibang, Lohit, Noadhing, Tirap and their tributaries.

Lacustrine Resources

The state is also rich in lacustrine resources. The lakes located in mid altitudinal zone are small to

medium size where as the lake located at high altitude are many but in small size. Majority of the lakes are located in the districts like Upper Siang, 'Nest Siang, Tawang Papumpare, Lower Subansiri bordering China, Tibet and Bhutan. The lake Mechuka (1900 m asl) in west Siang, lake Shelley (slightly over 2 ha), Mehao lake (20 ha.) are situated in lower Dibang valley. The lake Geker Sinyi (ganga) near Itanagar are quite accessible have coldwater fish fauna. But the lakes Shelley (2.2 ha) and Meheo (20 ha) lakes in Lower Dibang Valley have indigenous fauna comprising *N. hexagonolepis, Schizothorax spp. Barils* and introduced fishes like IMC, Chinese carp. The lakes located at high altitude (about 40) are scared, inaccessible, near to Indo- China border therefore, least or nil fisheries activities are there. However, good fish stock is available like Chinese carp, Snow trout, and mahseer in Meheo, Shalley, Mechukl, Sinang, Pegu, Gamin, Yungar, and Azore etc.

Reservoir Resources

The reservoir owing to damming the Ranganadi in lower Subansiri district and having an area of 15 ha has been handed over to Fisheries Department for fisheries development. About 8 reservoirs are coming up under hydroelectric power generation programme.

Tanks and ponds

In 13 districts of the state the big tanks created under mini hydel project are available. The places are China bridge, Keratang, Assam hill, Lower Gompa (Twang), Rupa (West Kemang), Tribin (West Siang), Mai and Togo (Lower Subansiri district). These tanks can be used for fish production. More than 1300 ponds having about 2200 ha area are available and are being used for fish culture under various scheme of Fisheries Department. The fish production in these ponds is around 1000 kg/ha/yr, which can be enhanced easily to 3-4 thousand kg/ha/yr; Seed availability of major Indian, Chinese carp and Mahseer is a great constraint.

Other Resources

The Rice wetlands are important resources in the state. A large area in Attapani plateau in Zero District is being cultivated under paddy cum fish culture. The fish production in these fields is low and scientific intervention is required to enhance the productivity. About 845 ha area is available for paddy cum fish culture in the district. More rice wetlands in existing or other districts having similar climate and soil can be created under the programme of paddy cum fish culture. About 863 ha area is having great potential fish cum rice growing. If we take into account the water quality and primary productivity of these fields and compare with present average production of fish (215-290 kg/ha), there is urgent need to improve the present rice fish culture practices. It can be achieved by stocking bigger size (3-4") of fingerlings at appropriate density of fish (0.5-1.5 fish/m^2) and creating proper size trenches in the field for sheltering the fish. Of course, nutrient and natural fish food available have to be taken into account to decide the practices of organic fertilizers and supplementary feed. There are possibilities to enhance the productivity to 3-4 times.

Fish Biodiversity

The status of fish species in the drainage system of the state indicates high diversity in number due to diverse climate and topography of the aquatic habitat. In all 137 fish species both food and ornamental value have been recorded. The important fish species are *T putitora T. progenies, Tor tor Neolissochilus hexagonolepis, N. hexastichus, Schizothorax richardsoni, Schizothoraichthys progastus, Labeo dyocheilus, Barils spp., Puntius spp, Garra spp, Gyloprothorax spp.* etc. Among the streams, the Deopani stream was reported having abundant stock of Katli. Shelly, a closed lake having an area of 2.0 ha and famous for mahseer angling exhibit good stock of Katli and major Indian and Chinese Carps and minor carps. The introduced IMC and Chinese carps figure well in catch. Good spawners of Katli in wild are available and breeds there.

Coldwater fishery in the State

The concept for established coldwater fish farming had come up from the year 1967 – 68 in the state for the replenishment of the local resources, which was mostly devoid of local fish with the exotic trout species. The favorable water temperature ranging from below freezing point to as high as 20°C led to the establishment of 1st Trout Hatchery along the stream of Nuranang at an altitude of about 12000 ft. in Tawang district with the Brown trout seed imported from Jammu & Kashmir. Subsequently, the encouraging results of trout farming could be further disseminated by way of establishment of another trout Hatchery at Shergaon, West Kameng district located at an elevation of 8000 ft. for culture of both Brown & Rainbow Trout.

Fish production in this largest state of the region increased from 50t in 1979-80 to 2,395t in 1999-2000. Despite such impressive growth rate, the current production can fulfill only 20% of the requirements of fish. The state with low temperature regime has pond productivity of 600 kg/ha/yr, which can be increased up to 2,500 kg/ha or more through intensive farming system.

Directorate of Coldwater Fisheries Research, Bhimtal is engaged in coldwater fisheries resources assessment and development of the state in collaboration with Rajeev Gandhi University, Ronohills, Itanagar and Department of Fisheries, Govt. of Arunachal Pradesh, KVK, West Kameng distrct and Tirap district. The Directorate is engaged in collaboration with the above mentioned organisation in demonstration of modern fish farming system in Ziro, W. Siang and Papumpare districts. Fish production enhancement through paddy cum fish culture in Ziro district, culture, breeding and seed production of Chocolate Mahseer (N. hexagonolepis) in pond environment at Roing in Dibang Valley, up gradation of trout stock, culture and breeding and on and off campus training programme for fisheries personals and farmers of Arunachal has been carried out successfully. Many other research based developmental programme are in line subject to more men power, funds, collaborative program.

Trout farming in earthen raceways

The Directorate of Coldwater Fisheries Research, Bhimtal has initiated a project on "Sustainable Utilization of Mountain Fishery Resources (partnership mode)" with five states (Arunachal Pradesh, Sikkim, Jammu &

Kashmir, Himachal Pradesh and Uttarakhand) under the leadership of Director, D.C.F.R. as a National Co-ordinator of the project.

In Arunachal Pradesh, modification of existing trout hatchery and rearing of trout at Shergaon trout farm has been taken as one of the import ant activity. Breeding and rearing of trout has been carried out during November – January 2008-2009 successfully. 15,000 seeds were produced in the farm. Hatchery produced seeds were reared in the farm and also stocked in Nurananag stream, a high altitudinal stream of Arunachal Pradesh. The trout seed stocked will certainly attract the anglers which intern will increase the economy of the local people. It may be worth mentioning that the area is situated near to Tawang, which attract lot of tourists every year and there is a great potential to develop fish based eco-tourism in these selected water bodies of Arunachal Pradesh.

To improve the quality of the stock of Rainbow trout, 10,000 nos. of rainbow trout eyed ova were transported from Jammu and Kashmir to Arunachal Pradesh and reared at Shergaon trout farm. The survival percentage of hatching and rearing was quite good under the agro climatic conditions of the farm.

The unique feature of Shergaon trout farm is that rearing of trout from fry to fingerling stage is carried out in earthen ponds constructed maintaining the slopes. The water inlet and outlets were designed in a conventional way with the help of split bamboo/wood to cut down the establishment cost. The hatchery complex, designed economically and eco-friendly is very much suitable to be adopted by the local entrepreneurs and farmers to make trout farming popular in hilly areas and thereby to increase the trout production.

Coldwater fisheries in India

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Coldwater Resources

The water resources above 914 m above sea level are generally known as coldwater whose temperature ranges from 9-25°C.The approximate area holding cold water fisheries in India includes 10000 km streams/ rivers, 20000 ha natural lakes, 50000 ha reservoirs and 2500 ha brackish water lakes and impoundment (Sunder and Joshi, 2002). The Himalayas and Siwalik mountains in the north are traversed by the Indus, Ganga, Brahmaputra and their numerous tributaries. Nineteen major rivers drain the Himalayas of which the Indus and Brahmputra are the largest each having a mountain catchments of about 160000 Km^2. Among the rest of seventeen, five rivers belong to the Indus system (Jhelum, Beas, Sutluj, Chinab, and Ravi) of which Beas and Sutluj have a total catchments area of about 80000 Km, nine to the Ganga system (Ganga, Yamuna, Ramganga, Sarda, Karnali, Koshi, Rapti, Gandak and Bagmati) belong draining nearly 150000 Km^2 and three (Tista, Raidak and Manas) belong to Brahamputra system draining another 110000 Km^2 (Sehgal 1999). The Sahyadri, Nilgri, Annamalai and Cardmom hills in the Western Ghats also harbour many tributaries of the Krishna and Kavery rivers. Important upland lakes are Wular and Dal in Kashmir; Nainital, Sattal, Bhimtal, Naukuchiatal in Uttarakhand; Ooty and Kodai lakes in Western Ghats. In addition, the Gobind Sagar and Pong are other important lakes in Himalayas. Apart from these a number of dams and barrages are under construction in Jammu and Kashmir, Himachal Pradesh, Uttarakhand and North Eastern states. Such diverse aquatic resources harbor numerous Fish species.

Our country is rich in fish biodiversity (about 2118 finfish species) with different varieties/stocks within these species. Out of these coldwater fishes about 258 species comprises of 21 families and 76 genera. Amongst these 255 species are recorded from North East Himalayas, 203 from the West and Central Himalayas and 91 from the Deccan Plateau. As for as fishes of commercially importance are concerned, some coldwater species are known for sports, some other as food fishes and few for their potential ornamental value. In the Indian Himalayas the cultivation of fish contributes little to the overall freshwater fish production. Virtually every facility created for fish cultivation in the Indian Himalayas produces fish for stocking streams and lakes primarily to meet the requirements of sport fishing. Commercial fishery is only dependent to some extent on the stocking of lakes and reservoirs with fry and fingerlings. While for a number of years fish hatcheries in the Himalayas have been raising eyed-eggs, fry and fingerlings of brown and rainbow trout, and fry and fingerlings of common carp for stocking, only recently have some hatcheries started producing seed for stocking the indigenous mahseers Rainbow trout and Schizothoracines. To meet the ever-increasing demands of angling, subsistence and commercial fisheries, there has been a need for modernization of some hatcheries, because in

the past this neglect has resulted into the decline in seed production. The degradation of hatcheries took place especially where water quality deteriorated and the silt load in streams increased.

Indigenous Coldwater Fish Biodiversity

Today, the available technologies allow the culture of a number of exotic and indigenous coldwater fish species in the Indian Himalayas. The most common exotic species are rainbow trout, brown trout, common carp, while the indigenous fish are: mahseers (*Tor putitora and Tor tor),* and *schizothoracines (Schizothoraichthys esocinus, S. progastus, Schizothorax richardsonii, S. niger and S. curvifrons). Among these Tor putitora, S. progastus and S. richardsonii* are preferred because of their wide range of distribution in the Himalayas.

The Snow trout or mountain barbel (*Schizothorax richardsonii*) is widely distributed in the Indian Himalayas, from Ladakh in the northwest to Sadiya in the east. This species is an inhabitant of snow-melt and glacier-fed streams in the Greater and Lesser Himalayas. They undertake migration during winter months when the temperature in the Greater Himalayan waters reaches the near-freezing point. This induces them to migrate downstream and frequent the warmer spring-fed streams in search of suitable spawning grounds. The optimum temperature for spawning is 18-21.5°C.

The *Tor putitora* is one of the important sport fish in India need restoration and conservation. DCFR Bhimtal is actively engaged with commercial production and ranching of this species.

The distribution of rainbow trout worldwide shows its ability to adapt itself to a variety of aquatic environments, including aquaculture conditions. Rainbow trout can be propagated artificially, which is important for its production as food fish. The fish can be fed with artificial feed and withstand temperatures up to 26 °C for short periods. It also tolerates low dissolved oxygen content of water, is resistant to some fish diseases, and grows fast. In open waters, water temperature and precipitation are the primary factors affecting the survival and production of naturalized populations. The optimum thermal regime for the species lies in the range of 12-20 °C (Graham, 1949), and the annual precipitation and freshets are important.

Aquaculture

The aquaculture of coldwater fish in the Himalayas is limited, considering the total area of this region and the vast resources of water. At the end of the 1980s only 63 ha were under aquaculture in an area of 594,000 km2. Table fish production of coldwater species in fish farms is still on a very low level. The main constraints in developing commercial farms are lack of reliable data on cost-benefit, shortage of trained manpower, insufficient level of biological and engineering research, and shortage of credit.

Research in trout farming began in the late 1970s by the Central Government Research Centre under the Central Inland Fisheries Research Institute, Barrackpore. At the beginning the Centre was short of funds for developing the required infrastructure. This resulted in establishment of a separate National Research Centre on Coldwater Fisheries at Bhimtal, Nainital, under the Indian Council of Agricultural Research, Government of India which started work with Broad Thrust Areas

- Undertake exploratory research on coldwater fish biodiversity and preparation of Inventory

- Expansion of Rainbow Trout breeding and farming in potential coldwater area
- Development of new fish farming system suitable for mid altitude areas
- Identification of prospective areas in different states for developing Aqua-tourism

The DCFR is now working in partnership mode with the five hill states namely Arunachal Pradesh, Sikkim, Uttarakhand, Himachal Pradesh and Jammu & Kashmir with the mandate of

- To conduct basic, strategic and applied research in coldwater fisheries and aquaculture
- To develop stock management models and culture technologies for major coldwater fish species
- To create awareness and provide training and consultancy

The research efforts have already resulted in an increase in survival rates in trout hatcheries through improvement of water quality, disease prevention and development of compound dry feeds. The present priority areas are: stock improvement of brown and rainbow trouts through selective breeding, and trials of high-yielding strains of rainbow trout under Himalayan climatic conditions.

At the beginning of the 1990s farming of trout was being carried out on several fish farms in Kashmir, Himachal Pradesh, Uttar Pradesh, Arunachal Pradesh and Sikkim. At present a heavy load of silt reaches these farms from February to September. This is the result of soil erosion in their largely deforested catchments. Only from October to January is the silt load low. This has adversely affected the performance of these farms. Even some of the more recently established facilities such as the Sangla hatchery, the Norwegian-assisted trout hatchery at Katrain in Himachal Pradesh, and the hatcheries in Sikkim and Arunachal Pradesh still face the same difficulty. Natural spawning and the time for egg stripping of brown and rainbow trout is related to the changing of the photoperiod. In Kashmir farms the conventional diet of trout consists of raw fish which results in nutritional deficiency.

During the incubation period trout eggs and alevins are prone to several diseases, and if left uncared for, there are heavy losses in trout farms of the Himalayas. Good maintenance of broodstock on a nutritious but conventional diet, careful handling of fertilized eggs, prophylaxis against fungus by flushing hatching troughs/ trays with malachite green in a ratio of 1:2,000,000 for 30 minutes twice a week, providing enhanced water supply, 'thinning' of hatching trays at eyed and alevin stages, etc., have resulted in a 94% survival from green egg to swim-up fry, as against 30% in conventional practice. The wide application of the improved technology has resulted in achieving 80-90% success in several hatcheries in Kashmir, Himachal Pradesh and Uttar Pradesh.

Trout hatcheries in the Himalayan region are of moderate size, having the capacity to incubate 64,000-480,000 green eggs. After the swim-up fry emerge, they are fed initially on emulsified yolk of hen's egg followed by a mixture of yolk of hen's egg and bovine liver emulsion in 1:1 ratio. After having learnt the acceptance of initial artificial feeds, the fry are transferred to outdoor nurseries. In the northwest Himalayan farms the emergence of fry of brown and rainbow trout coincides with spring rains and hailstorms. The hailstorms may chill the already cold water to a low temperature, which may lead to high mortality of the young fry. In March-April the snow /glacier-melt fed water containing fine silt is also detrimental to the

survival of trout fry in trout farms. During the first three months the survival of fry fed on a diet of bovine liver and dry powdered silk-worm pupae, varies between 10.8-15.8%. Thus the principal factors responsible for fry losses are silt load, hailstorm-cooled water, diseases such as myxosporidiasis, octomiasis, ichthyophthiriasis, and nutritional deficiencies. Better quality feeds result in a survival from 50 to 61%, with maximum feed efficiency of 79.9% at 35% crude protein level (Sehgal *et al.*, 1976). Yearlings and 1+ age group are raised in growing ponds and raceways. Trout is fed there on a conventional diet consisting of local raw fish, mutton, slaughter house waste, dry silk-worm pupae, etc. The most serious loss of growing trout is due to nutritional imbalance and non-observance of prophylactic measures.

The availability of trout for sport fishery depends on the availability of a healthy stocking material of required size and quantity. This has to be produced in hatcheries. Some hatchery managers, in their effort to fulfil the quota, still prefer to stock young fry in the streams to avoid the high mortality rate in the hatchery, which would interfere with meeting the hatchery's annual targets. At present trout is considered to be a highly priced fish in the Himalayas. Considering the demand for table trout in this country, which is said to be nearly 800 tones annually for five-star hotels and restaurants in four metropolitan cities, improved aquaculture practices could go a long way towards alleviating the shortage. In the Himalayas a number of small rheocrene/limnocrene springs exist which could be used for the production of stocking material for the nearby streams. The development agencies should provide technical know-how, hatching troughs, eyed-eggs, etc. while rural youths could assist in such programmes, giving them a chance for employment. The fry raised under a barn house could be released into spring brooks, which would act as nursing ground for the main trout stream. DCFR Bhimtal is now striving hard to conduct work in following priority / thrust areas

- Evaluation of exact fishery resource base in hills on GIS platform
- Ecological characterization, biodiversity assessment & gear inventory in hill aquatic resources.
- Assessment of productive potential for conservation of mahseer and snow trout in openwaters.
- Ecological model for fishery management in hill wetlands.
- Fishermen inventory and their socio-economics in hill regions.
- Brood stock development, advance maturation and table production of indigenous species especially mahseer & snow-trout.
- Evaluation of cage culture in hill wetlands.
- Strengthening transfer of technology and human resource development in coldwater fisheries sector.
- Expansion of resource base for coldwater aquaculture with focus on rainbow trout and exotic carps.
- Developing fish farming package for mid & high altitude areas with organic inputs. Scientific development of Sport Fisheries (mahseer and brown trout) both indigenous and imported exotics.
- Biotechnology, Fish health & post harvest in upland regions.
- Impact of Climate change on high mountain ecology.

Aquatic resource challenges: Current scenario

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"Access to safe drinking water is essential to health, a basic human right and a component of effective policy for health protection." **- (World Health Organization)**

With the ground water levels reaching a critical state, the spotlight has moved towards the surface water sources as an alternate course to ease the crisis. Socioeconomic losses due to water contagion have been grossly underestimated in India, sometimes due to lack of adequate database or due to ignoring the variety of health issues completely. Thus, there is an urgent need to have specific data bank of ground water worldwide. The UNEP stipulates that a country is considered "water-stressed" if its water availability is between 1000 to 1700 cubic meters per person. Per capita average annual availability of fresh water has reduced from 5177 cubic meters in 1951 to 1869 cubic meters in 2001 and predicted fall of up to 1341 cubic meters in 2025. According to United Nations Environmental Program (UNEP) India will possibly be "water-stressed" in coming years. About 200 millions (an estimated 90%) of the country's water resources are polluted with untreated industrial and domestic wastes, pesticides, fertilizers and geogenic chemicals. In India, ground water is being used as raw water for 85% public water supply. According to the World Health Report (1998) water supply varies widely in terms of region and country. In India, maximum population inhabits in village and slum areas where there is no safe drinking water supply. So they are always prone to loss of their lives or cost a big toll to save themselves from the occurrence of different water-borne diseases. In India diarrhoel disease kills 6,000 children's every day apart from millions who are debilitated because of water born diseases which hinder their education and impair their ability to a decent livelihood in the future. Water contamination due to pathogenic agents, chemicals, heavy metals, pesticides, disinfectants and their by products as a consequence of industrial and agricultural activities, leaching from soil, rocks and soil, rocks and atmospheric deposition and other human activities has become a hazard to human health in several regions of the world. The microbial agents have been found commonly in drinking water are bacteria i.e. *Escherchia coli*, *Yersinia entercolitica*, *Vibrio cholerae*, *Salmonella typhoid* and different species of *Campylobacter*, protozoan's i.e. *Giardia intestinalis*, *Cryptosporidium* and *Entamoeba histolytica*, viruses i.e. *polio viruses*, *enteroviruses*, and *hepatitis viruses*. Various parasitic worms and their larvae i.e. *Drancunculus medinensis*, *ascaris*, *taenia*, and *ancylostoma* have been found to make drinking water unsafe. The chemicals commonly found in drinking water above the prescribed permissible limits are fluoride, nitrate, arsenic, cadmium, chromium, lead, mercury, manganese and iron producing serious problems to human health.

Several types of pesticides like atrazine, 2,4-dichlorophenoxyacetic acid, aroclor, DDT and carbofuran have been reported in drinking water causing nausea, vomiting, dizziness and diarrhea. Water disinfectant like

chlorine in excess amount also form a number of by-products like chloramines, chlorite, trihalomethanes, chloral hydrate, bromated and chloroacetic acid with harmful long term effects on human health. Excessive level of iodine on drinking water also causes undesirable alterations in homeostasis of endocrine function.

Experience has shown that microbial hazards continue to be the primary concern in the developing and even in some of the developed countries. In India, in urban and peri-urban areas, water quality is critically affected because of intermittent supply systems. Given the poorly maintained water distribution systems, with innumerable leaks and unauthorized connections, ingression of faecally contaminated water occurs, when the pressure drops the situation is serious in the urban, peri-urban and rural areas which is reflected in the high endemicity of faecal and oral infections and other water and sanitation related diseases and periodic epidemics of the same. Water quality, its impact on human health and the standards for public consumption are issues of vital importance. Both chemical and microbial standards are critically linked to the safety and acceptability of drinking water. Development of standards and their enforcement are linked to a number of social, epidemiological and techno-economic factors. Technical, economic and institutional issues related to the water quality surveillance and management need thorough review and evaluation for the development of a time bound strategy and action plan.

In recent years scientists are paying much attention towards mitigation of these contaminants by using natural materials/indigenous minerals for their removal at minimal expenses and without need of skilled personnel. In this connection, our group has developed a number of low-cost adsorbents which were derived from agricultural waste material that was suitable for the removal of different categories of pollutants as well as for the disinfection of microorganisms. Groundnut husk and Eucalyptus bark material waste are utilized in drinking water purification to mitigate carcinogenic chromium, lead and cadmium. Chemically modified groundnut husk carbon shows promising bacterial disinfectant in water reclamation process.

Copper-silver ionization is brought about by electrolysis. Based on this principle, our group has brought out 'Copper-Silver electrode' as better water disinfectant over a broad range of bacteria of water origin. By this technique, we are able to get clean water free from any form of bacteria. This method is energy efficient, time saving and easy in handling without need of sophisticated instrument and skilled personnel. Keeping in view of the pressing need for clean water, the technical features of Copper-Silver electrode make it popular among the water purification process.

Effect of climate change on high altitudinal fisheries

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Coldwater fish vaguely refers to fish species belonging to family Salmonidae, viz., brown trout (*Salmo trutta*), rainbow trout (*Salmo gairdneri*) and eastern brook trout (*Salvelinus fontinalis*) which are much sought after fish by anglers all over the world. In India fishes inhabiting streams, lakes and reservoirs receiving snow melt water directly from their watershed are also included. These fishes tolerate temperature at lower levels of thermal scale. This thermal range affects composition of biotal community in upland waters and also limits existence of fish and aquatic life. The fishes tolerate near freezing temperature and the upper level determined survival and distribution of species.

