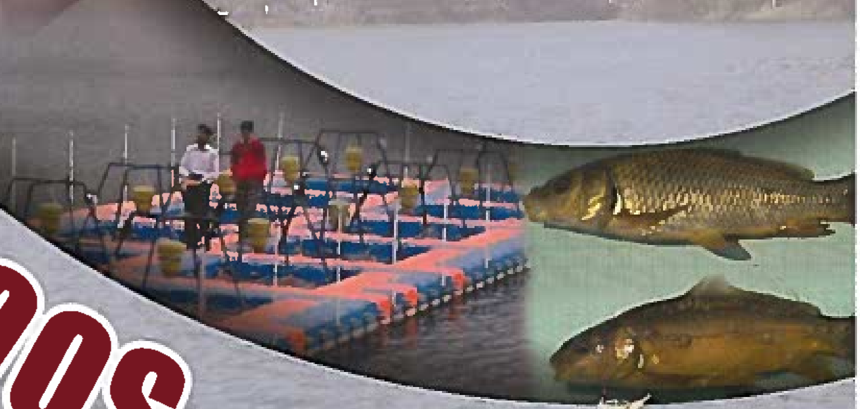
SOUVENIR-CUM-ABSTRACT BOOK

National Seminar
on
Mountain Fisheries: Challenges and Opportunity for Livelihood Security

5–6 November, 2012



Directorate of Coldwater Fisheries Research
(Indian Council of Agricultural Research)
Bhimtal -263 136, Nainital (Uttarakhand)

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch

National Seminar
on
Mountain Fisheries:
Challenges and Opportunity for Livelihood Security

5-6 November, 2012

SOUVENIR-CUM-ABSTRACT BOOK

Editorial Committee

N.N. Pandey | R.S. Patiyal | Neetu Shahi | M.S. Akhtar

Organized by
Directorate of Coldwater Fisheries Research
(Indian Council of Agricultural Research)
Bhimtal-263136, Nainital, Uttarakhand

भाकृअनुप
ICAR

National Seminar on

Mountain Fisheries: Challenges and Opportunity for Livelihood Security

5-6 November 2012

Organized by

Directorate of Coldwater Fisheries Research (Indian Council of Agricultural Research)
Bhimtal-263136, Nainital, Uttarakhand.

Chief Patron

Dr. S. Ayyappan
Secretary, DARE and DG, ICAR, New Delhi.

Patrons

Dr. B. Meenakumari
DDG (Fisheries), ICAR, New Delhi.

Dr. C. Vasudevappa
Chief Executive, NFDB, Hyderabad.

Convener

Dr. P.C. Mahanta
Director, DCFR, Bhimtal.

National Advisory Committee

Dr. M.V. Gupta

Dr. S.A.H. Abidi

Dr. M.Y. Kamal

Dr. B.S. Bisht

Prof. Brijgopal

Dr. S.P.Ayer

Dr. George John

Dr. A.S. Ninawe

Dr. P. Das

Dr. K.L. Sehgal

Dr. K.K. Vass

Dr. W.S. Lakra

Dr. Madan Mohan

Dr. S.D. Singh

Dr. A.G. Ponniah

Dr. G. Syda Rao

Dr. A.P. Sharma

Dr. T.K. Srinivasa Gopal

Dr. J.K. Jena

Dr. P. Jaysankar

Dr. J.C. Bhatt

Prof. W. Vishwanath

Co-conveners

Dr. A. Barat
Principal Scientist, DCFR

Dr. Debajit Sarma
Principal Scientist, DCFR

Organizing Secretaries

Dr. P.K. Sahoo
Senior Scientist, DCFR

Dr. Prem Kumar
Senior Scientist, DCFR

Joint Secretaries

Dr. S.K. Srivastava
Senior Scientist, DCFR

Dr. Shahnawaz Ali
Scientist, DCFR

Dr. Neetu Shahi
Scientist, DCFR

शरद पवार
SHARAD PAWAR

कृषि एवं खाद्य प्रसंस्करण उद्योग मंत्री
भारत सरकार
Minister of Agriculture & Food processing Industries
Government of India

Message

Coldwater fisheries have a great potential in income generation and in providing food and nutrition security to the economically underprivileged population of the hills region of India. Our hill areas are bestowed with valuable indigenous fish germplasm and pristine water resources with tremendous range in thermal regime. Thus, fishery production can be increased manifold if various natural Himalayan lakes located at different altitudes, newly created and existing upland reservoirs and other water sources are managed scientifically.