While stenothermal species tolerate a narrow range from freezing temperature to about 10°C, eurythermal species tolerate wider range of temperature, i.e., upto about 20°C. Trouts belong to the first category while snow trouts (*Schizothorax*), common carp (*Cyprinus carpio*) and barils (*Barilius*) belong to the later.

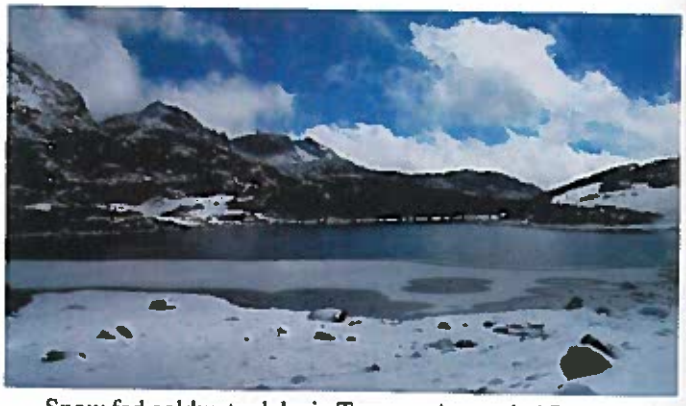
Coldwater Resources of India

Cold waters of India may be grouped into three.

Snow fed streams. These are found in the Greater Himalayas at about 1,470 m asl. These are in the form of streams which are small during winter and swell up and turbulent during summer.

Spring fed streams. These are found in the Lesser Himalayas at about 875-1,470 m asl. The streams are in the form of rapids and pools which maintain moderate throughout the year. The bottom are boulders and stones, covered with algae

Rain fed streams. These are found in the Siwaliks and Northeast India other than Brahmaputra basin and the Deccan. The streams are with great volume of water during monsoon, but most of them become lean or dried up during winter. The bottom is constituted by algae covered boulders and cobbles.



Snow fed coldwater lake in Tawang, Arunachal Pradesh

Coldwater Fishes of India

Trouts of the family Salmonidae, viz., *Salmo trutta fario*, *Oncorhynchus mykiss* etc. are introduced in many parts of the Himalayan region for coldwater fisheries. ***Lesser barils***, belonging to subfamily Rasborinae

(Family Cyprinidae) constitute major coldwater fishery in coldwater streams. The species are: *Barilius barila, B. bendelisis, B. vagra, B. dogarsinghi* etc.

The ***Indian trout*** include *Raiamas bola, R. guttatus,* which grow to comparatively larger than lesser barils. ***Carp minnows*** having both food and ornamental values are the zebra fishes: *Danio* and *Devario* species. ***Mahseers*** constitute major food fisheries. The species are: *Neolissochilus hexagonolepis* in Ganga-Brahmaputra basin and *N. stracheyi* in Chindwin basin. *Tor tor, T. putitora. T. mosal* are the delicacies of upland waters. ***Snow trouts*** of the family Schizothoracinae are restricted to coldwater torrents and greatly constitute to coldwater fisheries in the Himalayan subregions.

Other carps of value are *Bangana dero, Semiplotus* species, *Crossocheilus, Garra, Nemacheilines, Balitora* etc.

Cyprinus carpio

Barilius barila

Barilius dogarsinghi

Raiamas bola

Devario aequipinnatus

Schistura kangjupkhulensis

Schizothorax richardsonii

Tor putitora

Climate Change

The term 'climate change' commonly refers to influences on climate resulting from anthropogenic activities. Increases in the concentration of so-called greenhouse gases in the atmosphere resulting largely from burning of fossil fuels and deforestation, have led to an observed and projected warming of the earth, known as the 'enhanced greenhouse effect'.

The gases that contribute directly to the enhanced greenhouse effect are carbon dioxide, methane and

nitrous oxide emitted from combustion of fossil fuels, deforestation and agriculture, and sulphur hexafluoride, perfluorocarbons and hydrofluorocarbons arising from industrial processes. It is these six gases that are controlled under the UN Framework Convention on Climate Change. Some other gases, including carbon monoxide, nitrogen oxides and volatile organic compounds, contribute indirectly to global warming through chemical reactions in the atmosphere. Other emissions, such as sulfate aerosols have a cooling or dimming effect on the climate as they reflect some of the short-wave radiation before it reaches the earth's surface.

The concentration of carbon dioxide in the atmosphere in 2005 was 379 ppm, and is rising at 1.9 ppm per year (1995-2005 average). The increase in concentration of greenhouse gases in the atmosphere has altered the earth's radiative balance, resulting in more of the sun's heat being absorbed and trapped inside the earth's atmosphere, producing global warming. Unless mitigation measures are taken up, the concentration of carbon dioxide in the atmosphere is predicted to rise to at least 650-1200 ppm by 2100. As the concentration of CO_2 in the atmosphere is directly relatd to its temperature, it is expected that average global temperature may rise upto 6°C by the end of the century. To avert catastrophic impact it is desirable to restrict the atmospheric CO_2 concentration to 550 ppm, which may limit the temperature increase to 2°C.

The IPCC's (Intergovernmental Panel on Climate Change) 2007 report incorporating input from more than 450 lead authors, 800 contributing authors and 2500 scientific expert reviewers emphatically states dire picture of wildlife if steps are nor taken to protect species from global warming. Increasing temperature and associated climate change directly affect wildlife habitat.

Impact on aquatic system

The impacts affecting aquatic systems and fisheries, especially in estuarine and marine areas, are rising sea level, increasing acidity of marine waters, increasing global temperature, and changing rainfall patterns. Increased river temperatures will change species distributions (food web dynamics), as poikilothermic fish and invertebrates attempt to behaviourally thermo-regulate by migrating to cooler water in geographically constrained rivers and lakes. Metabolic rates increase with the consequent need for more food to support this higher metabolism.

Impact on coldwater fisheries

Coldwater fish are very sensitive to changes in water temperature and other environmental conditions. They are important ecological indicators for climate change. Native coldwater fish form a core part of our culture and identity of the country's legacy. Anglers make significant contribution to the local and state economy in pursuit of their passion.

In the face of changing climate condition, it is important to assess the potential impacts to coldwater fish and fisheries and implement adaptive management plans to ameliorate climate change impact on coldwater streams and inland lakes and their fisheries.

In freshwater systems water temperature stress will be most marked for stenothermal freshwater

invertebrates and fish. This will especially impact the higher altitude and very economically valuable freshwater recreational fisheries, which are based on capture of introduced trout species

Temperature and Water Quantity

The body temperature of a fish is essentially equal to the temperature of the water where it lives. Each species exhibits a characteristic preferred temperature. As the temperature rises to the preferred temperature from below, rates of food consumption, metabolism, and growth rise slowly. But the activities drop after it is exceeded until reaching zero at the lethal temperature.

The fishes respond strongly to natural variations in climate that involve changes in water volume, water flow, and water temperatures. Responses to such environmental changes fall into two broad categories: 1. changes in fish distributions, including shifts in the large-scale centers and boundaries of individual species and species groups, and shifts in the distributions of individual population members at local scales, and 2. changes in the overall production of the entire fish community in a particular region and changes in the relative productivity of individual populations within a community.

Individual fish actively select and rapidly change living areas based on suitable temperatures, oxygen concentrations, and food availability. Cold-water fish will actively avoid temperatures that exceed their preferred temperature by 2 to 5°C. They try to find refuge areas of cooler water such as groundwater or seepage areas and headwater streams. Boundaries of the zoogeographic range of species are determined in part by the interaction of thermal tolerance and behaviour of the fish with local climate. The potential effects of climate warming on such boundaries include expansion, contraction, or shift of species ranges. For freshwater fish, physical constraints such as drainage patterns, waterfalls, and land-locked areas play a large role in determining the location of zoogeographic boundaries, and in the rate at which a species may respond to the release of a climate-determined boundary.

Warming will have greater effects on streams and small inland lakes than on large, stratified lakes, because the large lakes usually have refuges of deep, cold, oxygenated waters below the surface layer for cold-water fishes. Upland streams, currently permanent ponds, and lakes are more likely to become wetlands, dry lands, or intermittent waters than lower main-stem rivers and drainage lakes. Lakes with associated wetlands will likely have a decrease in dissolved organic carbon inputs while those without such wetlands will see little change. In addition to the rural and urban development patterns, the glacial history of an area will also mediate hydrologic responses to changing climatic conditions, where groundwater-dominated areas will respond more slowly than those areas fed solely by surface waters.

In America, climate change will disturb distribution of freshwater species, It is likely to shift northward, with some extinctions of local species likely throughout the southern ranges of these species and expansion in their northern ranges. Warmer freshwater temperatures and changes in the pattern of flows in spawning rivers could reduce the abundance of species like salmon, trout, and bass. An 8°F increase in mean annual air temperature would eliminate more than 50 percent of the habitat of brook trout in the southern Appalachian

Mountains. In addition, projected changes in water temperatures, salinity, and currents could affect the growth, survival, reproduction, and distribution of marine fish species and their competitors and predators.

The loss of fishing opportunities due to climate induced changes in fisheries could be severe in some parts of the country, especially at the southern boundaries of the habitat ranges of cool- and cold-water species. Cold water fish habitats could be lost entirely in such states as Maine, Massachusetts, Connecticut, Ohio, and Nebraska. Presently, more than 750,000 people fish for trout in those states each year. This loss would make those people engaged in fishing jobless and have to switch to other profession.

Situation in India will be worse. Habitat already in danger due to various anthropogenic activities: human inhabitation, abstraction of water for human use and agriculture and construction of dams for irrigation and power generation would face more severe problems.

How to save Coldwater Fish?

The only way is to help reduce greenhouse gas. Cut emission of carbon dioxide and other heat trapping gases. Use fuel efficient (or non-motorized) mode of transportation and use energy efficient devised appliances.

Secondly, we have to protect fish habitat. Reduce threat – dams, deforestation, urban sprawl, pollution, chemical pesticides, fertilizers (which ultimately flows into streams & lakes). Volunteer clean local waterways, observe fishing regulations and protect wild stock.

Promotion of aquaculture through carp seeds production under mid altitude condition in Meghalaya

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The state of Meghalaya is rich in natural water resources in the form of rivers, lakes, reservoirs, bheels, pond and tanks for fisheries development. However, these resources are not tapped fully for fisheries and aquaculture development although a great potential exists. The district council or local bodies control some of these water bodies and thus a good coordination between the parent department (Fisheries) and local bodies or other govt. departments is required to utilize these water bodies for fish production.

Table.1. The fishery resources of the state of Meghalaya (Approx)

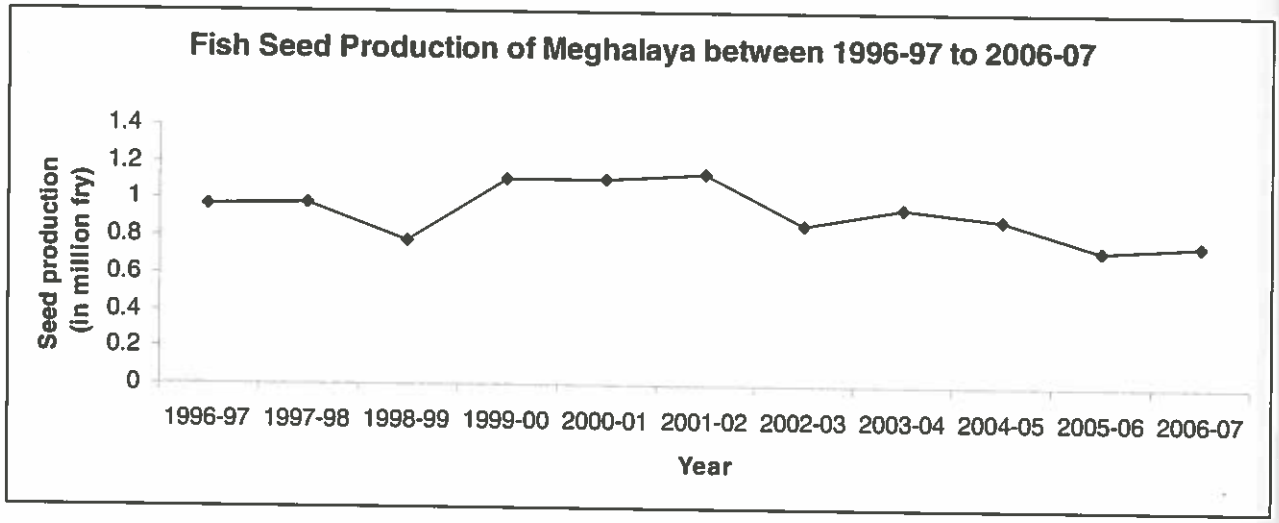
Sl.no.	Water bodies	Area /Length(Ha/ KM)
1.	Rivers & Streams	3329 km.(Approx)
2.	Reservoir	8489 ha .(Approx)
3.	Lakes	41 ha .(Approx)
4.	Bheels	358 ha .(Approx)
5.	Swamps & Low lying area	25 ha .(Approx)
6.	Ponds & Tanks	2500 ha .(Approx)

The state of Meghalaya with 22,429 sq.km area has two drainage systems namely Brahmaputra in the north and Barak in the south. Important rivers of Brahmaputra drainage are Umiam,Kopili, Myntang, Jingiram and Simsang, Kynshi,Umngot and Myntdu of Barak drainage. The state also has a few reservoirs namely Kydemkulai (80 ha), Nongmahir (70 ha), Umiam (500 ha) and Khandong falling in both Meghalaya & Assam(1335 ha).The state is known to harbour 165 fish species belonging to 85 genera under 31 families and 9 orders. Endemic fish species of the state are *Aborichthys garoensis* Hora, *Schistura elogatus* (Sen and Nalbant) and *Mesonemacheilus sijuensis* (Menon). Among the fish species of the state, 2 are reported to be critically endangered, 23 are endangered and 41 are vulnerable. The Umiam is the largest reservoir in Meghalaya, however there is no organized fishery in the reservoir. The common carp, *Cyprinus carpio* is the predominant species that is sustaining the fishery of reservoir, due to its cold-tolerant nature and propensity for auto stocking. *Neolissocheilus hexagonolepis* is an indigenous, cold water and threatened fish species, found in almost all the streams and rivers of Meghalaya. This is mainly a riverine species, also found in ponds, lakes, infact it is one of the main components of the fishery in Umiam, Kyrdemkulai and Nongmahir reservoirs.

Their growth is faster in the first 6 months period attaining an average size of 14 cms and thereafter gradually declines. Hence, it takes at least 3 years to reach to a size of 20-25 cm. It is highly esteemed by the anglers. Compared to last two decades, the catch per unit effort (CPUE) has drastically decreased.

The state of Meghalaya produces about 5000 MT annually against an annual requirement of about 11,000 MT. To meet the requirement, the state imports mostly the fresh water fish from neighbouring states , Assam, and Andhra Pradesh ,West Bengal etc.

Fish seed is the basic input for any fish culture operations. During the period 2005-06 the northeastern states produced the highest number of fish seeds amounting to 3970.76 million fry. Bulks of these seeds were produced by Assam followed by Tripura and Manipur. Contribution of Meghalaya is very little. However, in past 2-3 years, the fish seed production in the state of Meghalaya has improved significantly with establishment of carp hatcheries in the Govt. sector and at the ICAR Research complex, Barapani. During 2008-09, the state department reported a production of 1.13 million fry. Besides Indian major carps, other species cultured



in the poly culture system are Silver carp, Grass carp, Common carp, *Labeo bata, Labeo gonius, Puntius javanicus* etc. Among all the cultured species; Silver carp, Grass carp and Common carp are reported to perform better in composite culture system in the mid altitude conditions. The Fisheries division of the ICAR Research complex of NEH Region at Barapani , Meghalaya in past few years has been making a sincere effort to address the issue of seed availability in order to promote aquaculture for augmenting fish production in the region. The Fisheries division, ICAR RC-NEHR, Barapani which is located at about 900 meter above mean sea level(MSL) produced more than 1 million carp seeds of desirable size for stocking in various water bodies. Unlike the other states in the region, fish breeding season is relatively shorter due to low temperature regime. June –July months are found to be the best for undertaking fish breeding activities under the mid altitude condition. The seeds produced are distributed to the fish farmers at reasonable price fixed by the constituted committee of ICAR.

Scientific fish farming is slowly expanding to newer areas of Meghalaya with availability of required knowledge and fish seeds. Among all the districts of Meghalaya, Ribhoi is the best known district for fish culture activities as the temperature is relatively warmer. Since the Indian major carps do not perform very well in hill aquaculture, there is therefore need to find alternate candidate fish species which can grow well in shorter period of time. In this regard the ICAR at Barapani is making an effort to produce seeds of some of the indigenous minor carps and cold water fish species such as mahseer, labeo dero, semiplotus etc. for introducing in the culture system. Further, effort has also been made to introduce the genetically superior common carp variety in the culture system for augmenting overall fish production of the state.

Unfortunately, exotic species of undesirable varieties namely bighead carp (*Aristichthys nobilis*), Nile tilapia (*Oreochromis niloticus*) and African catfish (*C. gariepinus*) have already entered in the ecosystem of the region. These species were brought in by farmers and seed traders illegally and transplanted in the culture systems. Introduction of these species may cause serious threat on the indigenous species as well as on the legally introduced exotic carps. Further, there is possibility of hybrid fish production between Silver and bighead and, African catfish and Asian cat fish (*Clarias magur*). If such hybrid becomes fertile, it will cause serious effect on the cultivable and native fish species of the state.

Fishery resources in Uttarakhand State: Present status and possible management strategies

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The Uttarakhand state is spread over a geographical area of 53,204 km.^{2} in the altitudinal range between 198 m. to 7,816 msl in the Central Himalaya. Out of its total geographical area, 47,327 km^2 (88.9 %) area is under mountains. The state comprises four longitudinal physiographic sub-divisions: Trans Himalayan domain, Great Himalaya, Lesser Himalaya and Terai-Bhabar-Siwalik ranges. The highest mountain peak in the territory - Nanda Devi (7,816 m. from asl) is situated in the Trans Himalayan zone. The southern Terai belt (198 m. from asl) is located in the lowest altitudes in the state (Jalal 1988). The altitudinal and geographical variation, mountain slopes, expansion of river valleys and vegetation cover have given rise to varying climates in different parts of the state. The state is full of diversity in its geological, geographical, climatic, biotic and social features. The rich water resources are present in the form of mighty rivers, serpentine rivulets-streams, beautiful lakes and reservoirs. Many hill stations of the state are world famous for their pristine environment, beautiful landscapes, salubrious climate and mighty mahseers.

Water resources

The state is blessed with plenty of aquatic resources including lotic (rivers, rivulets, streams) and lentic waters (lakes, reservoirs). The region receives water from snowfall in higher peaks and rainfall in the lower altitudes. A number of glaciers are present in the state lying above 3,600 m. from asl. The important glaciers are Gangotri, Yamunotri, Pindari, Kafini, Sunderdhunga, Nakuri, Milam, Baldhunga, Poling, Balati etc. The major water resources of the state are:

The state harbours four major river systems- the Yamuna, the Ganga, the Kali and the Ramganga-Kosi systems. The total length of the major river systems in the state is estimated about 2,686 km. Many rivers in the state arise from glaciers so are snow-fed and perennial, where as a number of tributaries receives water from discharges of springs and seepage through faults, fractures, joints and permeable layers. Numerous rain-fed seasonal streams are also debauching into these river systems.

A number of natural lakes in the state also constitute valuable water reserve. The total water area under lacustrine systems is about 300 ha. The principal lakes in Uttarakhand are- Nainital, Bhimtal, Sattal, Naukuchiyatal, Khurpatal, Shyamlatal, Taragtal, Deoriatal. A number of lakes situated in the Greater Himalayan region like- Hemkund, Roopkund, Kagbhusandital, Kedartal, Sahastratal, Arwatal freezes during at least a part of the year.

A number of reservoirs have been constructed in the state under river-valley projects. The total area under reservoirs is 20,075 ha. The most of the reservoirs are located in Lesser Himalayan region. The main reservoirs are- Nanaksagar, Tumaria, Baigul, Kalagarh. Still some big reservoirs like Tehri, Dhauliganga, Maneri are under construction and some others- Pancheswar, Thuligad etc. are proposed for future construction.

Owing to the prevailing geological and edaphic factors, natural ponds do not exist in the mountain and Bhabar region of the state. So, only a few natural and manmade ponds are available for fish culture in the Terai region. In recent years a number of farmers have constructed different sized earthen and cement ponds at different elevations and brought under fish farming. The total area under ponds in the state is 628 ha.

Piscine diversity

The vast and varied water resources in the uplands of Uttarakhand harbours rich piscine diversity. The list of fishes comprises 83 species classified under 39 genera, 12 families and 3 orders. Out of these, 72 species are native, 8 exotic and 3 transplanted (Joshi, 2003a). As far as commercial importance is concern, 5 species are known for sports, 40 as food fishes and 8 for their potential ornamental value as detailed below:

Sport fishes

The important fishes in the state with good sport value are – golden mahseer (*Tor putitora*), deep-bodied mahseer (*Tor tor*), Indian trout (*Raiamas bola*) among indigenous species and rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta fario*) from exotics.

Food fishes

Besides the sport fishes, the piscine groups –snow trout, minor carp, carp, cat fish and eel are generally used as food fishes in the state. The important species among them are – snow trout (*Schizothorax richardsonii*), garra's (*Garra* sps.), minor carps (*Labeo* sps.), barils (*Barilius* sps.), exotic carps (*Ctenopharyngodon idellus, Hypophthalmichthys molitrix, Cyprinus carpio*), cat fishes (*Glyptothorax* sps. *Pseudechenesis* sps.) and eels (*Xenentodon cancila* , *Mastacembelus armatus*).

Ornamental fishes

Some very colourful and fascinating species are also inhabits in different aquatic resources of the state. Some of these have already recognized as ornamental fishes in other part of the country, where as a few other species also have suitable traits. These species are – *Puntius conchonius*, *P. gelius*, *P. ticto*, *P. sophore*, *Brachydanio rerio*, *Botia almorhae*, *Carassius carassius* and *C. auratus*.

As far as the cultured and cultivable species in the state are concern, the species could be classified as (Joshi, 2003a):

- Culture species: *Ctenopharyngodon idellus*, *Hypophthalmichthys molitrix*, *Cyprinus carpio*, *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala* and *Oncorhynchus mykiss*.

- Cultivable species: *Tor putitora*, *Tor tor*, *Tor chelynoides*, *Labeo dero*, *Labeo dyocheilus* and *Schizothorax richardsonii*. Due to slow growth rate these species are not used for culture in the region at present.

Causative factors for fishery depletion

The fishery resources of the state are under severe stress from habitat degradation, over exploitation and wanton destruction. The major factors responsible for the depletion could be attributed as below:

- There are innumerable causative factors responsible for destruction of the fish habitat. Some of these are -massive deforestation activities along the fragile mountains during the past to fulfill multifarious demand of the people, construction activities, grazing and browsing by domestic cattle herds, faulty farming practices, excessive drawal of river waters and damming of the rivers. All these anthropogenic activities facilitate the rate of soil erosion from the fragile mountain slopes.
- The resultant silt, cobbles and boulders from the mountain slopes find way to the adjoining streams, rivulets, rivers, lakes and reservoirs and causes shallowing of the systems and deteriorates the feeding and breeding grounds of the fishes. The sudden influx of the massive silt load in the stream or river waters after heavy rains, sometimes cause choking of the gill rackers, eye and head injury and mass mortality in the fishes. The heavy silt load coming from adjoining mountain peaks around Nainital lake have deposited a layer of about 6 m. on lake bottom in the last 5 decades. The excessive rate of soil erosion from the catchments has destructed the natural deep pools within the stream and rivers. The residue of the forest fire that is a common phenomenon during summer months further aggravates the problem. The fire burns the varied forest litter and also destroys the top soil layer. The first heavy shower wash away the inorganic matter along with the ash, eroded silt and debris into the nearby streams that ultimately reaches upto the river or lake and alters the physico-chemical characteristics of the natural waters and causes fish mortality.
- Commissioning of dams or barrages across the river under river valley projects abstracts the migratory route of the fishes like mahseer, snowtrout, bagarius and dero's. A barrage constructed in the river Sharda at Tanakpur have checked the upward migration of the bagarius and dero's as well as winter migratory route of the mahseer and snowtrouts. This could be a major factor towards depletion of the fishery in upstream waters. The massive newly constructed dams in the river Bhagirathi at Tehri and Chhirkila in the river Dhauli are posing serious threat to the migratory fishes. A number of small barrages constructed in many of the streams for irrigation purpose throughout the state are affecting the migratory run of mahseer and snowtrouts.
- The upland streams are highly prone to the human interference due to comparatively lesser and easily manageable water volume. The fishery resources particularly along the accessible stretches of the rivers and lakes are under severe stress from over exploitation. In most of the sites the people used to catch fish with the help of locally fabricated gears- cast nets, gill nets, mosquito net, traps, rod and lines. The

fishes are almost completely exterminated by the poacher from the smaller streams like Gandaki, during summer season, when water level is at its minimum level (Joshi, 2003b). The fishing pressure in most of the water bodies is at its peak during pre-monsoon and post-monsoon season (Joshi and Kapoor, 1994). The sizeable fraction of the resident fishes sheltering in the systems are completely destroyed when water level decreased to minimum and many of the mature fishes coming from the lower reaches for breeding in the upstream during monsoon and post-monsoon season are also killed. Such a phenomenon of high intensity fishing can be described as Malthusian Over fishing where brooders and juveniles have been virtually exterminated (Pauly, 1988).

- A number of highly destructive and illegal fish killing devices are also in vogue in the hill region of the state. Use of dynamite in the river pools, poisoning by extracts of some toxic local plants and bleaching powder and even electrocution in some river pockets causes mass scale destruction of the fishery resources. The complete sieving of a stream channel after diverting the main channel towards another side is also another fatal device.

Possible measures for fisheries development

There is immense potential for development of hill fisheries in the state. Hence, an integrated approach is urgently required for proper and sustainable development of the available diverse resources. The possible plan of action as suggested for the purpose is as below:

- **Horizontal and vertical expansion of fish culture activities:** A lot of sites are available in different parts of the state, which could be utilised for fish production through hill aquaculture. The most of the sites are lying along the banks of the rivers Ganga, the Yamuna, the Kali, the Kosi-Gaula river systems and their numerous tributaries. As per varied micro- climatic conditions of the state, such suitable patches of land/ water bodies should be identified throughout the state and be brought under any one of the three- pronged fish farming practices (Joshi, 1999a). The eco-climatic conditions of the foothills and river valleys located below 1000 m from asl are suitable for composite culture of Indian major carps and Chinese carps.A number of snow-fed rivers, rivulets and other lotic system in the region provide suitable water for trout culture and ranching. The most of the potential sites are situated above 1500 m from asl. With the objective to harness all the potential resources, the suitable areas in the state should be brought under trout culture. The rest of the sites spreaded throughout the state with suitable land and water could be utilised for Chinese carp culture (Joshi, 1999a).
- **Production enhancement in lentic systems:** The present level of fish production from the lakes and reservoirs in the state could be enhanced up to some extent by means of sustainable intensive culture practices i.e. rational stocking and harvesting, cage and pen culture based on autochthonous productivity of the water body.
- **Conservation and management of sport fishery:** The valuable sport fishes (especially the golden mahseer), available in the water bodies of the state are highly demanded among anglers throughout the

world. Therefore conservation and management of these species by means of habitat improvement, legal protection, *in-situ* conservation by creation of sanctuaries and national parks would provide better opportunities for tourism promotion. Further, as the whole ecosystems are being imperiled due to cumulative effects of the ongoing deleterious anthropogenic activities and over-exploitation, therefore a holistic ecosystem approach should be followed for better results instead of conservation of single important species.

- **Development of ornamental fishery**: Due to specific climato-geographic and edaphic conditions, the areas located in higher altitudes in most of the places are not suitable for construction of good size fishponds. However, such places could be utilized for culture of valuable ornamental fishes, in small sized ponds/tanks. Hence, collection, rearing and marketing of ornamental fishes (indigenous as well as exotic) could provide a lucrative profession to the progressive farmers, unemployed youths and others in the state.

- **Fishery-based eco-tourism:** Eco-tourism is a sustainable form of resource use, which contributes to environmental conservation, while providing accrued socio-economic benefits to the people through the non-consumptive uses and indirect values of the natural biological resources. Considering the vulnerable nature of our environment eco-tourism based on optimum multiple uses of the resources on sustainable basis must be encouraged. Fishery based eco-tourism is emerging potential area for employment generation. Valuable mahseer, rare Indian trout and exotic sport fishes available in coldwater regions are highly demanded among the anglers. Angling, or recreational fishing, is one of the most popular outdoor activities throughout the world. The revenues from fishing licenses support fish and wildlife management agencies at all levels of government, and the expenditures from recreational fishing contribute to local and regional economies, especially in regions where fisheries have been preserved in pristine or near-pristine conditions. The state of Uttarakhand is also a favorite destination for tourist's throughout the globe. The important angling sites in the state are Ashiganga, Birehi, Pinder, Bhagirathi, Yamuna between Tajwala (Haryana) to Dhak Pathar, Ganga between Rishikesh to Tehri and its tributaries, the Kali, Saryu, East & Western Ramganga, East & Western Nayar, Song and Kosi rivers. The lakes of Kumoun (Bhimtal, Khurpatal, Naukuchiatal, Nal Damyantital and Sattal) are also contributes substantially to mahseer fishery and provide ample scope for fish sport.

- Besides natural water bodies, the suitable ponds available along the picturesque valleys, mountains or riverbanks in the region could also be utilized for development of mahseer or trout based sport fishery units with development of infra-structural facilities like parking, restaurants, hotels, transport and the quality could be augmented with development of aqua-sports. Presently a progressive farmer in Pithoragarh district of Uttarakhand has developed an excellent exotic carp based sport fishery enterprise with integration of boating and swimming facilities. There is further scope for development of such sport fishery enterprises in the region. The farmers have converted their fish farms into a multi-dimensional venture with beautification of the landscape and addition of infrastructure like restaurant, boating and

angling facilities, besides the routine annual fish production. As a result a source of small-scale one time little earning has been transformed to an enterprise with round the year livelihood earner for the owners. Now such enterprises are emerging as a good source of income not only for its owner, but also to some workers engaged in the enterprise. There is further scope to enhance the income significantly through addition of aqua sports, trekking, mountaineering in the endeavor.

- **Fish watching:** Like bird watching, fish watching also has scope for its expansion. Moving shoals of different size, colour and shaped fishes always provide joy to the visitors particularly to children. Many of the religiously protected water bodies in the river stretch of Ganga at Haridwar and Rishikesh, Gomati river at Baijnath, Nal Damayanti tal are some examples of fish watching spots, which attracts thousands of tourists. Similar spots need be developed near tourist sites for visiting tourists.

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Present status of mahseer fisheries in certain habitats of Assam and Meghalaya

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Introduction

The North Eastern states of India are bestowed with untapped potential for both cold water & plain water fish and fisheries which make it a potential hub of economic growth of the country to a competent level. North East (N.E.) region shares its fish fauna predominantly with that of the Indo-Gangetic fauna and to a small extent with the Burmese and South-China fish fauna (Yadav and Chandra, 1994). The upland aquatic habitats of N. E. regions have also ample Mahseer fisheries potential in terms of capture fisheries and development of ecotourism and sports fisheries for uplifting socio-economic condition of local fishers.

Over the centuries, the fish genetic diversity of the N. E. region (both Cold water and Plain water varieties) has adjusted to the elasticity of the aquatic environment. The seasonal expansion and contraction of uplands waters through rain and floodwater ingress and egress via numerous natural channels, form the basis for reproduction, growth and stability of Mahseers fish population. Unfortunately, ill - conceived human interventions which have overlooked the importance of fisheries, have jeopardized the complex fisheries, altered and degraded fish habitats, and impeded natural recruitment of fish, resulting in loss of fish yield and biodiversity. In turn, this has negatively affected the nutrition and livelihood of millions people. On the other hand, upland aquatic resources and habitats are always considered as sensitive zone subjected to be threatened by climate change, deforestation, agricultural land use, pollution, channel modifications, inter-basin transfers of water and modified flow regimes, loss of habitat and habitat connectivity, introduction of exotic and predatory fish species and fishing pressure. Assam, the second largest province of N.E. India is a global hotspot for fish faunal diversity not only for plain water fisheries but also for cold water fisheries.

The Mahseer is a cultural icon of diverse economic, recreational and conservational values not only for other River System but also for Rivers of Assam. The Mahseer is an integral component of the aquatic ecosystem and an important indicator of its health. Two species of Mahseer *i.e.* Golden Mahseer (*Tor putitora)* and Deep bodied Mahseer (*Tor tor*) have been reported from Assam and other states of the Region.

The prominent Mahseer Habitats are available in the following water resources of Assam and its neighbouring State Meghalaya:

- The Manas & Jia Bharali (snow fed) River of Assam originated from Himalaya
- Three Rivers (Jatinga, Diyung & Kopili) of Dima Hasao District of Assam which are originated from Barail range. All the Rivers are Rain fed in Nature.
- Simsang Rivers of Garohills, Meghalaya (Rain Fed) originated from Nokrek Biosphere Reserve.
- Jinari Rivers of Goalpara district, Assam originated from Nokrek Biosphere reserve also cherished with Mahseer fisheries.

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A survey has been conducted since 2008, in all the above mentioned habitat of Mahseer (except River Jia Bharali) to throw some light on its present status. From the survey it has been reveals that the population diversity of Mahseer fisheries much more peculiar. In the present paper, effort has been made to highlight present status of Mahseer fisheries in the said water resources for sustainable management and conservation of the fishes. It is also worth mentioning here that this is a pioneering attempt to focus these water resources for the said species.

1. Mahseer fisheries in Manas River system:

The River Manas, drains about 18,300 sq. km in eastern Bhutan, rising beyond the Great Himalayan range. It enters Bhutan from the Kameng frontier district of India and runs southwest; again it enters India via Manas National Park. Prior to the entry of Manas National Park, the river bifurcated at Mothonguri to form a tributary named Beki. There are also number of tributaries of the Manas River namely, Sankosh, Saralbangha, Hel, Tanali, Gourang, Sidli (Bhor) Aai, Puthimari, Kaladia, Tihunala, Morapagaldia, Nona, Baralia, Pub-Bornodi and Dhansiri, flowing along the national park.

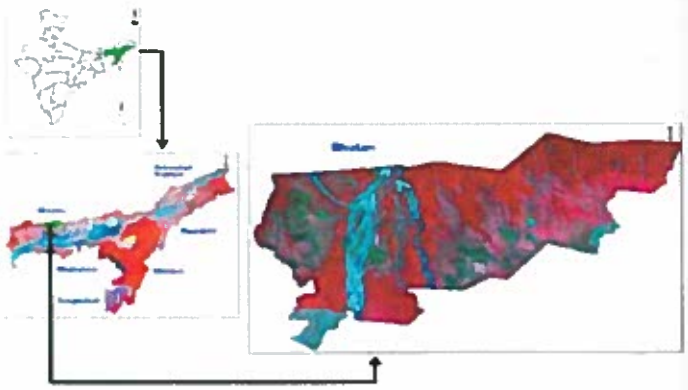

Fig: Map of Manas River system, Assam

Manas River and its tributaries are predominantly inhabited by cold-water fish species (Dubey, 1978) in general and Mahseer in particular forming major coldwater fisheries potential. Mahseer species in that area are locally called as *Gharua Roi* or *Gharua Rohu* attracted fishers in increasing rate due its high commercial value. It is noteworthy that, in April 2008, a *Tor tor* weighing about 36 kg has been recorded from the River System. **25** specimen of *Tor* species were collected from the River system.

Excessive fishing pressure couples with pollution and siltation are the main factors for the dwindling population of Mahseer population in the River System. As the River routed through famous Manas National park, hence there is a tremendous scope to develop sport fisheries and ecotourism for conservation of Mahseer's Microhabitat. Due to remoteness of the area as well as lack of awareness amongst the people, no strategies have been adopted to develop and maintain the sustainability of Mahseer populations of this river system.

2. Mahseer fisheries in Dima Hasao district of Assam:

The Dima Hasao district lies between 92°37' – 93°17' E longitudes and 23°30' – 25°47' N latitudes. The district is one of the twin Hill district of Assam with headquarter at Haflong. The district shares its boundaries with the states of Manipur, Nagaland and Meghalaya.

The district is blessed with many torrential Rivers, viz: The Jatinga River originated from Borail range and joining the Barak River in Cachar. The Diyung River is also originated from Barail range and joining the Kopili River in its downstream. The tributaries of the River Diyung are Moti & Langting River. These River harbours rich variety of Cold water Fishes along with *Tor* species. During survey period, 58 specimens of *Tor* species have been collected from Jatinga, Diyang and Kopili Rivers. Besides these, the sites are excellent for tourist for picnic and recreation. The indigenous techniques for catching of *Clupisoma garua* and *Tor species* in the said rivers are unique tale of the region.

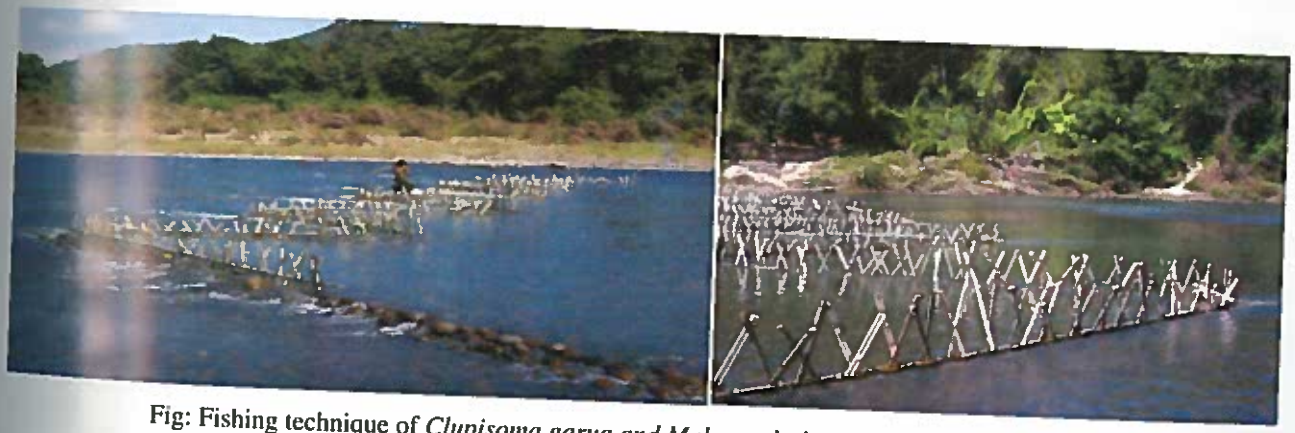

Fig: Fishing technique of *Clupisoma garua and Mahseer* during retreating monsoon in the Rivers of Dima Hasao, Assam

But due to absence of modernized socio-economic features and lack of employment as well as good infrastructure facility has compelled the poor people of this region to depend on fish faunal diversity for their livelihood generation. Instead of conserving the rich fish resources, the current process of development in resource use practices has led to depletion of the species at a non-renewable rate. Decline in population of endangered germ plasm of *Mahseer(Tor species)* is a matter of serious concerned. Hence, there is urgency in restoration of habitat of *Mahseer* population of these water bodies.

The fatal fishing techniques adopted by the local inhabitants through herbal poison, locally made Dynamite and pesticide including DDT are the serious concern in declining the population of endengered germ plasm of *Mahseer*(*Tor species*). However, few ITK (Indigenous Technological Knowledge) adopted in catching the fishes in the area surely be attract the interest of fishery technologist.

Fig: Locally made Dynamite using to catch fish.

3. Mahseer Fisheries in Simsang River.

The Simsang River is the longest river of the Garohills, Meghalaya. The river is also known as Someswari River at Bangladesh. It originates on Nokrek peak (Now declared as Nokrek Biosphere Reserve) located about 1412 m MSL. In Garohills of Meghalaya, the River flows between the altitudes of 1412m MSL (at Nokrek Biosphere Reserve) and 350 m MSL before entering into the plains of Bangladesh. The river has a winding course. The river as its passes along its courses springs up to beautiful waterfall of all shades, which has a unique tale of its origin.

The Rivers harbours a rich variety Cold water species along with plain varieties. Besides *Tor* species, the River is famous for **Electric Fish** (*Chaudhuria Khajurial*, Talwar Yazdani and Kundu, 1998) locally known as *Na-nil*. 32 specimen of *Tor* specimen collected from the River during survey period. Simsang River of Meghalaya is an important habitat for Coldwater fisheries that has witnessed severe damage due to Coal mining practices. Fishing through **herbal poison** is also one of the causes for depletion of fish diversity besides above mentioned factors.

Fig: Mass killing of Tor species through herbal poison during Community fishing

One villages of the area called **Rombagre** protected certain area of the River from fishing as well as other activities by declaring it as an ***Aquatic sanctuary***. It has been felt that certain measures are critically needed to revamp the conservation measures adopted by the said villagers for restoration of habitat of *Tor* species.

4. Mahseer Fisheries in Jinari River, Goalpara, Assam

Jinari River, a small tributary of River Brahmaputra originates on Nokrek peak (Now declared as Nokrek Biosphere Reserve) located about 1412 m MSL which lies 13 Km south-east of by two faults. Than it flow through certain areas of west Garohills and East Garohills and finally meets plains of Assam (at Goalpara District, in 47.06 m MSL). Before joining to River Brahmaputra at Goalpara, the River flows through a wetland (locally known as Beel) called Urpod Beel(included in Asian wetland Directory). During its journey from Nokrek Biosphere Reserve, several small rivers join it at various point of East and West Garohills. The species diversity of the River so much peculiar that its harbour both Cold water and plain water fishes. A total of 12 specimen of *Tor* species have been collected from various location of the River.

However, in recent years, the species abundance of Mahseer of the River has witnessed severe damage due to various activities like over fishing, pollution, poisoning etc. The physico-chemical parameters of the river system have reported rapid changes.

From the survey, it is felt that following are critical need for restoration of habitat of Mahseer population in the said habitats.

- Details morphometry of the said rivers to find out distribution of fish species, seasonal distribution, abundance and microhabitat along with the limnology and productivity of the river in correlation with the fish catch in a particular pocket of water body.
- To develop the prospectus of eco-tourism

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Upland aquaculture: Strategies for development in NE India

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Introduction

North Eastern Region (NER) of India is the most productive freshwater zone embracing diversified inland aqua resources with 1,43,740 ha wetlands and lakes, 19,150 km stretch of rivers, 23,792 ha reservoirs, 40,809 ha pond and Mini barrage and 2,780 ha paddy field (Sugunan, 2003). The region is politically divided into eight states with new inclusion of Sikkim, which is not included here in this paper due to deficiency of data. The whole region is a sheet of rich fish diversity representing 353 or more species, which include a host of precious ornamental fish species, coveted commercial food fish species and many other species of conservation interest. In spite of having very productive water condition, enormous rate of fish consumption and fishing tradition, aggregation of devoted scientist experts in the field of research and all institutions having fisheries curricula, aquaculture fails to grow in the region because of two reasons- **firstly,** not a single full fledged aquaculture centre is established in the region and **secondly,** aquatic biodiversity is very rich and human consumable aqua products are still available in its water habitat. However, it is the need of the hour to think that aquaculture development is inevitable to reduce the pressure on capture fisheries. Continuous exploitation of aquatic bio resources from all kind of aqua bodies becomes a self style trade among the dependents, which is encouraged by the consumers. Here the aquaculture development in the region may stand as a substitute of natural fisheries.

In the present scenario, the region is undoubtedly losing its piscine and non piscine products in its productive sheet of environment, which reflects in loss of species, reduction in density and biomass as well as endemicity in fish biodiversity status. Now the conservation of aqua resources through peoples' participation (in-situ) and through cultural programme in Live Gene Bank (ex-situ) is getting its momentum. To strengthen these conservation aspects a full-fledged aquaculture centre with its branch needs to develop in any north eastern state.

The present paper envisages some aspects of aquaculture need of the north- eastern states and conservation aspects through establishment conservation based habitat like live gene banks.

Water Resource Potential of North Eastern States

NE region represents variation of fish habitat resources from large rivers, tributaries, hillstreams, beels/ swamps/lakes (wetland) pond and mini barrage, paddy fields, which contribute to the fish germplasm diversity and productive potential of the region. The hill states are mostly dominated by rheophilic streams followed by

slow moving potamogenic courses and stagnant lakes/wetlands while the two valleys of Assam (Brahmaputra and Barak) are dominated by river and tributaries followed by flood plains (beels) and hill streams. The maximum water area is explored for fisheries in Assam (87.39%) and the minimum in Nagaland (7.91%) – Table-1.

Table-1 Water Resource Potential of North Eastern Sates showing explored and unexplored ratio

State	Water Resource Potential		Explored (%)	Unexplored(%)
	Lentic(ha)	Lotic(ha)		
Aruanachal Prdesh	7660	2000	43.4	56.6
Assam	177918	5050	87.39	12.61
Manipur	99750	2000	45.36	54.64
Meghalaya	16205	5600	57.94	42.06
Mizoram	3387	1700	57.48	42.52
Nagaland	34315	1600	7.91	92.09
Tripura	19900	1200	76.70	23.30
Total	359135	19150	---	---

Production-demand gap

Considering the present plight of the per capita availability of fish, the production scenario of fishes in the north east is still far a cry compared to the rest of the country. All N-E states are still running deficit, which register the availability of fish biomass at the rate of 2.80 kg (Arunachal) to 9.63 kg (Tripura) per capita availability (Table- 2) against the National Per Capita Consumption Rate (11.0 kg). The per capita availability spectrum explicit the situation as follows:

Tripura > Assam > Manipur > Mizoram > Nagaland > Arunachal > Meghalaya

Assuming 5% increase in population inj the current decade in all N-E states and trend of increase in fish production in certain states like Assam(15%), Tripura(10%) and the rest (5%) during 2001-2007, it is relevant

Table: 2 Requirement and production of fish in the North Eastern States:

States	Projected population	Requirement of Fish (t/yr)	Production (t/yr)	Per capita availability (kg)	Deficit (%)
Arunachal Pradesh	1145673	12602	2514	2.80	80.09
Assam	27970327	307674	161450	6.89	37.36
Manipur	2455566	27011	16281	6.63	39.07
Meghalaya	2421372	26635	4910	2.02	81.64
Mizoram	935611	10291	3034	3.24	70.54
Nagaland	2088086	22968	5250	2.51	77.18
Tripura	3350726	36858	32279	9.63	12.45
North East	40367343	44039	249935	6.12	44.29

to mention that per capita availability of fish in the states like Arunachal Pradesh, Nagalnd and Mizoram is highly deplorable while Tripura, Assam and Manipur register a marginal deficit with steady increase (Table-2).