I am happy that know that the Directorate of Coldwater Fisheries Research, Bhimtal, is organizing a national seminar on 'Mountain Fisheries: Challenges and Opportunity for Livelihood Security' in commemoration of its Silver Jubilee celebrations during 5-6 November, 2012.

It is hoped that the deliberations and recommendations from the seminar will generate new vistas and action plans for enhancing aquaculture productivity, and thus provide livelihood security to the disadvantaged population of the hills region.

I extend my best wishes for the success of the seminar.

(Sharad Pawar)

सत्यमेव जयते

हरीश रावत

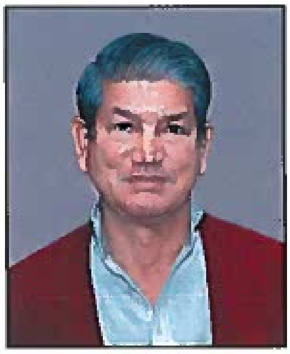
HARISH RAWAT

राज्य मंत्री

कृषि, खाद्य प्रसंस्करण उद्योग एवं संसदीय कार्य

भारत सरकार

Minister of State Agriculture, Food Processing Industries
& Parliamentary Affairs
Government of India



Message

The emerging production technologies, higher economic growth, population explosion and shifts in the dietary patterns are leading to rapid growth in production as well as demand of food of animal origin. Coldwater fishery sector in India contributes to the livelihood security of a large section of economically underprivileged population of the hills regions. Thus, it is very important to adopt conservation practices through public participation and development of feasible fish-framing techniques in cold water fishery sector to face newer challenges in hills such as population upsurge and urbanisation.

I am happy to know that the Directorate of Coldwater Fisheries Research, Bhimtal, is organising a national seminar on 'Mountain Fisheries: Challenges and Opportunity for Livelihood Security' during 5-6 November, 2012 on the occasion of the silver jubilee celebrations.

I hope that the national seminar will help in the development of fisheries and welfare of fisher-folk in the ensuing years.

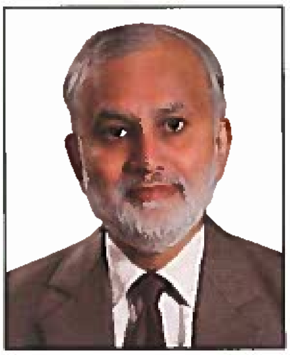
(Harish Rawat)

सत्यमेव जयते

डॉ एस. अय्यप्पन
सचिव एवं महानिदेशक
Dr. S. Ayyappan
Secretary & Director General

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 001

Government of India
Department of Agricultural Research & Education
and
Indian Council of Agricultural Research
Ministry of Agriculture, Krishi Bhavan
New Delhi 110 001



Message

India has significant coldwater fisheries resources, and the Directorate of Coldwater Fisheries Research, Bhimtal, has contributed significantly in the development of these resources. It is working on the enhancement of productivity of natural water bodies for sustainable utilization, of fish production through expansion of hill aquaculture, species diversification, system diversification for mitigating climate change, disease monitoring and control, value-addition and market development and water conservation

It is a matter pleasure that the institute is organizing a national seminar on 'Mountain Fisheries: Challenges and Opportunity for Livelihood Security' during 5-6 November, 2012.

I hope that the technologies developed at the Directorate of Coldwater Fisheries Research will continue to energise coldwater fisheries sector, and the seminar will address all the issues related to this sector to ensure livelihood security of hill people.