Fish Fauna: The Pride of North East

The pride of North East fish fauna which may be considered as large growing groups represented by-6 species of Indian Major Carps, 7 species of catfishes, 1 species of feathereback, 4 species of murrels, 1 species of Indian shad, 5 species of large growing hill stream carps and three species of eel

Some of the species having intermediate sizes and high market quality are somehow maintaining their population despite increasing habitat shrinkage, human interference, and other environmental resistance.

Besides that all hill states like Meghalaya, Manipur, Mizoram, Nagaland, Sikkim and the hilly terrains of Assam and Tripura are the treasury of small hill stream species mostly having ornamental value, which are not cited here in the list.

List of some coveted fish species of north eastern states of India

Major Carps: *1. Labeo rohita, 2. Labeo calbasu, 3. Labeo gonius 4. Labeo nandina 5. Catla catla, 6. Cirrhinus mrigala*

Cat Fishes: *1. Silonia silodia 2. Wallago attu 3.Sperata aor 4.S. seenghala 5.Hemibagus enoda 6.Bagarius bagarius 7. Pungasius pungasius*

Murrels: 1.*Channa marulius, 2. C. striatus, 3. C. aurantimaculata, 4.C. barka.*

Featherback: 1.*Chitala chitala*

Eel: 1.*Monopterus cuchia 2.Anguilla bengalensis 3.M. alba 4.Mastacembellus armatus.*

India Shad: *Tenualosa ilisha*

Hill stream species: 1. *Tor tor, 2.T. putitopra 3.T. progenies 4.Labeo pungusia 5. L. diocheilus 5 .Neolissocheilus hexagonolepis*

Some other economic food species:

1.*Clarius batrachus, 2.Heteropneustes fossilis, 3.Labeo bata, 4.Chagunius chagunio, 5.Osteobrama belengari, 6.Puntius sarana, 7.Ailia coila, 8.Eutrochpichthys vacha, 9.E. murius, 10.Mystus cavasius, 11.M. bleekari, 12. M. vittatus, M. tangara 13. Ompok bimaculatus, 14. O. pabo, 15.O. pabda, 16.Gudusis chapra, 17. G. varieyata, 18. Anabus testudineus*

Development strategy

Relevant Aquaculture Programme of North Eastern States

Relevant to the aqua-zones of the north eastern states the value added products and avenues of aquaculture are identified and awaiting for overwhelming response of peoples' participation and flow of fund

1. Fin fish aquaculture: Food fishes
2. Ornamental fish culture and breeding
3. Freshwater prawns, crabs and mussels
4. Cultivation of ornamental plants, culture of biological fish feed, spirulina culture and cultivation of toxic plant
5. Hill stream fish aquaculture
6. Integrated farming with paddy and live stock

A swot analysis

Strength

1. Healthy fish habitat potential.
2. Coveted species of cultivable fish germplasm
3. Institutional guidance and skilled human resource
4. 90-95% fish eating population and high market demand of fish
5. Abundance of fast growing fish species

Weakness

1. Technology backwardness
2. No proper utilization of unemployed youth
3. Poor and slow development of aquaculture infrastructure
4. Unorganized planning and lack of united efforts for aquaculture development among the states
5. Negligence in integrated aquaculture
6. Inadequate utilization of non-piscine product mix in aquaculture
7. Poor management strategies
8. Non availability of nutritional fish feed ingredients in the region and non availability of fish feed preparation industries
9. Lack of follow up action of the worked out plan offered by various central organizations, local researchers and planners
10. Absence of grass root level research in the region on culture and breeding programmes of aquaculture
11. Poor understanding for linkages among the researchers of institution, institutes, Govt. departments, NGO's etc.

Opportunity

1. Institutional and institute guidance and help
2. Opportunity to receive Central Government and International fund
3. Project allocation from various agencies
4. Presence of vast cultivable water area
5. High diversity of ornamental fish species
6. Presence of fish breeding infra structure
7. Research on fish culture & breeding and fishery economy and aquaculture environment

Threat

1. Decline of fish population/increasing number of threatened and vulnerable fish species
2. Shrinkage of fish habitat
3. Ignorance of values of avenues of aquaculture by local population
4. Infrastructure bottlenecks
5. Failure of confidence building among the people of NER by the Central Government

Need of aquaculture components in the North East

- Construction of high standard scientific aquaculture farm in every state with regional emphasis.
- Application of aquaculture engineering to design regionally viable structure of aquaculture tanks, cages, raceways, pens, circulatory and re-circulatory ponds etc.
- Micro-laboratory facilities for water, soil analyses and disease monitoring
- Strong infrastructure for brood stock management and breeding components
- Fish genetic engineering research components for genetic up gradation of cultivable species of fish and other non piscine aquaculture products
- High quality fish feed production units to be established in every North Eastern state and to utilize locally available ingredients besides cultivation of plant products
- Cultivation plants for herbal toxin engaging unemployed youths
- Strong infra – structure development for non-piscine product mix
- Processing and packaging units for preparation of fish meal items in regional basis
- Creation of marketing network for edible item of fish / fish food by each state aiming surplus production within the NE states, within India and other countries.

- Establishment of cold storage and adequate industrial development for ice production, fish feed production and essential accessories for culture breeding and trade
- Training of aqua culturists

Table 3: Statewise opportunity of aquaculture

States	Aquaculture opportunity
ARUNACHAL PRADESH	Paddy cum fish & live-stock cum fish integrated farming, Mini-barrage, Ornamental fish culture and Culture of large growing hill stream carp and trout etc
ASSAM	Pond culture, Integrated farming (paddy cum fish, live-stock cum fish), Pen culture in beels and swamps, Cage culture in river & beels and Non-piscine culture
MANIPUR	Cage culture in reservoir, Mini-barrage, Pond culture, Ornamental fish culture and Integrated fish farming
MEGHALAYA	Cage culture in reservoir, Mini-barrage, Pond culture in flat lands, Integrated farming and Raceway culture
MIZORAM	Pond and Mini-barrage, Paddy cum fish and Prawn culture
NAGALAND	Paddy cum fish culture, Pond & Mini-barrage and Ornamental fish culture
TRIPURA	Pond culture, Cage & Pen culture in wetlands, Cage culture in river and reservoirs and Culture of prawn and other non-piscine product mix

Delineation

The culture based fisheries potential over capture fisheries can be increased in many folds to achieve a ratio of 4:1 in terms of production sharing 80:20 to reduce pressure on capture fisheries. In the present scenario all states are still dependent on fish production potential of capture water resources and in that, Assam registers the highest (from rivers and beels etc) followed by Manipur and Tripura. Again, considering the habitat diversity of fish in 19150 km of streams and rivers, 23792 ha reservoirs (besides 68760 ha for expansion), 179696 ha beels and swamps, 40,809 ha aquaculture ponds/mini barrage (besides 12286 ha for expansion) and 11544 ha paddy cum fish culture (besides 48910 ha for expansion) as depicted in Table-1, there has been enough scope to organize suitable aquaculture packages among all N-E states. Compared to the capture fisheries habitat (excluding 19150 km stretch of rivers) the existing aquaculture area so far available in the region is extremely meager (5.27%), i.e. in a ratio of 95:5 and it is far below (about 1.0%) when river fishery is taken into consideration. Development of aquaculture and application of its state based technologies in north eastern states will definitely help to increase production and to reduce the gap.

Certain possible Ecotourism sites in Fisheries Sector of Assam and Meghalaya

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Introduction

Sustainable fisheries development for strengthening nutritional as well as livelihood security of a major section of rural communities of India is the present day need, to confer on them lasting social and nutritional benefits. In our national economy, fishery sector plays a predominant role not only as a contributor to our food basket, but also act as a cheap source of animal protein support to rural health to the daily food supply.

The North Eastern states of India are also bestowed with untapped potential for both cold water & plain water fish and fisheries which make it a potential hub of economic growth of the country to a competent level.

The aquatic habitats of N. E. regions have also ample fisheries potential for development of ecotourism and sports fisheries for uplifting socio-economic condition of local fishers. Development of Ecotouirsm on the other hand includes negotiating and arranging for adequate environmental conditions and promoting physical improvements to enhance the support capacity of the environment for fish.

Eco-tourism is often viewed as alternative method for not only conventional form of tourism but it will act as alternative mode of conservation of dwindling inland fishery resources as well as also to increase employment opportunities in fisheries and aquatic resources.

The International Eco-tourism Society defines ecotourism as responsible travel to natural areas, which conserves the environment and improves the welfare of the local people. Hence, a cruising through a river is not eco-tourism unless that particular cruising somehow benefits the environment and the people who live there.

Development of ecotourism in marine sector are now become an established industries in the country like Japan, Australia, Malaysia even in certain region of India. Tourism sector in inland fisheries are already keeping momentum in the state like Tamilnadu & kerala. Cruising in the River Periyar, Kerela for Otter (semi aquatic mammal) and other aquatic fauna are keeping momentum day by day.

Ecotourism prospects (fishery resources) of Assam and in certain region of Maghalaya

The heterogeneous fish habitat of Assam and Meghalaya can easily be converted into ecotourism site

due to its faunal diversity, endemism as well as for spectacular and scenic beauty of the region. The habitats are also endowed with a rich avifauna and other aquatic fauna can possibly make it an attractive **holiday eco-tourism destination** for both foreign and domestic travelers. The mighty river Brahmaputra and Barak along with its myriad of tributaries, are harbours, large variety of fish fauna of both Indo-Gangetic and Indo-Malayan origin. Till today, 170 species of fishes have been reported from the Assam and 270 in N. E. region.

Over the centuries, the fish genetic diversity in N.E. region has adjusted to the elasticity of the aquatic environment. The seasonal expansion and contraction of floodplain waters through rain and flood water ingress and egress via numerous natural channels, form the basis for reproduction, growth and stability of riverine - floodplain fish populations. Unfortunately, ill - conceived human interventions which have overlooked the importance of open capture fisheries, have jeopardized the complex fisheries, altered and degraded fish habitats, and impeded natural recruitment of fish, resulting in loss of fish yield and biodiversity. In turn, this has negatively affected the nutrition and livelihood of millions of floodplain dwellers.

Therefore, the state's tourism agenda should revamp to promote ecologically sustained tourism in aquatic resources which focuses on the local culture, diversity and habitat of endemic fish, wilderness adventures, indigenous technological knowledge etc.

1. **Simsang River,** Garohills of **Meghalaya** is an important habitat for Coldwater fisheries has now witnessed severe damage due to Coal mining practices couple with Climate Change. Considering the importance of River Simsang River, (Besides *Tor* species, the River is famous for **Electric Fish** (*Chaudhuria Khajurial*) as well as depending upon dwindling fish diversity of the River, one villages of the area called **Rombagre** (35 km from Tura and behind Williamnagar -Tura Road) protected 1 km^2 of the River from fishing as well as other activities by declaring it as an **aquatic sanctuary** where schools of fish are found swimming in the clear waters, turning the place virtually into a tourist spot as many travelers are often found enjoying the fish in the protected water pool. Watching tower is also constructed for the tourists (*Sarma et al, 2009*). This noble venture can be called as **Role Model** for conserving dwindling fish diversity by rural people.
2. The picturesque river **Jia Bhoroli,** famous for eco-camp has already been established as tourist spot especially for anglers of Mahseers. Bhalukpung of the same River is also famous for angling and water sports.

Tourist watching fishes from watching tower at the bank of River Simsang, Garo Hills

3. The wetland of **Dibru-Chaikhowa national park** is the breeding ground of innumerable fish including endangered species, *Channa barca*. During retreating monsoon and winter, the scenario of the area can be termed as ***Amazon Valley***. Besides Elephant and Buffalo, the wetlands of the park also have tremendous potential to attract tourist as well as this laudable venture will also conserve the aquatic resources of the area.

4. The world Heritage site, the **Kaziranga National Park** harbours a rich variety aquatic fauna besides aquatic avifauna. The Park covers 24.32 km^2 as lentic and 6.8 km^2 as lotic environment. There are many places where the freshwater turtles can be seen basking on the fallen tree trunks and on the banks of the rivers. The Gangetic dolphin (*Platinista gangetica*) is also reported in the Dipholu River passes through the park. Besides Rhino, the Park can also declare as Aquatic sanctuary without any expenses.

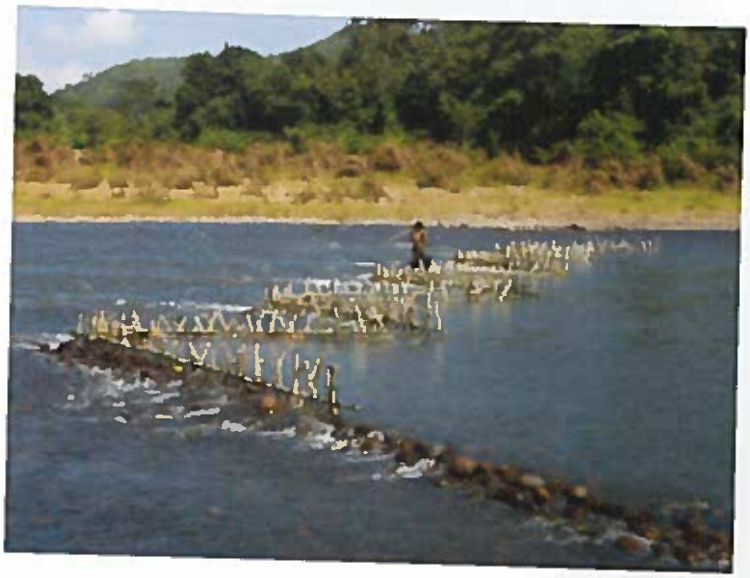
Migratory birds of Deepar Beel

5. The **River Manas** and its tributaries are predominantly inhabited by cold-water fish species forming major coldwater fisheries of the State. The Manas River flows through Manas National park, famous for the tiger project, also habitat for various wild animals and relatively undisturbed or uncontaminated natural areas. This site can also be converted into ecotourism sector with specific objective of studying, admiring and enjoying the scenery of coldwater species.

6. **Deepor beel**, the State's lone Ramsar Site and a wetland of immense significance which are already been declared as wildlife sanctuary has tremendous scope to convert ecotourism site for fish faunal diversity besides avifauna.

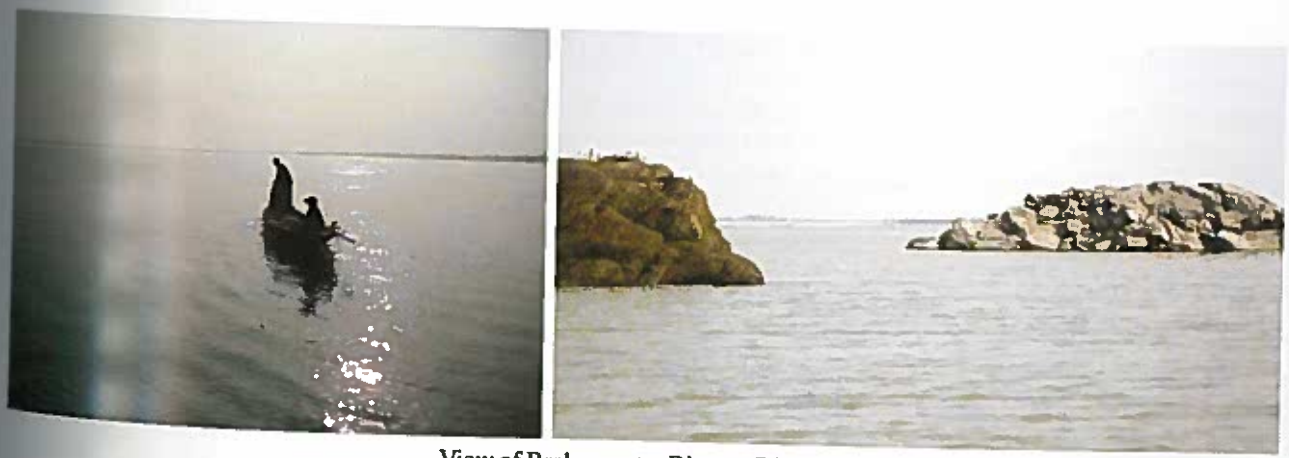
Katol set for pabo at Goronga Beel

7. The spectacular scenery of **Pobitora wild life sanctuary**, Morigaon, not only attracting tourist for terrestrial wildlife but also retain tremendous potential due its rich variety of Ichthyofauna. The Goronga beel of the sanctuary only possible site where the highly endangered species like *Puntius sarana* and *Ompok species* could be seen. Therefore, it is critical need to conserve the area by turning it into tourism site to save the species for posterity.



8. The **Dima Hasao** district of Assam where few hills station of the state are located with unsurpassed sylvan beauty. The cold water species (*Labeo dyocheilus dyocheilus Tor sp.* etc) of Jatinga, Dihangi & Diyung River of the district are also excellent site for tourist. The indigenous techniques for catching of *Clupisoma garua* and other species in the said rivers are unique tale of the region.

9. In **Brahmaputra River**, the diversity of fish is found to be more numerous in lower reaches up to Bangladesh. Besides, River Dolphin, the region also known to be as granary for the fishes of the family: Clupiidae, Bagriidae, Sisoriidae, Siluroide, Schilbeidae, Channidae etc. Few years back, a large size **Sting Ray** was captured in Brahmaputra River at Goalpara, The environment friendly **ITK** adopted by the local fishers (especially by the Bin Community) for *Clupisoma garua*(Sarma, *et al*, 2007), Giant River Prawn(*Macrobrachium. sp.*), *T. ilisha*, *Gudusia chapra etc* retain tremendous potential to attract tourist to the region. In addition to that, the numerous char area harbours a rich variety of



View of Brahmaputra River at Dhubri

migratory birds along with tremendous scope for various water sports; the visitors will also feel another *Bharatpur sanctuary* in Assam.

10. In Goalpara, the **River Jinari** (inlet of Urpod beel and originated from Nokrek Bioshere Reserve of Garo Hills) also harbours species like *Chaudhuria Khajurial*, *Sisor sp* (Sarma *et al.*2009) etc. along with several picnic spot in the bank may also be converted the River into ecotourism site.

View of Jinari river Sisor rhabdophorus & Chaudhuria Khajurial collected from the River

Therefore, it is critical need for restoration of habitat and to define the factors and process that maintain and manage the fisheries resources of the region as well as it is urgent need to developed and promoted certain water area of fisheries into tourist attractions for providing gainful employment avenues to thousands.

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Development of management strategies for mountain fisheries in India

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Introduction

On a global level, mountains are the world's largest repositories of biological diversity. Mountains cover about 24% of earth's landscape and home to at least 10% of world's population. They represent as much as 28% of world's forest areas sheltering about half of the world's biodiversity hotspots. The lakes and streams situated in the mountainous region are a source of freshwater for many of the riparian human communities residing in the hill, support many industries, provide water for storages for irrigation and hydropower electricity production and for fish. The long stretch of Himalayas of around 2500 km from west to east and 200-400 km from north to south comprising an area of 5,33,604 km^2 contains different types of coldwater resources mainly in the form of upland streams, rivers, high and low altitudinal lakes and reservoirs located in different hill states of India. Around 8,243 km long streams and rivers, 20,500 ha natural lakes, 50,000 ha of reservoirs both natural and manmade and 2500 ha brackish water lakes at high altitude inhabits large population of indigenous and exotic coldwater fish species in these mountain water bodies which have immense potential for aquaculture practices as well as capture fisheries to some extent. The mountain ecosystems are susceptible to accelerated soil erosion, landslides and rapid loss of habitat and genetic diversity. On the other side, there is widespread poverty among mountain inhabitants as about 80% of the people who live in these areas are impoverished. Due to burgeoning population coupled with habitat degradation most of the global mountain areas are experiencing environmental degradation. With the increasing realization that the natural resources of mountain areas are vital for the upland as well as lowland people, the global agenda for sustainable development has brought mountains to the sharp focus. Hence, proper management of mountain resources and socio-economic development of the people deserves immediate attention.

Indian Himalayan region

The Indian Himalayan region spreading between 21 ° 57' – 37 ° 5' N latitudes and 72 ° 40' – 97 ° 25' E longitudes with 250-300 km across stretches over 2,500 km from Jammu & Kashmir in the west to Arunachal Pradesh in the east. These mountainous region covering partially or fully twelve states of India, viz., Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya and hills of Assam & West Bengal. The region has a total geographical area of about 5,33,604 km^2 being inhabited by 3,96,28,311 people, representing about 16.2% of total area and 3.86% of total population of India, respectively. The region is vast, uneven and versatile inhabiting rich biological floral and

faunal diversity. These areas are broadly divided into eastern Himalaya, central Himalaya and western Himalaya, each of these having different physiography and faunal diversity. The broad classification of Indian Himalayan region is given in table 1.

Table 1. Major division of the Himalayan region

1. The Greater Himalayas (*Himadri*)	Longest and continuous, mostly north part of Nepal and parts of Sikkim. Average altitude of about 6100 m (20,000 ft) asl.
2. Lesser Himalayas (*Himanchal*)	In the south and north of Siwalik. Average altitude ranging from 3700m (12,000) - 4500m (15,000 ft) asl.
3. Siwalik (*Outer Himalaya*)	Siwalik is the lowest and narrowest section of Himalaya. Average altitude about 900m (3000ft) to 1200m (4000 feet) asl.
4. Trans-Himalayas	Stretches across Himalaya from West to East for about 1,000 km. Average altitude varies from 4500 to 6600 m asl.

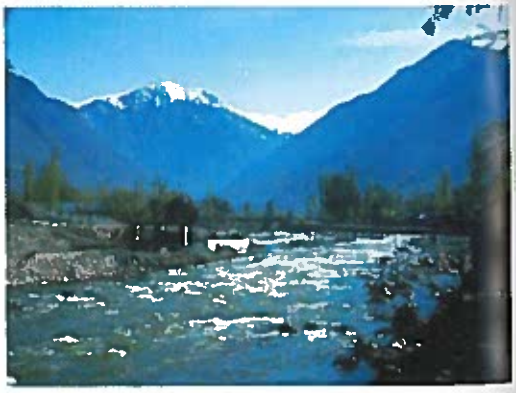
The agro-climatic zones in the Indian Himalayan region is based on the altitudinal gradient, which are broadly classified as warm sub-tropical (< 800m) to arctic zone (> 3,600m). The Indian Himalayan region

Table 2: Principal glacial-fed river systems of the Himalaya

River	Mountain Area (km^2)	Glacier Area (km^2)
Indus	268842	7890
Jhelum	33670	170
Chenab	27195	2944
Ravi	8092	206
Sutlej	47915	1295
Beas	12504	638
Jamuna	11655	125
Ganga	23051	2312
Ramganga	6734	3
Kali	16317	997
Karnali	53354	1543
Gandak	37814	1845
Kosi	61901	1281
Tista	12432	495
Raikad	26418	195
Manas	31080	528
Subansiri	81130	725
Brahmaputra	256928	108
Dibang	12950	90
Lohit	20720	425

[Source: Hasnain, 1999]

River Sutluj in Himachal Pradesh



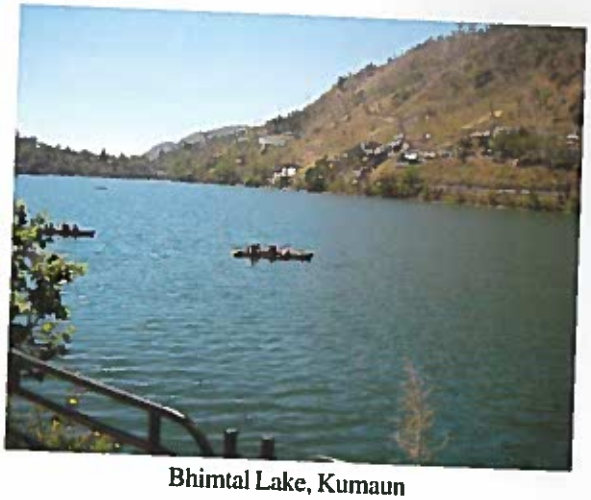
Trout stream in Kashmir (FAO, 2003)

has vast fresh water resources primarily in its streams, rivers, lakes and glaciers. Fluctuations in snow and ice cover are responsible for climate and hydrological variation to a great extent. The Himalayan region is drained by 19 major rivers. The main river systems draining the region are the Indus, the Ganges, and the Brahmaputra. The Indus and the Brahmaputra are the longest, each having a mountain catchment of about 160,000 km^2. Five rivers belong to the Indus system, of which the Beas and the Sutlej have a total catchment area of 80,000 km^2; nine rivers (Ganga, Yamuna, Ram Ganga, Kali-Sharda, Karnali, Rapti, Gandak, Bhagmati, Kosi) belong to the Ganga system, draining nearly 150,000 km^2; and three rivers (Tista, Raidak, Manas) belong to the Brahmaputra system, draining another 110,000 km^2. Most of these rivers flow in deep valleys until they exit the mountains (Sehgal, 1999). The principal glacier fed river systems of Himalayas are given in table 2.

There are numbers of lakes situated in the mid and high altitudes of Himalayan regions. These lakes have

Table 4: High and mid altitudinal lakes of Himalayan region

Lakes	Altitude (m asl)
Suraj tal	4950
Tsomo Riri	4524
Panggon	4350
Hemkund Sahib	4329
Vasukital	4300
Chandra tal	4300
Daityatal	4275
Dasir lake	4270
Chandratal	4270
Manimahesh	4080
Gandhi Sarovar	3970
Sheshnag	3570
Konsernag	3670
Kishnasar	3677
Nako lake	3662
Tsomgo (Changu)	3658
Tulian lake	3353
Deoriatal	3255
Wular lake	1537
Dal lake	1585
Manasbal lake	1587
Nilang	2180
Nainital	1938
Bhimtal	1331
Naukuchiatal	1220
Khrupatal	1670
Sattal	1286



Bhimtal Lake, Kumaun

Dal Lake, Kashmir (FAO 2003)

diverse origin such as retreat of glaciers, landslides and tectonic movements. The sizes of these lakes also vary as some are of large area while others have small. In the Great Himalayan and Trans-Himalayan region lakes are present at high altitude, with the highest lake situated at 5297 m a.s.l. Jana (1998) lists 13 lakes situated from 3400 m to 5297 m, some of them being brackish or saline. Freshwater lakes in Kashmir Valley are believed to have originated as oxbow lakes of the Jhelum River (Raina, 1999). Large lakes having 15,300 ha of surface area are located at middle altitude (1537 to 1587 m) in the State of Jammu and Kashmir while Kumaon lakes situated (1237 to 1930 m asl) in the state of Uttarakhand are much smaller, with the largest only 72 ha. In Himachal Pradesh coldwater lakes are situated between 1306 and 4815 m asl. All these lakes inhabit diverse fish fauna.

The water bodies of the Himalayan region inhabit diverse kind of fish fauna. Out of total fish fauna available in India 17% fishes were documented from the mountain ecosystem establishing the status of the area as a center of origin and evolution of biotic forms (Ghosh, 1997). About 36 species of freshwater fishes (out of 1,300) are endemic to the Himalayan region (Ghosh, 1997). For the whole Himalayas, 218 species are listed (Menon, 1962). The distribution of fish species in the Himalayan streams depends on the flow rate, nature of substratum, water temperature and the availability of food. The species distribution in the upper reaches of the stream/river where water has a torrential flow is different from the mid and lower reaches of the stream where flow is moderate and water current is soft. A number of fish species (table 5) are found distributed in the different reaches of the river.

Table 5: Important Coldwater Fishes

The eastern Himalaya drained by the Brahmaputra has a greater diversity of coldwater fish than the western Himalayan drainage. Among all these species a few supports the capture fishery while some are being cultivated in the farm condition at different altitudes based on their temperature tolerances.

Fisheries development in mountain region

Mountain regions are characterized by the presence of cold waters, many of which harbour fish and support largely subsistence fisheries. The farming or husbandry of trout has a relatively long history in Europe and North America. In the Indian Sub-continent two main types of trouts *viz.* brown trout (*Salmo trutta fario*) and rainbow trout (*Oncorhynchus mykiss* (Walbaum)) were transplanted from Europe by British settlers around the beginning of the last century primarily to meet their needs for sport fishing or recreational angling. The transplantation of brown and rainbow trout was attempted independently in the Himalayan and in the non-Himalayan States. In the Himalayan States the brown trout (*Salmo trutta fario Linnaeus*) was first brought in Kashmir through the private efforts of F.J. Mitchell in 1899. These introductions in the hill states could be considered as the formal beginning of coldwater fisheries or mountain fisheries development in India. For many decades the mere intention remained to develop recreational fisheries to satisfy the needs of anglers for sports. Later on, these species were started being cultured for food and hatcheries were setup for the production of seed. The development of hill fisheries thus started in the selected locations particularly in the Kashmir valley and some parts of the peninsular India. The breeding and culture techniques for the rainbow and brown trouts were standardized and now being practiced with greater success and accuracy. Post independence development of coldwater fisheries started with the effort of Central Inland Fisheries Research Institute, Barrackpore, which initiated research program in sixty's onwards for increasing survival of egg to fry and also rearing and culture of trouts. The State Government in hill states also taken enthusiastic steps in the development of fish and fisheries of both exotic and indigenous coldwater fishes from 1960's onward resulting in the establishment of hatchery and grow out facilities in their states (Singh, 2002). Early researchers mainly concentrated on the ecology, fish population dynamics, habitat, biology, maturity, breeding grounds and natural seed availability of some of the commercially important fishes (Jhingran and Sehgal, 1978). The erstwhile NRCCWF, Bhimtal has made concentrated effort and achieved success in breeding and seed production of golden mahseer (*Tor putitora*) (Joshi, 1988). This species is considered an excellent game fish and is popular sport among anglers. Apart from this, ranching programe has been started by the DCFR (erstwhile NRCCWF) to enhance the natural stocks of golden mahseer in the natural waters in the Kumaon region of the Central Himalayas.

Future strategies

The aquaculture production potential of the coldwater sector has not been exploited to its fullest extent. As far as coldwater fisheries development is concerned except a few hill states like Kashmir valley and Himachal Pradesh other mountain regions of India are still poorly developed or under exploited. These hill states endowed with natural lakes and reservoirs could be utilized for the fish production under culture based capture fisheries programme. Initiatives for open water cage culture in Himalayan lakes can also be taken up

for the stock enhancement as well as for the fish production using natural productivity. Introduction of composite fish farming using Chinese carps for mid-altitudes is a major success in increasing the fish production from the hilly regions. Integrated fish farming for the hills could also an important inexpensive aquaculture practice for the rural population residing in the mountain areas of the country.

Major occupation in the mountain region of the country is agriculture based activities. The land holding in the hill area is smaller (700-900m^2) as compared to the national average (1370 m^2). The farmers in the hill region have integrated type of farming pattern. Fish can serve as an additional source of income if integrated with the water conservation and harvesting programme. Keeping in view the squeezing land and burgeoning human ratio, mountain fish resource base is of great relevance and development of such areas. Keeping in view these facts different technological approach and support services are needed for the fishery development of mountain areas. The major issues concerning the development of coldwater sector in India are:

- Low level of production
- Lack of Infrastructure for aquaculture
- Availability of seed for production
- Introduction of new candidate species for aquaculture
- Habitat destruction
- Wanton destruction
- Aquatic pollution
- Conservation policy
- Management policy
- Climate change

The aquatic resources in hills are quite valuable for the development of fishery both for food, sport, recreation and employment but scientific management of these resources is necessary to achieve the objectives. In order to manage these ecosystems, so that they can contribute to fishery development in remote hilly regions on a sustainable basis, the following issues need attention.

1) Resource mapping of the fishery resources in mountain/hill region needs to be taken up on priority basis for the integrated development of the coldwater sector.
2) In order to develop the riverine and lacustrine fisheries it is necessary to go for stock enhancement programme through ranching.
3) A legal framework should be formulated to stop all types of destructive fishing method.
4) The breeding grounds of the fish need special protection by declaring them as 'No-fishing Zone' or 'Protected Area'.

5) A balanced strategy for lakes, for tourism and fishery development is required.

6) Development of sport/recreational fishery for tourism and employment generation.

7) Education, training and extension support to the hill communities for resource conservation and utilization.

8) Promotion of mountain-specific policy formulation and legislation.

9) Promoting sustainable use of mountain natural resources and conservation of biological diversity and mountain ecosystems.

There is a vast scope and potential in improving fish production in hills by bringing natural Himalayan lakes located at different altitudes, under scientific management for fishery enhancement. This would actually reduce the gap between actual fish yield and production potentials. Through application of modern techniques, significant scope exists for promoting trout farming, which in long run, will have both domestic and export demand. There is also a great potential for sport fishery development and ecotourism in hill regions. Use of modern techniques such as molecular and biotechnological intervention, selective breeding programme for improvement of strains both of exotic and indigenous species, coldwater fish health management for the containment of diseases have now become imperative. Providing decision support system using GIS and remote sensing would be helpful not only for resource assessment but also for aquaculture development in the hills. Ornamental fish culture for small scale enterprises in the hills can provide an alternative source of employment.

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Project Directorate on Foot and Mouth Disease, Mukteswar

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Almora, Uttarakhand

Vivekananda Parvatiya Krishi Ansuandhan Sansthan (ICAR), Almora is working in the field of agriculture for N-W Himalaya. The Institute has made significant contribution in the fields of Crop Improvement, Crop Production, Crop Protection and Social Sciences by developing more than 120 improved varieties of 25 crops, their production protection technology and dissemination of developed technologies to farmers of the region. The Institute won Sardar Patel Outstanding ICAR Institution Award twice for the year 2000 and 2007 in recognition of its valuable research contribututions. Institute's publication entitled, ***"Uttar Paschimi Parvatiya Kshetron Main Krishi Utpadan Ki Vridhi Ke Liye Uttat Krishi Taknike"*** has been popular amongst the farmers and won Dr. Rajendra Prasad Puruskar of ICAR. Intitute's inventions Vivek Mandua/Madira Thresher got NRDC Meritorious Invention Award 2006 and Eco-friendly Novel Technology for managing white grubs in North-West Himalayas got NRDC Societal Innovation Award for the year 2008 and WIPO Gold Medal for 2009. The institute has commercialized VL Millet Thresher, VL Paddy Thresher, VL Seed-cum-Ferti Drill and Insect Trap for trapping of white grub beetles etc.

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A premier research institute in the field of cataloguing, characterization and conservation of fish germplasm resources of India

MANDATE

- Collection, classification and cataloguing of fish genetic resources of the country.
- Maintenance and preservation of fish genetic material for conservation of endangered fish species.
- Evaluation and valuation of indigenous and exotic fish species.

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- Development of diagnostic kits for pathogens using molecular tools.
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- Application of remote sensing and GIS for aquatic habitat assessment.
- Habitat fingerprinting for fish diversity conservation and management.

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S.No.	Title of Publication	Price
1.	Fishes of North East India	Rs.950/-
2.	Ornamental Fishes of North East India: An Atlas	Rs.750/-
3.	Freshwater Fish Diversity of Central India	Rs.500/-
4.	Ornamental Fishes of the Western Ghats of India	Rs.900/-
5.	Fish Introductions and Quarantine: Indian Perspective	Rs. 200/-
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9.	Lucrative Alien Ornamental Fish Species for Aquarium Trade of India	Rs.300/-
10.	Fish Biodiversity of India	Rs. 750
11.	Fish Pathogens and Diseases in India: A Bibliography	Rs. 500 (Discount 30%)
12.	Participatory Approach for Fish Biodiversity Conservation in North East India	Rs. 500 (Discount 20%)
13.	Indian Fish Pathologists Directory	Rs.300 (Discount 30%)
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Vision

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Mission

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Mandate

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- To enhance production efficiencies through biotechnological tools
- To undertake studies on diversification of aquaculture practices with reference to species and systems
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Mandate

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- To create awareness, provide training and consultancy in inland open waters.

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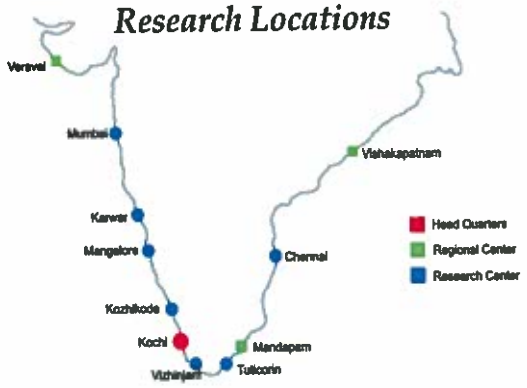

Technologies / Products

Green Mussel extract(GMe)

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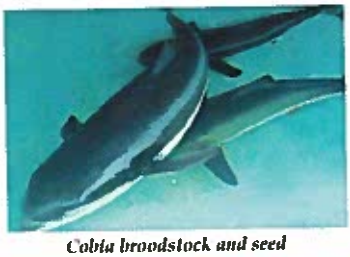

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PART–II
ABSTRACTS

Diversity and risks assessment of upland fisheries

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Mountains because of its resourcefulness have always attracted human activities, but its complexity in understanding has led to misuse and abuse. Coldwater fisheries resources exist diversified and queer type of fish fauna in different hill regions comprise of about 258 fish species from Indian uplands of which 203 are recorded from the Himalayas while 91 form Deccan plateau. The coldwater fisheries play an important role in the socio-economics life of the people dwelling in the mountainous zones of the country. The majority of dependents on fish as means of livelihood are now facing problems to meet their both ends owing to sharp decline in fish catch in the upland areas. This has been resulted in abruptly disturbed the feeding and breeding grounds. The ever increasing population pressure on the mountain regions has adversely affected the fragile ecology of these regions. The risk face of all the facts just mentioned is that if the fish stocks dwindle, there would be a grave threat to food security; anything that transforms the uplands would affect inhabitants by the virtue of their habitation, notwithstanding the dependence of hinterland population burial of matter is a deposit for posterity, and so on. While it is practical to think that coldwater fisheries management should benefit the contemporary society, it is more ethical and wise to think about the tomorrow's of life. Therefore, risk assessment is as much important as exploitable resource assessment. An active consciousness about risks would allow an optimal integration of consumerism and conservation, which are the decisive factors of sustainable development. At the core of understanding the major issues of coldwater fisheries is the need to diagnose the inner risks and evolve wise practices to counter their possible adverse effects.

Keywords: Coldwater fisheries, Mountains, sustainable development

Hill stream fish diversity of North-East India and their conservation

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The rich freshwater diversity of northeast India is attributed to the Himalayan orogeny, the resultant river basin evolution and the habitat diversities. The region is drained by four river systems. Over 300 species of fishes occur in northeast India of which more than 100 species under 25 genera and 7 families are highly modified for torrential mode of life and are permanent residents in the hill streams. Dr. Sunderlal Hora's epoch making publication of 1922 on the hill stream modifications of fishes was based on his extensive study of the fishes of this region. The special adhesive devices, viz., mental disc, thoracic apparatus, plaited paired fins; labial folds etc. in *Garra, Glyptothorax, Pseudecheneis, Pseudolaguvia, Oreoglanis, Erethistes* etc. of the region have been examined and found to have many interesting characters. New forms have been discovered. The fishes are under serious threat caused by overexploitation, habitat destruction, pollution, flow modification, invasive species and climate change. IUCN has carried out Redlist Assessment and Species mapping of more than 500 freshwater fish species of the Eastern Himalayas in the past one year. The publication of the reports is awaited. On availability of the report, species under threat would be identified and planned for conservation.

Survey of ichthyofauna and dolphin in downstream of Subansiri River

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138 fish species belonging to 32 families and 84 genera were recorded from downstream of Subansiri R. and adjoining beels. Among the species recorded 32 species are either threatened or vulnerable category. 5 species of commercially important shell fish have also been recorded in the downstream. Besides, 29 dolphins were encountered from the dam site to the confluence of the Brahmaputra with a density rate of 0.26 dolphin/km. A total of three factors, either individually or in combination contribute the availability of the dolphin in R. Subansiri. The deeper pools (between 6.0 m. and 15.3 m) of the Subansiri become the natural habitat of dolphins during lean months. Proposed huge reduction in water discharge will be catastrophic for downstream freshwater ecosystems. The abrupt diurnal changes in the volume and rate of flow will destabilize many aquatic biota including fish and dolphin. Moreover, low flow rate during the day and abnormally high during night in dry months will have negative impacts on the physiology and behaviour of aquatic fauna. The present paper deals with the probable impact of the ongoing 2000 MW dam on fish and dolphin population of the river.

Keywords: Subansiri River, ichthyofauna, dolphin, dam impact.

Effect of *Spirulina* fortified diets on growth and survival of chocolate mahseer (*Neolissochilus hexagonolepis*)

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Chocolate mahseer, considered as a new candidate species for hill aquaculture, was selected in the present study to assess the efficacy of *Spirulina* (*S. platensis*) fortified diets on its growth and survival. Five isoproteic diets (with 35% protein) with different percentages of *Spirulina* (0, 3, 5, 7 and 10%) were formulated. Fish were fed @ 5% of their body weight in two split doses for 90 days. Highest weight gain (302 and 313%) and lowest food conversion ratio (FCR) were recorded in case of 5% and 10% *Spirulina* fortified diets (1.48 and 1.43) while, lowest weight gain (182%) and highest FCR (2.46) were recorded for the control diet. The specific growth rate (SGR) was recorded highest (8.46%) for 10% *Spirulina* fortified diet and lowest (5.77%) for the control diet. Comparing the cost of the formulated diets, it is revealed that 5% *Spirulina* fortified diet resulted in better growth performance, effective utilization of feed and maximum survival percentages in chocolate mahseer.

Key words: Chocolate mahseer, *Spirulina*, isoproteic, growth, survival.

Glycerol production to acclimatize the cold environment in Indian snow trout

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Indian Snow Trout, *Schizothorax richardsonii*, an indigenous coldwater fish is available in almost all hill aquatic resources. During winter time it can sustain a temperature even at 5-6^{0}C and summer it thrives at 22-24^{0}C. It remains very active and forges for food during winter time even at lowest temperature. Below that temperature, it tries to migrate to a warmer area, down stretches of the river. In regard to this activity we tried to know what is the mechanism/adaptability in this fish so that it thrives in low temperature and different from that of the species in warmer places. The experiment was designed. The fishes were collected from wild resources and acclimatized in laboratory condition at the temperatures they are adaptable in winter and summer temperatures i.e., 5-6^{0}C and 22-24^{0}C and the experiments was continued for 12 days. The sampling of blood and tissues like liver, muscle, heart, spleen, fin and brain were done starting from 0 hours with an interval of 24 hrs upto 12th days. The activities of different enzymes were studied which were found to play key role in glucose metabolism. All the enzymes were found to be increased except Pyruvate kinase. Interestingly, it was observed that the fishes kept in 5-6^{0}C showed elevated levels of Glycerol approximately 3times than the fishes kept in 22-24^{0}C. It was also evident in the fishes like rainbow smelt, *Osmerus mordax*, which produce glycerol to adopt the cold temperature. This study on Indian snow trout would reveal the mechanism of possible cold adaptation.

Keywords: Indian snow trout, Cold adaptation, Glycerol, low temperature

Trinucleotide repeats and neuropsychiatric disorders

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A microsatellite trinucleotide repeat (CAG)n was found to play some neuropsychiatric disorders in mammalian system. The diseases are caused by expansions of CAG repeats, encoding polyglutamine tracts, within the coding regions of a variety of unrelated genes. The similar expanded CAG repeats were found in some fishes, but the functions were unknown in those organism. It was also not even evaluated any genetic instability due to the CAG repeat. The present study was carried out with an aim to find out whether, the same CAG repeats occurring in the fish genome of coldwater fishes. EST database of carp species through NCBI GENBANK was used for mining of SSR markers. A sequence containing "CAG" repeat motif was found during searching of common carp EST databases using TANDEM REPEATS FINDER v.3.01. The specific primers were designed containing CAG repeats using the Primer Select Program (DNASTAR). PCR amplification was carried out with the primers using genomic DNA of seven coldwater species (*Schizothorax richardsonii, Garra gotyla, Raimas bola, B. bendelisis, B. bola,* and *Tor putitora)* collected from Kosi River of Kumaon region. Initially the expected amplification size for the CAG repeats of 128 bp was not observed after repeated PCR trials. However, a fragment of 260bp was observed through 1.5% Agarose gel electrophoresis in all the fish samples used. Therefore, it would early to conclude that the same microsatellite marker is not present in any coldwater fish species unless we have the sequence analysis through cloning of 260bp fragment.

Keywords: CAG repeats, polyglutamine, neuropsychiatric disorders, EST-SSRs.

Evaluation of biointensive IPM module in Okra fruit and shoot borer *Earias vitella* (Fab.)

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Okra is an important vegetable crop cultivated in U.T. of Puducherry. In U.T of Puducherry it is being cultivated in an area of 144 acres with a production of 1152 tonnes. The production and yield of this crop is quite hampered as Okra is highly susceptible to shoot and fruit borer. An experiment was conducted at PAJANCOA & RI during 2010 to evaluate the best Integrated Pest Management (IPM) module for the management of shoot and fruit borer in Okra. Five modules *viz.*, M1-Chemical module, M2-Biointensive module, M3-Integrated module, M4-Farmers module, M5-Control were studied. The experiment was laid out in RBD with Arka anamika variety and it is replicated four times. At 32 days after sowing (DAS) the per cent infestation of shoot in M3 module was 3.98 as against 10.57 in the control. Similar trend was noticed at 39 and 46 DAS. The per cent damage in Okra fruits was 6.00 in M3 module and 23.55 in control at 45 DAS. At 65 DAS, the per cent infestation was again less in M3 module 9.83 and in control it was 30.42. At 75 DAS also similar trend was noticed. The yield was more in M3 module (7922.89) as against (5916.67 kg/ha) in the control plot. Among the different modules tested M3 was found to be superior.

Bacterial decolorization of synthetic and kraft lignin at high pollution load by axenic and mixed culture and their metabolic products

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Pulp paper effluent has very high pollution load because of lignin and its derivatives as the major coloring and polluting constituents. In this study, two lignin degrading bacteria IITRL1 and IITRSU7 were isolated and identified as *Citrobacter freundii* (FJ581026) and *Citrobacter* sp. (FJ581023), respectively on the basis of 16S rDNA gene sequence analysis. Results revealed that the mixed bacterial culture was found more effective compared to axenic culture as it decolorized 85 and 62% of synthetic and kraft lignin whereas axenic strains IITRL1 and IITRSU7 decolorized 61 and 64% synthetic and 49 and 54% kraft lignin, respectively. The lignin degrading enzyme characterized as manganese peroxidase by SDS-PAGE yielded a single band of 43 KDa. Further, the GC-MS analysis has shown the presence of several lignin related aromatic compounds in control and bacterial degraded samples. In addition, 2,4,6-trichlorophenol (RT-16.0), 2,3,4,5-tetrachlorophenol (RT-18.8) and pentachlorophenol (21.8) were produced as new metabolites while bis (2-ethylhexyl) phthalate (RT-30.4) and hexadecanoic acid (RT-24.8) were found as most recalcitrant compounds during the degradation of natural and synthetic kraft lignin, respectively.

Keywords: Bacteria, Synthetic lignin, Kraft lignin, Decolorization, GC-MS analysis

Upland fish and fisheries resources of Dima Hasao district of Assam, India

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The Dima Hasao district of Assam lies between 92°37' – 93°17' E longitudes and 23°30' – 25°47' N latitudes. The district is one of the twin Hill district of Assam with headquarter at Haflong. The district shares its boundaries with the states of Manipur, Nagaland, and Meghalaya. Few hills station of the state is located in the district with unsurpassed sylvan beauty. The district is blessed with many torrential Rivers, viz: The Jatinga River originated from Borail range and joining the Barak River in Cachar. The Diyung River is also originated from Barail range and joining the Kopili River in its downstream. The tributaries of the River Diyung are Moti & Langting River. These River harbours rich variety of Cold Water Fishes along with *Tor* species. The area is known to be as granary for the fishes of the family: Clupiidae, Bagriidae, Sisoriidae, Siluroide, Schilbeidae, Channidae *etc*. The fish species like A. *bengalensis* are also incidentally reported in the market of the region.

However, nothing has been reported regarding upland fish and fisheries of the district. A survey was conducted since 2008 for exploration and inventorization icthyofaunal diversity of upland water resources of Dima Hasao district along with its limnology. A total of 87 species have been collected till date, out of which 27 species were identified as inhabitants of torrential River. However, it has been observed that the species diversity of all the Rivers of the district has witnessed severe damage due to various activities like over fishing, pollution, poisoning etc. The fatal fishing techniques adopted by the local inhabitants through herbal poison, locally made dynamite and pesticide including DDT are the serious concern in declining the population of upland fisheries resources. However, few ITK (Indigenous Technological Knowledge) adopted in catching the fishes in the area surely be attract the interest of fishery technologist.

Spatial decision support system for aquaculture in high altitude region

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The GIS based decision support systems known as spatial decision support system (SDSS) is a class of computer systems in which the technologies of both GIS and decision support system are applied in making authentic decisions of spatial dimension. Aquaculture is one of the fastest growing food production systems in the world. With stagnating yields from many capture fisheries and increasing demand for fish and fishery products, expectations for aquaculture to increase its contribution to the world's production of aquatic food are very high.

A decision support system for aquaculture was developed in which the suitable aquaculture sites are assessed using the parameters of soil, water and infrastructure facilities in GIS based models. In present study, the Nainital district of Uttarakhand having geographical area of approximately 401,992 ha and lying between latitudes 28° 59' and 29° 36' N and longitudes 78° 52' and 79° 58' E was considered. The different parameters like large water bodies, stream and rivers, road network, markets, hatcheries etc. are digitized based on the toposheets of the Nainital district on Geomedia professional 6.0 software and thematic maps on villages and forest cover of Nainital district were prepared based on the digital open series map data of Survey of India, Dehradun. Soil texture, slope and other soil parameters were also prepared in the GIS software. The aquatic zones of Nainital district were categorized based on the altitude and water availability, water quality parameters. The Analytical Hierarchy Process (AHP) model is used to assess the importance of different water quality parameters. A modeling was carried out with all thematic maps using the criteria of suitable sites for aquaculture in Nainital district. An area of 51112 ha falls in most suitable, 61164 ha as moderately suitable and 13,844 ha was found as not suitable and 275,872 ha as constraints like forest, lakes, streams, rivers, roads.

Keywords: SDSS, GIS, Multicriteria, Aquaculture site selection

Fish diversity of Lower Brahmaputra Valley along with certain rivers of Garohills district of Meghalaya

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The North Eastern states have vast untapped potential for fisheries in terms of many rivers, streams, floodplain wetlands, lakes, ponds and large areas under rice-fish culture system. The North East Region shares its fish fauna predominantly with that of the Indo-Gangetic fauna and to a small extent with the Burmese and South China fish fauna (Yadav and Chandra, 1994). Assam, the second largest province of N.E. India is a global hotspot for fish faunal diversity. The diversity of fish species in the North East India is attributed to the recent geological history, especially the Himalayan orogeny (Kottelat, 1989). Thus the fauna of the state includes both Assamese and Burmese elements (Hora and Mukherji, 1935). The mighty river Brahmaputra along with its myriad of tributaries, harbours large variety of fish fauna of both Indo-Gangetic and Indo-Malayan origin. Till today 170 species (both plain varieties and hills stream varieties) of fishes have been reported from the Brahmaputra drainage system. The river is system also connected with hills streams and a large number of floodplain wetland.

The diversity of fish is found to be more numerous in lower reaches of Brahmaputra basin up to Bangladesh (Ghosh, 2007). However, from the market survey of the last five years as well as according to local fishers, fish germplasm diversity of this region drastically reduced due to habitat destruction, overexploitation, siltation, pollution and use of destructive fishing gear etc. Garohills district of Meghalaya is an important habitat for open water fisheries that has witnessed severe damage due to Coal mining practices couple with Climate Change. In recent years, the physico-chemical parameters of the certain River such as Simsang, Nitai, Bhogai etc have reported rapid changes especially in water temperature and DO_2 level. As a result of which fishery resources of the River system reduced drastically.

Alterations in the serum electrolytes, calcitonin cells and parathyroid gland of Wistar rat in response to administration of cadmium

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Wistar rats (male) were daily administered orally with cadmium chloride at a dose of 5 mg/kg b wt and 10 mg/kg b wt. Rats were sacrificed on 1st, 2nd, 4th, 6th, and 8th week after initiation of the experiment. Changes in serum electrolytes (calcium, phosphate and magnesium) and endocrine systems (calcitonin cells and parathyroid glands) were investigated. Hypocalcemia, hypophosphatemia and hypomagnesemia were recorded in cadmium exposed rats. The parathyroid glands and calcitonin cells exhibited increased activity which is evident by increased nuclear volume of these cells. The effects of cadmium on the serum magnesium content have not been investigated before hence this study is the first report.

Fish germplasm resources of Uttarakhand: Present status and possible conservation & management measures

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Uttarakhand is a Central Himalayan state with 88.9 % of its area under mountains. The state is situated in the altitudinal range between 198 to 7,816 masl. The altitudinal and geographical variation, mountain slopes, varied rainfall pattern, expansion of river valleys and vegetation cover portray varying micro-climatic zones in the state. The state is blessed with plenty of aquatic resources in the forms of Ganga, Yamuna and Kali rivers with their numerous criss-crossing tributaries, rivulets, streams, lakes, reservoirs and some ponds. These diverse water resources form myriads of micro habitats which harbour rich piscine diversity. The list of fishes comprises 83 species classified under 39 genera, 12 families and 3 orders. As far as commercial importance of the species is concern, 5 are known for sports, 40 as food fishes and 8 for their potential ornamental value The principal species are - *Tor putitora*, *Tor tor*, *Tor chelynoides*, *Labeo dero*, *Labeo dyocheilus*, *Schizothorax richardsonii* among native species; *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala* are the transplanted and *Ctenopharyngodon idellus*, *Hypophthalmichthys molitrix*, *Cyprinus carpio*, *Oncorhynchus mykiss* are the exotics. *Tor putitora* and *Schizothorax richardsonii* have wide distribution and great economic importance. Presently most of the lotic systems are under severe deterioration from incoming silt load, decreasing flow rate, and large-scale abstractions. The excessive rate of soil erosion from the fragile catchments has destructed the natural deep pools within the stream and rivers. As a result the healthy pool and riffle ratio (1:1) has lost existence in most of the lotic systems.

As a result of the cumulative effect of all the above adversities, the rich fishery wealth of the state in general and sport, food, typical hill stream fishes in particular are under severe stress. The fish fauna, particularly in the water bodies traversing near townships, villages and roadside are under massive threat from wanton killing with the help of illegal destructive devices like – dynamiting, poisoning, channel drying and even electrocution. The valuable fish germplasm of the state has to satisfy the need of the people as subsistence fishery, candidate for culture, sport fishery and eco-tourism. The details of the status, utilization and conservation measures will be discussed in the paper.

Fitting of Fox model with autoregressive of order one using expected value parameters

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Although Schaefer model is most widely used surplus production model, it provides a curve of symmetrical parabola, which need not necessarily be always true to the natural phenomena since maximum sustainable yield (MSY) may vary considerably depending on temporal and spatial changes in the ecosystem. However, in Fox model, catch increases asymmetrically towards the total biomass with increasing effort, which is more realistic than Schaefer model, and hence biologists prefer to Fox model. When we employ nonlinear estimation procedures for estimating the parameters, high parameter correlations is generally observed, which is undesirable. Moreover, catch-effort fisheries data are collected during a certain time period and hence data points are generally correlated among themselves. In the present investigation, utility of expected value parameters to make parameter correlations low is highlighted and a method of fitting a Fox model with serially correlated error structure using expected value parameters is proposed which is illustrated with an example, considering the catch-effort data observed from Gobindsagar reservoir, India. A perusal of the estimates of MSY for different forms of Fox model reveals that a simple Fox model have over-estimated the MSY and optimum effort values as compare to the values of MSY (691 tones) and optimum effort (1217 no. of gill nets) estimated by reparameterization of the Fox model with AR(1).

Plant extracts and essential oils: A perspective for the control of predatory insects from fishery pond

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Predatory aquatic insects of a fishery pond, belonging to the families *viz.* Nepidae, Belostomatidae, Gerridae, Dytiscidae, Gyrinidae, Hydrophilidae etc. and Damselfly and Dragonfly not only prey upon different stages of fish but also compete with them for food. Synthetic insecticides such as organochlorines, organophosphorus, carbamates, synthetic pyrethroids, soap oil emulsion, gammexene, dimethyl-2:2-dichlorovinyl phosphate (DDVP), Hyoxide-1011 and Teepol B-300 are used to control the predatory aquatic insects leads to destabilization of the ecosystem, resistance in pest, undesirable affect on non-target organisms and reduction of fish production. Moreover, the synthetic insecticides are expensive too. A wide variety of plant extracts and essential being biodegradable, non-toxic to non-target organisms, cheap and safe are advantageous to synthetic insecticides and possess varying degree of insect controlling properties *viz.* insecticidal/ovicidal, antigonadal and insect growth regulators. Plants constitute rich source of bioactive chemicals such as alpha-terpineol, thiophenes, pulegone, mono- and sys-quiterpenes (e.g., á–terpineol and pulegone) and phenolics and monophenols (e.g. Thymol, Carvacrol and eugenol) and alkaloids. These chemical compounds are insecticidal and have diverse modes of action like hormonal, neurological, nutritional and enzymatic. The plant families important in producing such secondary plant metabolites are Asteracea, Fabaceae, Euphorbiaceae, Myrtaceae and Lamiaceae; which could be use in the eradication of predatory insects from the fishery ponds. However, survey of literature provides very limited information on the bioactivity of plant extracts and essential oils in the control of predatory aquatic insects from fishery ponds and is confined only to crop protection and mosquito control. Therefore, there is a great need to intensify research on the biological control of predatory aquatic insects of fishery ponds through vast array of plant extracts and essential oils leading to high fish production.

Effect of intramuscular Ovaprim hormone injections on induced breeding of grass carp (*Ctenopharyngodon idella*)

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The present study was conducted to investigate the effect of synthetic hormone ovaprim intramuscular injections on grass carp (*Ctenopharyngodon idella*) for effective breeding. For this purpose, experiments are conducted by using 44 fishes (*Ctenopharyngodon idella*) at a Carp hatchery of College of Fishery Sciences, Pantnagar. The dose of ovaprim was given according to the body weight and sex of the fishes at evening time after the proper conditioning for 6-8 hours. After 10-12 hrs of the injection, the spawning took place in early morning. The three sets of experiment were analyzed and it was found that fertilization and hatching rate was increased as increase in temperature. There is positive correlation between the weight before spawning and weight after spawning of the fishes.

Keywords: Grass carp, ovaprim, spawning

Ichthyofaunal Biodiversity of Rapti River at Balrampur District U.P.

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The present study deals with fish biodiversity undertaken during period July-2008 to July-2009 to census and commercially important fishes in the Rapti River. The present paper deals with the variety and abundance of fresh water fishes in Rapti River at Balrampur district U.P. India. The results of present investigation reveal the occurrence of 52 fish species belonging to seven order 14 families and 26 genera. Among the collected species order Cypriniformes was most dominant constituting 50 % followed by order Siluriformes constituting 19%, order Perciformes constituting 14.28%, order Steoglossiformes and Synbranchiformes constituting 2.38% of total fish species.

Keywords: Fish biodiversity, Economic value, Rapti River, Balrampur

Dwindling ground water sources & deteriorated water quality the major menace of sustainable development of Rajasthan

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Ever increasing demands of water for domestic, irrigation as well as industrial sectors have created water crisis worldwide. Unfortunately, Rajasthan is the most water deficit state of our country, where each drop of water is as precious as diamond. Increased demographic pressure and societal advancement result in acute water shortage for drinking, agriculture and industrial purposes. Rajasthan is the largest state of India covering 10.4% of the total area of the entire nation. On the other hand, the State is having only 1.15% of total water resources of the country to cater the needs for about 5.5% of the nation's population. Ground water is the only dependent source in larger part of the state except a few district areas, where canal water or surface sources are also available. Deeper water levels and inferior quality of ground water (highly saline, enriched with high nitrate and fluoride) followed by periodic occurrence of droughts and famines. Further deteriorates the situation putting tremendous pressure on limited available fresh water aquifers. Though the state is endowed with lot of good cultivable land but inadequate rainfall and lack of water resources from other sources hamper good agriculture production. Industrial development also greatly suffers for want of water at suitable locations. As results of increase in hydro-chemical parameters, lives of human beings, flora and faunas have been adversely affected which inturn have affected their socio-economic status. Therefore, for sustainable development proper management efforts must be made viz. maximum utilization of rain water by reviving and strengthening traditional water harvesting structures, proper soil conservation measures by afforestation, watershed development, artificial recharge of ground water, Dry farming, drip and sprinkler irrigation techniques have to popularized to minimize use of water for irrigation, installation of reverse osmosis plants, De-fluoridation plants and above all it is exigency to educate and create mass awareness amongst consumers of water for its judicious use.

Haematotoxicity in fish *Trichogaster fasciatus* induced by dipterex

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Pesticides impose harmful effects on environment especially on aquatic environment and aquatic flora and fauna. Among them organophosphate pesticides are very important. They are non-biodegradable and accumulate in water. From there it goes to body of aquatic organisms. Dipterex is widely used organophosphate and it goes to environment and pose toxicity. It accumulates in fish's body, which is eaten by humans. These ill and damaged fishes create health hazards. Further, other organisms also affected by pesticides and dead fishes contaminate the water. Haematology is the mirror of organism's health, so that it is estimated in the present study in case of *Trichogaster fasciatus*. Sub-lethal dose was given to fishes and results indicated serious haematological alterations. Increase in TLC, ESR while decrease in TEC, Hb. conc. is significant under toxicity of dipterex. The need is to restrict and regulate the use of pesticides to conserve our aquatic flora and fauna.

Protective effect of *Aloe vera* against hepatoxicity induced by sulphur dioxide gas in rats

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Oxide of Sulphur are probably the most wide spread and most intensely studies all the anthrogenic air pollutants. It is a ubiquitous air pollutants present in low concentration in the urban air and in higher concentrations in the working environment. It causes adverse effect on human health. Hepatotoxic effects of any toxic substance is mainly diagnosis by mankers of liver enzymes such as alkaline phosphatase (ALP), Glutamic oxaloacetic transaminase (GOT), Glutamic pyruvic transminase (GPT), Gamma- glutamyle transferase (GGT). *Aloe vera* is a perennial succulent belonging to the liliaceae family. Aloe has been used for medicinal purposes since the time of the ancient egyptions. Present study is designed to assess the protective effect of *Aloe vera* against hepatotoxicity induced by SO_2 gas in rats. Freshly prepared aqueous extract of *Aloe vera* was orally administered as a dose of 200mg/kg bw per day for 30 and 60 days to healthy and adult albino rats of both sexes (120-155g). They were grouped in three sets- control set (1) was exposed to ambient air, experimental set (2) was exposed to 80ppm of SO_2 gas for one hour per day for 30 and 60 days and experimental set (3) was exposed to 80 ppm of SO_2 gas with pre-exposure oral administration of *Aloe vera* for one hour per day for 30 and 60 days. A reduction in serum liver enzyme [GOT ($p<0.01$); GPT ($p<0.001$); GGT ($p<0.05$); ALP ($p<0.001$)] activities. In comparison to SO_2 of exposed rats shows provides strong evidence that *Aloe vera* significantly reduced the liver toxicity induced by sulphur dioxide gas exposure in albino rats.

Keywords: *Aloe vera,* serum enzyme, SO_2, albino rats.

Combined effect of *Eichhornia crassipes* and *Emblica officinalis* on serum electrolytes and enzyme profile after arsenic intoxication in albino rats

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The present investigation was carried out to evaluate the combined effect of *Eichhornia crassipes* and *Emblica officinalis* on serum electrolytes and enzyme profile after arsenic intoxication in albino rats. *E. officinalis* has been used as a valuable ingredient of various medicines in India. Recent investigations have given ample evidences of various uses of *Eichhornia crassipes* as hyper accumulator of various toxins. Three groups of ten adult male albino rats were administered 0.102 mg/L arsenic drinking water (collected from Sikandara area of Agra) for 30, 45 and 60 days and another three groups of ten rats were treated first with arsenic water in the same way as mentioned above and then treated with combined *E. crassipes* (10gm/ Kg body weight) and *E. officinalis* (500 mg/Kg body weight) fruit extract (mixed in ratio of 1:2) orally for 15, 30 and 45 days, respectively. Results showed a very highly significant ($p<0.001$) increase in arsenic in the serum, a very highly significant ($p<0.001$) decrease in calcium, magnesium, sodium, significant ($p< 0.05$) decrease in potassium, very highly significant ($p<0.001$) increase in serum AST, ALT and non-significant ($p>0.05$) increase in LDH after arsenic water intoxication; while a very highly significant ($p<0.001$) decrease in serum arsenic, a very highly significant ($p<0.001$) increase in calcium, potassium, a non-significant increase in magnesium, non-significant ($p>0.05$) decrease in sodium, a very highly significant ($p<0.001$) decrease in serum AST, ALT and non-significant ($p>0.05$) decrease in LDH after combined *E. crassipes* and *E. officinalis* treatment, respectively. *E. crassipes* reduces the serum arsenic burden through chelation bio-mechanism and provides nutrients; while *E. officinalis* acts as a strong antioxidant. We concluded that *E. crassipes* and *E. officinalis* have compensated the arsenic toxicity that affects the body metabolism.

Key Words: Enzyme profile, Serum Electrolytes, Albino rat, Arsenic water, *Eichhornia crassipes* and *Emblica officinalis*.

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Impact of fishing on the riverine fish diversity of Sikkim

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Socioeconomic characterization of fishing activities in Sikkim was used to determine the impact on fish germplasm of Sikkim and to implement Government / agency sponsored fisheries development programme. Survey was conducted on the fisher communities in all the four districts of the state. The survey determined the socioeconomic status, fishing characteristics and threat perception and conservation concerns of the fishers. Literacy rate was 77.3% of which 53.1% were primary grade. The fishing-gears predominantly used in the rivers were rod and line, cast net, loop and line and hook and line. Majority of the interviewed (96.47%) considered fishing as their secondary occupation. Fishers devoted an average of 66 days per year for fishing with a catch of 1.0 kg per day giving an annual income of US$71.7. It contributed about 10.5% of the total annual income of the fisher who sold 60% of their catch. The frequency of availability of fish was as follows in descending order: *Schizothorax spp* > *Neolissocheilus spp* > *Garra spp* > *Pseudecheneis spp* > *Barilius spp* > *Semiplotus spp*. During the month of May *Schizothorax spp* and *Neolissocheilus spp* comprised 78.82% of the catch. There was strong awareness about fish-diversity with 82.94% acknowledging decline of different kind of fish in the rivers. The respondents expected that the government gave topmost priority to patrolling of the water bodies, organizing awareness programmes and trainings, issuance of license for controlled fishing and enact some regulations for judicious use of water in hydroelectricity projects for conservation of riverine diversity. It was concluded that the riverine fish diversity of Sikkim showed decreasing trend. It could be improved with the fishers' participation in the implementation of different Government/agency sponsored programmes for conservation and maintenance of diversity of fish germplasm.

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Water potentiality for aquaculture in Sikkim

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Many factors like water quality and temperature determine aqua biodiversity. The physical and chemical properties of water with respect to aquaculture in various water bodies situated at various altitudes from 300 to 4500 m asl throughout the state of Sikkim was determined. Water samples from rivers i.e. Teesta and Rangeet tributaries (53), natural lakes (15), samples from private ponds and tanks (20) and Govt. fish farm (16) were collected. The place of observation, month of sampling along with altitudes, air temperature, humidity and wind velocity, water temperature and pH, dissolved oxygen and alkalinity were recorded at each site. Fish samples were collected by fishing with the help of local fisherman, and local market. The morphological parameters of 220 fish samples of various species were measured.

Air temperature and humidity at sampling site during January and February varied from 5.57 to 27.8°C and 39.73 to 60.18 whereas during July and August it was 15.85 to 32.3° C and 55.53 to 71.07%, respectively. Wind velocity observed was from zero to 2.56 m/sec. In most of the tributaries during winter water was crystal clear and become dirty near township areas. Water temperature recorded during month of January to February and July to August was ranged from 3.91 to 16.16° C and 10.8 to 19.8°C, respectively, depending upon the weather condition. Water becomes slightly alkaline during winter compared to Monsoon and the values for pH ranged from 7.47 to 8.3. The highest amount of dissolved oxygen recorded was 11.15 mg/liters in East cold desert during January when water temperature was 3.91 °C followed by 10.2 mg/l dissolved oxygen in West high hills with the water temperature of 13.6° C. However, the lowest observed value for dissolved oxygen was 3.33mg/l with the water temperature of 10.80° C at North cold desert. Free carbon dioxide in water ranged from 0.65 to 1.23 mg/l. Total dissolved solid (TDS) in the water varies from 9.10 to 48.45 ppm and hardness of water calculated ranged from 7.0 to 20.67 mg/l. Calcium salts in the water ranged from 1.76 to 8.58 mg/l; magnesium 4.09 to 17.59 mg/l and chloride from 4.05 to 8.73 mg/l. The frequency of fish species found in the market and during fishing in the river tributaries, lakes, ponds were mostly *Neolisocheilus hexagonolepsis, Schizophorax progastus, S. richardsonii and Garra gotyla, Gara annandalei*. Common carp, silver carp, grass carp, Thilapia, patta Gold fish, Mashaseer, etc. On the basis of observations water was found suitable for aquaculture.

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Macromolecular alterations in stinging catfish, *Heteropneustes fossilis* (Bloch) after exposure to fluoride

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Environmental pollution may induce certain biochemical changes in fish prior to manifestation of drastic cellular and systemic dysfunctions. Fluoride is also one of the toxicant that gets accumulated in the tissues of animals and alters the biochemical constitution and metabolism. In the present study, the toxicity of fluoride to freshwater catfish, *Heteropneustes fossilis*, a common edible fish of India was evaluated after chronic exposure to sublethal concentration 77.20 mg F/L (one fifth of 96 hour LC_{50} value) for a period of three months. Alterations in macromolecules such as total protein and lipid were estimated in different tissues such as gill, liver, kidney and muscle of exposed fish and observations were made after 45 and 90 days. The levels of both the biomolecules was found to be decreased significantly in comparison to control after both the durations. The result revealed that fluoride is capable to alter normal biochemical profile resulting in great loss of nutritive value in fishes. It can also cause heavy loss to aquaculture due to less production both in terms of quantity as well as quality. Owing to their diversity, fishes can be used as excellent bio-indicators of pollution in aquatic environment. Alteration in biochemical constitution of fishes due to chemical contaminants after standardization can be helpful in aquatic pollution monitoring, risk assessments and various other environmental management programmes.

Key words: Fluoride toxicity, Protein, Lipid, Soft tissues, *Heteropneustes fossilis*.

Spread of Exotic Fish Species and the Aquatic Environment

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We documented the invasion of exotic fishes in aquatic systems such as rivers lakes, reservoirs and wetlands that differed broadly in locations, aquatic environment and fish diversity. The invasion of exotic fishes was determined and the present status was ascertained. Examination of fishes for their reproductive stages was done to confirm their breeding status and the same was reconfirmed with the life stages of the captured specimens i.e., fry, fingerlings, maturing and mature fishes. The impacts of introduced fishes available in natural aquatic bodies were assessed through the Fish Invasiveness Screening Test (FIST) which included the ability of the exotic fish to reproduce naturally, their dispersal ability (propagule pressure), fast growth, phenotypic plasticity (tolerance of range of salinity and temperature), ability to live off a wide range of food types and other successful invasive characters. The spread of exotic species and the environmental factors have been correlated to conclude that deteriorating aquatic environment facilitated the spread of exotic fish species in new environments causing adverse impacts.

Mitochondrial DNA: A tool to study taxonomic and phylogenetic relationships in fishes

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Phylogenetic studies as a basis for systematic reconstructions and analyses of direction and rate of evolution take an important place in biological sciences. Great interest in taxonomic & phylogenetic reconstructions and problems connected to them gave rise to various divisions, tendencies and methods that are used to clarify and specify the similarity and differences among taxa in all levels of organization. The development of this inference has resulted in wide use of comparative analysis of nucleotide sequences to solve taxonomic and systematic problems in all groups of the organic world. To compare DNA sequences and uncover differences various methods are used at the present time, ranging from different variants of DNA–DNA-hybridization to direct comparison of nucleotide sequences of genes and genome regions. The accumulated empirical data allow the assertion that molecular-genetic analysis can be successfully used to solve many disputable questions of systematics and phylogeny of taxa. Molecular methods also reveal cryptic species indistinguishable by morphological characters. One of the most widely used approaches now a day is comparative analysis of mitochondrial DNA (mtDNA). The mtDNA is characterized by a number of traits that make it suitable for these purposes. Analysis of mutations in mtDNA and their distribution in the species habitat allows not only the differentiation of the taxa but also the retrospective reconstruction of the consecution of the origin of taxa and intra-species groups.

Phylogenetic analyses of mtDNA have been used worldwide to solve some systematic questions as well as to study taxonomic and evolutionary relationships in fishes. The advantage of this method is the possibility to analyze extended mtDNA fragments that have substantially different rates of evolution and correspondingly, different levels of resolution for phylogenetic reconstructions. Therefore, this new approach has been used to analyze species in fish taxa whose taxonomic status and phylogenetic relationships have not been unambiguously established.

Assessment of Heavy metal pollution of Gomti River at Lucknow, U.P.

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A study was made for water quality assessment of Gomti River (Lucknow City stretch) at six sampling sites between Gaughat (upstream) and Pipraghat (Downstream) and seven major drains outfalling into Gomti. The river receives toxic substances through a large no. of tributaries and drains flowing in the catchment of the river. The toxic substances of particular interest are heavy metals derived from urban runoff as well as municipal sewage and industrial effluents. In this study fractionation of metal ions has been carried out with the objective to determine the ecotoxic potential of metal ions. In the collected water samples, five metals (Mn, Cu, Pb, Fe, Zn) were analyzed on ICP-AES (Inductively Coupled Plasma Emission Spectroscopy) Labtam Plasmalab 8440. From Gaughat to Harding bridge, the river is slightly polluted and is fit enough for almost all beneficial uses except for drinking without treatment but Harding bridge to Pipraghat the water is significantly polluted is not fit for irrigation, drinking and fish culture. Except iron and lead all other heavy metals such as, Mn, Cu, Zn were found to be well within the permissible limits prescribed as per BIS and WHO recommendations.

Keywords: Heavy metal, Gomti river, Gaughat, Pipraghat, BIS, WHO

Phytochemical, medicinal and chemical investigation of *Indrajau (Wrightia tinctoria)* plant

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Wrightia tinctoria R.Br. (Roxb.) plant belongs to Apocynaceae family is called as *Indrajau* and widely used in ornamental, commercial and medicinal purposes. It is 1.8-7.5 m in tall and 60 cm in girth and used for a variety of purpose in agriculture, land management, homeopathic, unani and ayurvedic medicine. It occurs in Garhwal region of Northern Himalaya, Western ghat, Myanmar, Sri Lanka, Nepal, Malaysia and Australia. Flowers, fruits are used as vegetable to Tribal people of Garhwal region while leaves are used as cattle fodder. Flowers are a source of blue dye called *Mysore Pala Indigo* and leaves are used as a wrappers for *Bidis*. Bark possesses proteolytic activity and several amino acid have been isolated from bark. Bark and seeds are used in flatulence and bilious affections. Seeds possesses aphrodisiae and anthalmintic properties. Fresh leaves are very pungent and chewed for relief from tooth ache. Alcoholic and aqueous extracts of leaves and roots as demonstrated on cats, possess hypertensive properties. Plant yield a cream coloured latex with caoutchouc (rubber) content varying from 2.4-28.4%. The latex containing more than 5% rubber can possibly be commercially exploited. Several amino acids have been isolated from leaves and also â-amyrin. Seeds, leaves and roots have been shown to contain an indigo yielding glucoside. Tree bears handsome clusters of white, jasmine-scented, star-shaped flowers in profusion which are much esteemed by Hindus for offering at the temple. Plant is reported to be a potential source of industrial gum and commercially used in textile, sugar, pudding, paper, ice-cream industry. Present study is deals with the extraction, phytochemical and chemical investigation of plants, seeds etc. Extraction of seeds and other plant part is done by several solvent of different polarity. Thin layer chromatography and paper chromatography of the different extracts shows the presence of different phytochemicals. Most suitable solvent system was upper layer as ethyl acetate: methanol: water; ammonia (6:1.3:1:0.06) and used *p*-anisidine phosphate as spray reagent to detect the phytochemicals and sugars present in the hydrolysate of the plant extract. Preliminary phytochemical screening of this plant parts showing the presence of tannins, alkaloid, resin, saponins and also the nutritive agents such as polysaccharide and amino acids. Presence of tannin is much more in dry fruit as compared to fresh dried part of plant. Paper chromatography and TLC of hydrolysed methanol extract of seeds reveals the presence of different sugars like D-galactose and D-mannose in 1:3 molar ratio and L-rhamnose, sucrose and L-arabinose in traces. Seeds polysaccharide yielded methyl sugars by Hakomari and Purdies method for the elucidation of polysaccharide structure.

Toxicity evaluation of Biotoxins and its implication to Health risk

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Biotoxins are those substances which are produced naturally and can be of plant or animal origin or from microorganisms. There is always a safe limit for any toxin and every known substance can produce a toxic effect beyond a certain point. They enter into the body either by ingestion through food or water or by direct exposure in air through aerosols or by bites and stings. These biotoxins are reactive molecules and in very low concentrations can react with specific target sites. Due to this property some of the biotoxins have been used as pharmacological tools to study the physiology of the body. The biotoxins produced by microorganisms like bacteria and fungi can also be very potent and may lead to several health hazards including allergy and mortality. However in developing countries the situation is complicated by wide variety of predisposing factors that determine the susceptibility of the individual. Marine biotoxins are found to be very common in the coastal region, mostly containing proteins of low/high molecular weight, lipids, amines, alkaloids, guanadines bases and mucopolysaccharides and have been responsible for several epidemics due to its biomagnifications in food chain.

Ciliate protozoan: A threat to aquaculture

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Fish cultivation is a commercially important aspect of Aquaculture. It plays an important role in the livelihoods of many urban dwellers employed as fish vendors. But, contamination of fresh water resources like ponds and rivers (where these fishes are reared) due to microbial pollution, poses a most significant threat to the viability of freshwater fishery production directly and indirectly and also may result in huge mortalities and loss to fishery industry. Thus, a study was undertaken to screen the presence of the pathogenic ciliate protozoan from some of the most common edible fishes from Lucknow city namely, *Gudusia chapra, Puntius sophore, Labeo rohita, Heteropneustes fossilis, Anabas testudineus* and *Mystus tengara.* The fish samples were collected from local fish markets located at different areas of Lucknow, where these fishes are being sold. Thus, for our study, 6 samples of each fish were collected from local fish markets. Fish sampling was done 3 times after every 15 days. The samples were screened for microbiological analysis with special reference to pathogenic ciliates. The various organs screened were gills, skin and intestine of fish. In each sample, pathogenic ciliates were observed and recorded from organs of fishes like skin and gills. None of the protozoan were observed or recorded from intestine. The biological characterization of ciliates was carried out and a total of three species of parasitic ciliates, *Tetrahymena* were recorded from gills of *Gudusia chapra* and *Puntius sophore* and *Ichthyophthirius* were recorded from gills of *Labeo rohita* and *Heteropneustes fossilis* while *Chilodonella* was recorded from gills of *Mystus tengara* and *Epistyles* from skin of *Anabas testudineus*.

Presence of pathogenic ciliates in these edible freshwater fishes should not be underestimated and those responsible for managing the cultivated area should be provided with adequate knowledge about preventive care and hygiene. Although much information has been accumulated on parasitic protozoan especially during the last three decades, many problems still remain in this field. More intensive studies are needed to clarify the parasitic fauna of freshwater fishes and control and preventive methods should be designed to combat such protozoan infections. The biology of these pathogenic protozoans should be well studied in relation to disease outbreaks in these common edible fishes which are of commercial importance. Detailed studies may contribute for the benefits of fish pathology. Determination of the prevalence of pathogenic ciliates in fish and definition of their potential to inflict disease conditions upon their hosts is of basic interest for fish pathology. Thus, further investigation is needed to understand the host-parasite relationship in order to develop preventive measures.

Key words: Ciliate protozoan, Fish pathology, Aquaculture, Microbiology

Digenetic Trematodes of Freshwater Fish *Channa punctatus* from Meerut District

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Fresh water fish are an important source of protein for people in many areas but sometimes being infected with parasites. Extensive work on fish hosts and their helminth parasites has been made; still little is understood regarding the relationship of common fish parasites with the growth of their hosts. Various manifestations indicated by several workers are loss of fish weight, retardation in growth rate, loss of appetite resulting in the death of host. Digenetic trematodes or digeneans of fishes belong to 2 important biological categories those that live in fishes as adult and those that live in fishes as metacercaria. About 135 specimens of *Channa punctatus* were investigated from September 2009 to February 2010. Live specimens of the host fishes were procured from different water bodies or were purchased from the local fish markets of Meerut region. All fishes for the study measured between 7 to 12 cm .The fishes were desensitized and thoroughly examined for possible ecto and endo parasites by dissecting under a compound microscope. *Allocreadium* (adult digenean) were found in intestine of *Channa punctatus*, metacercaria of *Clinostomum* were recovered from branchial region or body cavity of fish and metacercaria *of Euclinostomum* were reported from the kidney of fish. The metacercaria of *Clinostomum t*ongue-shaped were 3.28-4.27 mm in length and .94-1.46 mm in width. *Allocreadium* were elliptical and 1.38-4.42 mm in length and .59-1.41 mm in width. The metacercaria of *Euclinostomum* were elongated with round ends, 3.58-4.42mm in length and 1.62-1.98 mm in width. Examination of helminthes parasites indicated that ecological factors play a key role in their distribution and that the host lengths do influence the occurrence of helminthes parasites. *Channa punctatus* is feeding on crustaceans, copepods, worms' larvae and small fishes not only on the bottom but also from the water column. This feeding habit has increased possibility of ingested food infected with many parasites.

Habitat preference, abundance and assemblage pattern of the fishes in a tropical Indian river

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Fish and habitat sampling was conducted at 50 sites in river Ken, a tributary of river Ganga basin from 2007 to 2010 and data were analyzed for 5186 fish individuals of 24 fish species of conservation and fishery management interest. Out of the total fish species seven belong to the 'endangered' (EN) and 8 belong to the vulnerable (VU) category are of regional conservation concern. A Cyprinid, *Puntius sarana* was recorded to be the most widely distributed species (frequency of occurrence 76%) and accounted for about 18.03% of the RA out of the total species in this study. We used canonical correspondence analyses to determine the influence of environmental conditions on species abundances, species occurrences and assemblage characteristics. Regarding the microhabitat, hydromorphological parameters (depth, current velocity and substrate) followed by DO and conductivity and TDS are of significant for the structure of the fish community. Furthermore, local habitat variables, overhanging vegetation and land use are of subordinate but significantly important for the assemblage of the fishes in river Ken. The most species rich group was associated with deep waters with slow water current, higher percentage of sandy substrate and presence of rangeland land use. The groups with the fewest species associated with average and lower concentration of dissolved oxygen and conductivity. Our results suggests the importance of local environment influences on the fishes which are of conservation and management interest and provide a framework and reference for conditions and assemblage structure in other tropical rivers in India.

Arsenic removal from water by using natural material

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Arsenic (As) is an emerging drinking water contaminant of mainly geogenic origin in ground water sources. It poses serious health hazard among consumers and causes arsenicosis and variety of cancer. Several biological and physico-chemical processes are being used for removal of As from water. In this study, attempt has been made to use *Hibiscus rosasinensis* flower pulp after extraction of natural dye as biosorbent for removal of arsenic from water. Studies were performed in batch mode to assess the efficacy of removal at optimum conditions. 96% removal of As on equilibrium position was noticed with 1.0 gm / 100ml of biomass with agitation rate 150rpm after contact time of 5 hours at pH 7.0,temperature 25°C, It is suggested that the adsorption data follows both Langmiur and Frendlich isotherm models in this study. The findings exhibited that Langmuir model is better fitted than Frendlich isotherm model for adsorption data. This study indicates that the flower of *H. rosasinensis* even as waste material from dye industry exhibits a large binding capacity for arsenic. Therefore, this herbal biosorbent is cost-effective, eco-friendly and may be used for mitigation of As contamination in ground water.

Characterization and phylogenetic analysis of mahseer species using ribosomal DNA sequences for use in conservation program

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Mahseer is the common name of the fishes belonging to family Cyprinidae (carps) under the genera *Tor*, *Neolissochilus* and *Naziritor*. They are commercially important food as well as excellent game fish found in India and adjoining countries. They fetch high market price and are potential candidate species for aquaculture. There is taxonomic ambiguity in nomenclature/ classification of different mahaseer in genus *Tor* in India. Moreover, a recent decline in mahseer fishery, due to various anthropogenic stresses, is an alarming call for developing appropriate management and conservation strategies. The molecular biology studies helped in understanding the genetic variability and provided information about the phylogenetic relationships among the species for evolving aquaculture and conservation strategies.

The effective management and conservation of typically multi-species mahseer fisheries will require collection of DNA sequence data on species-specific basis. In the present study, the specimens of eight mahseer species, namely *T. khudree*, *T. mussullah*, *T. putitora*, *T. chelynoides*, *T. progeneius*, *T. mosal mahanadicus* and *N. hexagonolepis* belonging to genera *Tor* and *Neolissochilus* were collected from different water bodies of the country. Detailed karyomorphological investigations were carried out in all the species using Giesma, Ag-NOR, CMA_3 staining and C-banding techniques. The 45S and 5S rDNA regions were amplified, cloned, sequenced and the sequences were submitted in GenBank with different accession number. Phylogenetic relationships were drawn between these mahseer species. The 45S and 5S rDNA sequences were localized on the chromosomes using dual color FISH. Two pairs of 45S rDNA signals were observed in *T. khudree*, *T. mussullah*, three pair in each *T. putitora*, *T. chelynoides*, *T. progeneius*, *T. mosal mahanadicus*, *N. hexagonolepis* and five pairs in *T. tor*. One pair of 5S rDNA signals were found in all the species, although one additional 5S rDNA signal in *T. mosal mahanadicus* has been observed. Organization of 5S rRNA in five geographically isolated populations of *T. putitora*, examined through southern blot hybridization, showed the presence of single type of 5S rDNA repeat of 201 bp long. The implications of the finding have been discussed.

Isolation and characterization of *Schizothorax richardsonii* hypothetical protein

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Proteins interacting with the biological information molecules DNA and RNA play important cellular roles in all organisms. One widespread super family of proteins implicated in such function(s) is cold stress proteins. However, cold temperatures are no barriers to aquatic life, as various trout fishes flourish in cold environments. In an attempt to isolate Cold stress proteins from *Schizothorax richardsonii* (Indian Snow trout), tissue samples (Liver, kidney, Brain, Fin, Heart, spleen, Muscle, Intestine) were collected from Sikkim (4-5'C) in RNA later solution. The RNA was isolated by using the Trizol Reagent. After quantification the cDNA was synthesized by using the cDNA synthesis kit. The cDNA of different tissues was amplified by using the primer designed from Eelpout (ACC. No. U20439) AFP-III protein. A 285 bp amplicon was observed in fin cDNA shows non-hepatic expression. The amplicon was cloned in the p GMT easy vector and sequenced. After sequencing the sequence did not revealed any significant similarity with any known proteins submitted in public domain databases. However, it was submitted to the GENBANK (ACC. NO. HM641836) as uncharacterized hypothetical *Schizothorax richardsonii* specific partial mRNA.

Keywords: *Schizothorax richardsonii*, AFP, cDNA, Fin, Liver

Role of soil amendments on the bioavailability of heavy metals from zinc mine tailings containing soil to plants, using the Indian mustard plant (*Brassica juncea*)

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Zinc mine tailings constitute a major soil contaminant, but the levels of the toxic material are too low to make conventional recovery technology cost effective. If unmanaged properly, the metallic residue will persist and enter biological systems. So the approach suggested in the study to make them biologically unavailable through matrix sequestration, offer promise for field application. For this, a study was conducted to test the effects of soil amendments on the bioavailability of heavy metals in a zinc mine tailings containing soil to plants, using the Indian mustard plant (*Brassica juncea*) as a test organism. Zinc mine tailing containing soil was amended with humus soil and phosphatic clay. The zinc mine tailing containing soil was characterized for heavy metals (Pb, Cu, Zn and Mn). It was mixed with phosphatic clay and humus rich soil, and four mixtures were prepared. The first mixture contained zinc mine tailing soil, and served as a control. The second mixture contained zinc mine tailing soil and phosphatic clay in the ratio of 1:1 (w/w). The third mixture contained zinc mine tailing soil and humus rich soil in the ratio of 1:1(w/w). The fourth mixture containing zinc mine tailing soil, phosphatic clay and humus rich soil in the ratio of (2:1:1) (w/w). The study was conducted at the interval of 14, 28 and 42 days. The bioavailability of Pb, Cu, Zn and Mn from zinc mine tailing soil alone in *Brassica* plant was in the range of 94-99% up to 42 days. Addition of phosphatic clay and humus rich soil to the zinc mine tailing soil reduced the bioavailabilities of Pb by (15%), of Cu by (20%), of Zn by (20%) and of Mn by (25%) in the mustard plant. The data showed that phosphatic clay in the presence of humus rich soil had a high affinity for the heavy metals in the order of Pb, Cu, Zn and Mn.

Bacterial degradation and detoxification of melanoidins from post methanated distillery effluent (PMDE) for environmental safety

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This study deals the bacterial degradation and detoxification of melanoidin, a major colouring and polluting component in distillery effluent, metabolite characterization and toxicity assessment test on *Phaseolus mungo* L. seeds. Results revealed that the developed bacterial consortium was capable for 70.66% melanoidin degradation at optimized laboratory conditions. The HPLC analysis of control and bacteria degraded melanoidin showed reduction as well as shifting of peaks compared to control indicating the biodegradation and biotransformation of melanoidins. Further, the LC-MS-MS and other spectrophotometric analysis has shown that compounds dihydroxyconiferyl alcohol, 2,2'-bifuran-5-carboxylic acid, 2,3-dimethyl-pyrazine methylbenzene 3-pyrroline and acetic acid detected in control samples were completely degraded by bacteria. While compounds 2,2'-bifuran and indole with were produced as new metabolite and compounds 2-nitroacetophenone, p-chloroanisol, 2-methylhexane and 2,3-dihydro-5-methylfuran were found to be most recalcitrant in nature during the bacterial degradation of melanoidin. In seed germination test, it was observed that 60, 80 and 100% undegraded melanoidin concentration inhibited 20, 40 and 60% seed germination, respectively. But, after bacterial degradation, 60% melanoidin concentration showed 100% germination. In addition, 80 and 100% melanoidin concentration showed complete inhibition of root development. Further, the *Phaseolus* seeds treated with 60 and 80% undegraded melanoidin showed reduced amylase activity and it become completely absent at 100% melanoidin concentration. But, seeds treated with bacteria degraded melanoidin showed amylase activity and the molecular weight of á-amylase enzyme determined by SDS-PAGE was approximately 47.5, 46 and 44.5 KDa, respectively.

Biodegradation of phenol by axenic and mixed culture isolated from distillery sludge - Identification and degradation potential

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Among organic pollutants, phenol is well known for its high toxicity for humans and animals. Phenol is a commonly pollutant of industrial waste. It is prevalent in the waste generated from the factories of iron-steel, coke petroleum, pesticide, paint solvent, pharmaceutical, wood processing chemicals, distilleries and pulp paper mills. Seven isolated aerobic bacterial strains from distillery sludge, screened for phenol tolerance on mineral salt medium (MSM) at different concentration of phenol. Bacterial strains were unable to utilize phenol in absence of glucose, indicated the phenomenon of co-metabolism. Among the seven isolated bacterial strains, only ITRC BK-4 and ITRC BK-7 found potential and identified as *Paenibacillus thiaminolyticus* (DQ435022) and *Bacillus cereus* (DQ435023) respectively. Phenol degradation was monitored routinely with spectrophotometer and further confirmed by HPLC analysis. ITRC BK-4, ITRC BK-7 and mixed culture was found to degrade 700 ppm phenol up to 51.72, 80.00 and 84.57% respectively in MSM at temperature 37±1°C, pH 7.5±0.2, aeration rate 120 rpm in presence of 1% glucose (w/v) as an additional carbon source within 144 h incubation. Further, the mix culture was found more potential for phenol degradation as compared to axenic. The axenic and mixed strains of these bacteria would be useful for bioremediation of phenol containing distillery waste in the environment.

Keywords: Bacillus cereus; Degradation, HPLC; Paenibacillus thiaminolyticus; Phenol

Arsenic contamination of groundwater in endemic areas of Uttar Pradesh: A case study

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In recent years much attention is being paid to explore the correlation of varying factors to groundwater arsenic poisons. Herein, this has been investigated that ground water samples of Ballia (UP) meet to exceed the Bureau of Indian Standard (BIS) limits for the arsenic and physico-chemical findings of these water samples provide evidence ample discrepancy with water standards. Here, it was investigated that iron was also identified above their recommended permissible limit as set by BIS. Out of 150 selected sources of water, 91 samples have all analyzed parameters beyond desirable limit and water from these sources can't be used for drinking purpose without special pretreatment. 59 sources of water have some parameters more than desirable limit but still within permissible limit, water from these sources can be used for drinking purpose in absent of alternate source. The expected outcome of the present research work is to explore the mobilization of arsenic in Gangetic plains by correlating the various contributing factors in water arsenic poisoning and developing concern to initiate the remediational measures to tackle this present crisis in drinking water reclamation process.

Study on life-history traits of endangered golden mahseer, *Tor putitora*, in *ex-situ* condition for conservation

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Despite their abundance at one time, mahseer is declining very rapidly in number and size in different parts of India. The National Commission on Agriculture (1976) in its report on fisheries stated that there was a general decline in the mahseer fishery due to indiscriminate fishing of brood and juvenile fish and adverse effects of river valley projects, and also suggested extensive surveys and detailed ecological and biological investigations. Sarma *et al* (1988) conducted culture of *Tor putitora* at Ghomansa Fish Farm in Jammu and Kashmir. In Nepal, Shreshtha (1988) explored possibilities of mahseer culture with management. Shegal and Malik (1992) and Singh (1992) have already emphasized the need of aquaculture of the golden mahseer (*Tor putitora*) in Himalayas and Terai area of Kumaun Himalaya, respectively.

The present work was aimed to study on biology of an endangered golden mahseer *Tor putitora* in pond (fresh water) condition for its management and conservation. The results of physico-chemical parameters, morphometric measurements, length-weight relationship, and condition factor, age and growth determination by scales, relative length of gut, gastro-somatic index, gut length in relation to body length, gut content analysis and frequency occurrence of different food items of *Tor putitora* cultured in pond condition were recorded. During the period under investigation, the maximum recorded water temperature, transparency, pH, dissolved oxygen, free carbon dioxide and total alkalinity were found to be: 35^{0}C, 32.7 cm, 7.5 ppm, 7.5 ppm, 4.2 ppm, and 110 ppm, respectively while the corresponding minimum values were 14^{0}C, 15.5 cm, 6.5 ppm, 5.2 ppm, 1.2 ppm and 45.8 ppm. Morphometric characters showed proportional increment with the body length and age.

The observation of length-weight relationship indicates the allometric growth. The value of "r" which is a measure of the degree of association between "L" and "w" (co-relation coefficient) was 0.95214 which indicated that the relationship between length and weight was significant at 1% level. The exponent value "b" was found to be 2.6035 and condition factor 0.86626. Age and growth study indicates that the growth of *Tor putitora* is more in first year than successive year classes. The 1st ring appeared in 140-150 mm age group, 2nd in 230-240 mm and 3rd in 410-420 mm. Scale radius also increases with the increase in size. During the present investigation, the mean relative length of gut was found 2.7 while mean gastro-somatic index was 2.4 indicating that the fish is omnivorous in habit. In the present study, the gut length with respect to body length shows non-linear relationship but it increases with the fish length in general. Fish prefers the animal matter as food (52.63%). Artificial food was also found in good percentage in the gut content.

Results of the present study indicate that *Tor putitora* has tendency to adopt themselves in the different environmental conditions with slight modification in the morphometry such as mouth gap, lips *etc.* The allometric pattern of growth was followed by the fish under pond conditions. The ring formation also differs from natural environment to control condition. Alimentary canal shows some variations according to the different habitats. Artificial feed is also taken by the fish in good quantity. So, it is clear that fish is adoptive in nature to artificial food. It is concluded that the golden mahseer can be cultured in different eco-biological conditions with proper management. If this fish attains sexual maturity and breeds in the pond conditions, then it will prove a great milestone towards its conservation.

Biodiversity in Icthyofauna and Hydrological Parameter of Chando lake, Basti (U.P)

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Chando lake is situated at 8-10 km from Basti District head quarter in the south on the way to Kalwari. It is believed that in ancient time, there was an state name Chandra Nagar, which had been later converted into a lake as a result of natural disaster (Degradation) and became the famous Chando lake. It is an unexplored lake from research view point and stretched in about 5.0 km long and 4.0 wide. Around this lake fisherman and others are still getting ornaments. Migratory birds also use to visit in this lake every year. Keeping vast area in view, present paper has been framed to study its hydrological parameters and biodiversity of Icthyofauna of this vast lake from July 2009 to June 2010. The average value of water temperature was recorded 28.2°C, pH 7.4, transparency 59.6 cm, dissolved oxygen 4.4 mg/l, free CO_2 3.9 mg/l, Nitrate 7.2 mg/l, Phosphate 0.8 mg/l, Sulphate 61.6 mg/l, BOD 4.1 mg/l, COD 55.2 mg/l, Fluoride 0.5 mg/l, Total alkalinity 262.6 mg/l. The fish biodiversity of this lake comprises of 9 orders, 14 families, 22 genera and 36 species. Out of which 14 fish species are found in abundance, 15 fish species are found moderate, 7 species are rare, 21 fish species are of much economics significance, 8 species are of less economics and rest 8 are found to be commercial important species.

Effect of stage and seasonal differences on length-weight relationship and condition factor of chocolate mahseer (*Neolissochilus hexagonolepis*): A new candidate species for hill aquaculture

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The paper embodies to develop a comprehensive length-weight relationship of chocolate mahseer considering its different stages of life and various seasons. In the present study 155 specimens of chocolate mahseer of variable sizes ranging from 21-168 mm total length and 0.14-44.2 gm body weight were sampled from culture system at Directorate of Coldwater Fisheries Research, Bhimtal. ANCOVA results suggested that the length-weight relationship of this fish species is not affected by different seasons and various stages of its lifespan. Nonlinear model fitted to the dataset has shown appropriateness, which follows isometric growth. The condition of the fish is found to be progressively better in the advanced stages whereas the maximum average condition and relative condition factors are observed during spring season.

Keywords: morphometric character, isometric growth, nonlinear model, condition factor.

Regulatory norms and guidelines for transgenic crops: An overview

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The genetically modified crops have been developed worldwide with increase in cultivated area more than 50-folds during last 10-years globally. Although nature is doing modifications from generations however, manmade modifications at the genetic level created hue and cry as it may lead to toxicity in human and may also affect flora and fauna. Many countries have established labeling systems based on their own criteria, with thresholds for unintentional mixing of GM crops to the level of contamination at 0.9% in the EU, 3% in Korea,5% in Japan etc. However, so far no GM Food is being allowed to be marketed in India except Bt cotton a feed to be cultivated in 9 states viz. Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharastra, Tamilnadu, Punjab, Harayana and Rajasthan. As such DBT have instituted biosafety regulations i.e. Environmental Protection Act (EPA) 1986, Rules on GMO's as notified on 5.12.1989. This rule covers manufacture/use/import/export/storage and research on GMO's and one needs to take the approval from Review Committee on Genetic Manipulation (RCGM) through Institutional Biosafety Committee (IBSC).Recently Supreme Court has also issued the guidelines for GM to be allowed in field trials but its contamination not to exceed 0.01%. One of the relevant issue in Indian context is to regulate the presence of GM (Transgene) in import & export consignments as we have threats from countries like China, Thiland, US, Canada etc, where many GM crops are freely cultivated. IITR has initiated efforts to detect and quantitate transgenes in GM crops by recent, advanced, highly sensitive, DNA based protocols using PCR and Real Time PCR techniques. This can help in identifying the transgenes in very low copy number in any food component with special reference to MON 810- GMMaize (Cry1Ab), RRSoy (epsps), GM Rice (Galanthus Nivalis *aglutinin*).

Carcass and minerals composition of *Semiplotus semiplotus*

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Semiplotus semiplotus is considered to be one of the most important fish species of North-East Himalayan region. This may be considered as a new candidate species for hill aquaculture. The purpose of the study was to investigate proximate and mineral compositions of this species. Specimens were caught from Arunachal Pradesh, India. Mean values for the proximate composition (wet basis) were: protein 17.582%, lipid 9.493%, Moisture 68.5825 and ash 1.073%. This study revealed that the tissue of *Semiplotus semiplotus* is an important source of protein for. Mineral (Sodium, Potassium and Calcium) ranging from 0.133-0.701 mg/100gm. Trace elements *viz.* Iron, Manganese, Zinc and Selenium contents varied from 0.184-3.889 mg/ 100gm. The data obtained provide the nutritional fact of this particular fish, which will be fundamental importance for the consumers.

Key words: *Semiplotus semiplotus,* protein, fat, minerals, trace elements.

Temperature dependent changes in mortality and behavioural responses of freshwater mussel *Lamellidens marginalis* (Lamarck)

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Temperature is a crucial determinant of biogeography, directly affect behavioral and physiological activity of the organisms. Increasing threat of global warming produced a matter of great concern for the scientist to obtain relevant knowledge about the tolerance of organisms to the temperature. The present, short-term (96h) static bioassay was conducted to evaluate the effect of temperature on dimethoate toxicity to freshwater mussel *Lamellidens marginalis* which is a sedentary slow responsive and hardy animal, remain well protected with in calcareous shell valves. The mussel, were exposed for 24h, 48h, 72h, and 96h at different concentrations of dimethoate in month of January at water temperature 14.9±1.2°C (Concentrations 155.00, 160.00, 165.00, 170.00, 175.00, 180.00, 185.00, 190.00, 195.00, and 200.00 mg/l) and in month of August at water temperature 28±0.5°C (Concentrations 35.00, 37.00, 39.00, 41.00, 43.00, 45.00, 47.00, and 49.00 mg/l). The 96h LC_{50} value recorded in the month of August at higher temperature was 36.34 mg/l and in month of January at low temperature was 163.59 mg/l. The mussel exposed in month of August at higher temperature show more sensitive behavioral responses like huge mucus secretion, sudden closure of shell valve, quick post-mortem changes and increased oxygen consumption in comparison to exposure in the month of January at low temperature. The bioassay results demonstrate that the mussels are more sensitive to dimethoate at high temperature than low temperature. Therefore, the increasing threat of global warming increases the risk of pesticide toxicity in the exposed organisms.

Keywords: Freshwater mussel, Toxicity, Temperature, Behavioral responses, Global warming.

Genetic characterization of three species under genus *Schizothorax* using RAPD-PCR assay

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The usefulness of random amplified polymorphic DNA (RAPD) was examined as a potential tool to differentiate *Schizothorax* species (Cyprinidae: Pisces). It proved to be a quick, effective mean of finding genetic markers to separate three *Schizothorax* species of morphologically difficult to distinguish, *S. richardsonii, S. progastus* and *S.niger.* The samples for *S. richardsonii* were collected from Teesta river near Ranipul, Sikkim, *S.progastus* from Alaknanda river near Uttarkashi, Uttarakhand and *S.niger* from Jhelum river near Srinagar, Jammu & Kashmir. Species specific markers were observed using 10 mer random primers through RAPD-PCR assay. The statistical analysis of RAPD was performed with the software POPGENE version 1.31. For all statistical tests we chose a significance level a= 0.05 and a simulation of 1000 permutations. The 5 RAPD 10 mer primers generated a total 25 consistently scorable bands size ranging from 2500 -150bp. Only 2 species specific fragments (2000bp and 2500bp) were detected for *S. richardsonii* and *S. progastus* respectively. Nei's genetic diversity (h) was found to be highest in *S. richardsonii* with 0.44 followed by 0.39 and 0.35 in *S. progastus* and *S. niger*, respectively. The total gene diversity (H_t) in the population was 0.47, within sample gene diversity (H_s) = 0.340 and the genetic differentiation (G_{st}) of all populations was 0.1510 with a gene flow (Nm) = 2.81. Dendrogram based on UPGMA, was constructed and revealed a close relationship between *S. richardsonii* and *S. progastus* forming single cluster and another cluster consisted of *S. niger*.

Keywords: *Schizothorax richardsonii, S. progastus, S. niger*, genetic characterization, RAPD-PCR, genetic diversity

Genetic diversity of *Tor putitora* population-inferred from mitochondrial DNA sequence

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Tor putitora, also known as Golden Mahseer is a high valued indigenous fish of the Himalayan region. It is one of the most important coldwater fish, in social, ecological and economic term and attracted the attention of amateur anglers throughout the world. In recent times it was observed a decline in the natural stocks in several water bodies of the above species. A research programme entitled Outreach Activity on "Fish Genetic Stock", was formulated particularly by Fisheries Division, ICAR with some objectives related to registration and ex-situ conservation of some species including golden mahseer. Within this programme DCFR team is trying to determine the genetic variation of the natural populations of above species using mtDNA. The application of mitochondrial DNA as a genetic marker has become widespread for population genetic studies. In most species mtDNA is highly variable and is therefore a useful marker for detecting possible genetic differentiation. Direct sequencing of mitochondrial DNA (mtDNA) Cytochrome b gene (307 bp) was used to investigate genetic variation of three population of *Tor putitora*. The genetic variation and phylogenetic relationship of three geographically isolated populations of *Tor putitora* (collected from Bhimtal, Manan and Himachal Pradesh) were investigated at mtDNA level. Nucleotide diversity was estimated by DnaSP (version.5), the overall nucleotide diversity was ranging from 0.46952 to 0.51238. Nucleotide diversity for Bhimtal population was low 0.04571, for Manan population was 0.06857, and high for Himachal Pradesh population 0.08571. In addition, phylogenetic relationships amongst mtDNA sequences were examined using UPMGA tree, the phylogenetic analysis revealed that the *Tor putitora* mtDNA consisted of two divergent clusters. The data shows close relationship between Manan & Bhimtal populations rather than Himachal Pradesh population. The findings from the present study have important implication for aquaculture, management and conservation of *Tor putitora*.

Keywords: *Tor putitora*, mtDNA, Cytochrome b, nucleotide diversity.

Genetic analysis of three wild populations of *Barilius bendelisis* by Mitochondrial DNA marker

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Barilius bendelisis (Cyprinidae: Pisces) from three wild populations were analysed for nucleotide sequence variation for mitochondrial (mtDNA) gene Cytochrome b (Cyt b). The three populations of *Barilius bendelisis were* collected from Saryu river at Ghat, Kalsa river at Chanfi and Kosi river at Ramnagar. The aim of the present study was to present a preliminary assessment of the genetic variability of three wild populations, based on the nucleotide sequence of Cyt b region. A segment of approximately 307 base pairs (bp) that corresponds to the Cyt b region of the mtDNA was amplified by Polymerase chain reaction (PCR). Sequences of the mtDNA Cyt b region of *Barilius bendelisis* were deposited in GenBank, under the accession numbers: HM 636836-636848. The statistical analysis of mtDNA sequences was performed with the software MEGA 4.0 and DNA SP 5.1. Common substitutions detected in these populations were transitional mutations, the nucleotide frequencies are 0.221 (A), 0.295 (T/U), 0.29 (C), and 0.194 (G). Nucleotide diversity was high (0.0096) in Kosi river population and low (0.0094) in Saryu river and Kalsa river populations. Dendrogram based on UPGMA, was constructed and revealed a close relationship between *Barilius bendelisis* Saryu river *and Barilius bendelisis* Kalsa river forming single cluster and another cluster consisted of *Barilius bendelisis* Kosi river. The data shows that Kosi river population of *Barilius bendelisis* is highly diversed then other two populations. The obtained data can be useful in selecting fish stocks that preserve a better genetic diversity of *Barilius bendelisis* for use in conservation and hatchery programs.

Keywords: *Barilius bendelisis*, mtDNA, Cytochrome b (Cyt b), Genetic analysis, nucleotide diversity.

Polytanks is better alternative of fish culture in mid hills

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A pond is mulch with the polythene is called polytank. Polytanks (10 no.) of a total volume of 1200 m^3 were constructed for water conservation cum irrigation tanks in Dharauj village of Champawat district under "Enhancement of Livelihood Security through Sustainable Farming Systems and related farm Enterprises in North-West Himalaya; NAIP Component-3" during 2008-09. The depth of the tanks were kept 1.5-2.0 meters and they were stocked during March 2008 with the 2.5 fingerlings per cubic meter of water at the rate of 20% Silver carp, 40% Grass carp and 40% common carp. The average growth of fishes were observed in the polytanks are given in the table-1 and the physicochemical parameters are show in the table-2.

Table 1. Growth of Fishes

Species	Length (mm)	Weight (gm)	Average Weight (gm)
Silver Carp	275-350	200-360	298
Grass carp	185-340	160-800	363
Common Carp	140-255	145-255	211

Table 2. Water Quality Parameters

Cluster	Water temp (°C)	pH	DO (ppm)	FCO_2 (ppm)	Alkalinity
Dharauj	6-28	7.5-8.5	6.0-10.4	0-2	46-74
Mudyani	7-30	7.4-7.7	7.0-11.0	0-2	36-54
Makot	12-32	7.7-8.5	4.0-7.6	2-4	48-76

It can be concluded that on an average about 691 gm per cubic meter growth was observed and a 67 % survival rate was recorded. The growth of the fishes is about 87 % more than of the earthen and cemented tanks this is due to the water temperature increment 2-6 °C in the polytank than that of earthen and cemented tanks. Therefore, the polytanks are more suitable for composite fish culture in the mid hills.

Salicylic acid interferes with the mitochondrial bioenergetics of *Helicoverpa armigera*

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Salicylic acid (SA), a phenolic compound, is an important effector molecule influencing the secondary metabolic system in plants. Exogenous application of SA on plants has long been known to activate expression of pathogenesis related genes and induce resistance to plant diseases and insect pests. Elevated levels of SA in plants are associated with increase in the expression of resistance to insect pests and plant pathogens. The present studies were therefore undertaken to investigate the effect of SA on the oxidative phosphorylation, and the enzymes involved in electron transport chain in the mitochondria of cotton bollworm/legume pod borer, *Helicoverpa armigera,* one of the most devastating pest of field crops. This pest has developed high levels of resistance to commonly used insecticides. The isolated mitochondria were also investigated for the presence of terminal oxidase by oxygen uptake studies using oxygen electrode, expecting its role in development of resistance to insecticides, because it is known that terminal oxidase has the ability to bypass inhibition of parts of the electron transport chain that contributes to development of resistance to fungicides. The present studies revealed that SA induced increased respiration at lower concentrations (< 0.1 mM), but severely inhibited respiration at higher concentrations. SA at 2 mM concentration inhibited 32.1%, 58% and 57% of oxygen uptake for the substrates succinate, NADH, and pyruvate, respectively. The residual activity was found to be 80.3%, 55.5% and 87% for the enzymes NADH dehydrogenase, succinate dehydrogenase, and F0F1 ATPase in the presence of 5 mM of SA. Cyanide resistant oxygen uptake was not observed with any of the substrates, suggesting that terminal oxidase is not present in the mitochondria of *H. armigera.* Since SA interferes with the oxidative phosphorylation in mitochondria of *H. armigera,* elevated levels of SA in plants might render the host plants less suitable for growth and development of insects.

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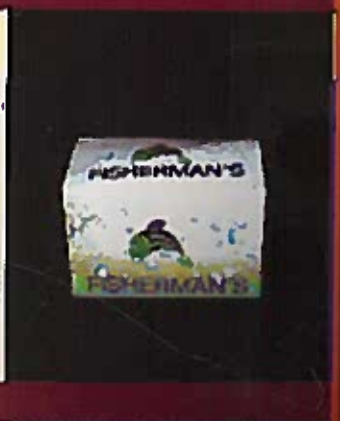

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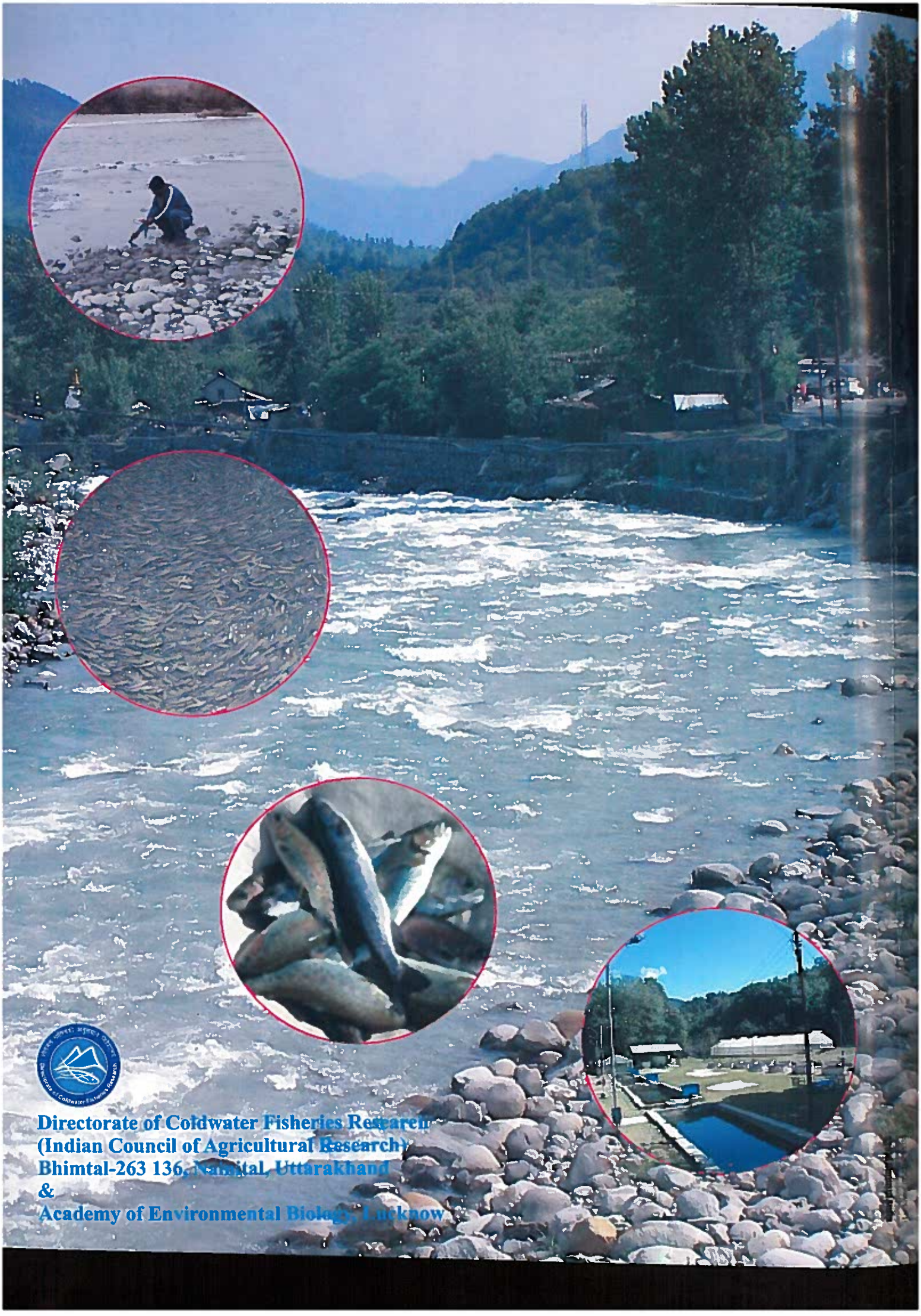

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