I wish the seminar a grand success.

(S. Ayyappan)

Dated the 23rd October, 2012
New Delhi

डॉ (श्रीमती) बि. मीनाकुमारी
उप महानिदेशक (मात्स्यिकी)
Dr. (Ms) B. Meenakumari
Deputy Director General (Fisheries)

भारतीय कृषि अनुसंधान परिषद
कृषि अनुसंधान भवन-II, नई दिल्ली 110 002
Indian Council of Agricultural Research
Krishi Anusandhan Bhavan-II, Pusa
New Delhi 110 001

Message

I am pleased that the Directorate of Coldwater Fisheries Research, Bhimtal is organizing a two day national seminar on "Mountain Fisheries: Challenges and Opportunity for Livelihood Security" during 5-6 November, 2012 in commemoration of its silver jubilee year. This will provide the platform to discuss the current important issues in coldwater fisheries sector and their possible solutions. The availability of fishery resources in hill regions in terms of gene pool is diverse which include large population of indigenous and exotic fish species and have tremendous potential for upland aquaculture practices, sports fishing and eco-tourism. The coming decades are expected to pose newer and greater challenge to coldwater fishery sector. The themes of seminar are quit concern with the immerging issues of coldwater sector. I hope that the recommendations emerged out of this national seminar will pave the way for overall development of the coldwater fisheries sector in India.

I felicitate the organizers and wish the seminar a grand success.

(B. Meenakumari)

Preface

P.C. Mahanta
Director, DCFR

I am very happy to be heading the Directorate of Coldwater Fisheries Research (DCFR), Bhimtal under Indian Council of Agricultural Research (ICAR), when it is completing its twenty fifth splendid year of research. In the past twenty five eventful years, the Directorate and the coldwater fisheries sector has witnessed many triumphant moments. The interactions and linkages with stakeholders are helping the Directorate to accomplish its mandates in a satisfying manner.

Coldwater fisheries have a great potential in generating rural income and providing food security to the upland rural community of India. The coldwater sector includes immense fisheries resources and a great reservoir of biodiversity that can be tapped for food and nutritional security. The Directorate is on its glorious path of virtually actualizing its vision by imparting quality research in sustainable coldwater fisheries production, management and conservation.

Sustained support from Indian Council of Agricultural Research in terms of budget and manpower and continual flow of funds from project sponsoring agencies like National Agricultural Innovation Project of ICAR, Department of Science and Technology and Department of Biotechnology have helped us to enrich the facilities and equipments.

This national seminar has been made possible by the wholehearted support of scientists and staffs of DCFR. I thank each and every one of them on my own behalf for the determined and persistent efforts and tremendous support in organizing the event. We sincerely welcome the delegates and exhibitors for this national seminar. We earnestly wish the seminar will fulfil its objective and will bring out concrete recommendations for the sector to flourish and sustain in the long run.

(P.C. Mahanta)

CONTENTS

Contd...

CONTENTS

Contd...

CONTENTS

Contd...

CONTENTS

Contd...

CONTENTS

Contd...

CONTENTS

Contd...

CONTENTS

SOUVENIR ARTICLES

Coldwater Fisheries in India: Issues and strategies for development

B. Meenakumari[1] *and P.C. Mahanta*[2]
[1]Fisheries Division, ICAR, KAB-II, Pusa, New Delhi-110012
[2]Directorate of Coldwater Fisheries Research, Bhimtal, Nainital, Uttarakhand

Introduction

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.

Subtle Issues and Hazards in Coldwater Fisheries

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 modem 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.

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).

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

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.

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.

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).

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.

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.

Potential of coldwater fisheries for livelihood security

- Trout farming has immense scope in the Himalayan and some peninsular regions, where sufficient quantity of quality water is available. In India, production of farmed trout from the hill region is estimated about 500 t/year and the quantity is increasing year by year.
- Even though, successful collaboration with some foreign organizations in last two decades, the rainbow trout farming in the states of Jammu & Kashmir and Himachal Pradesh, has accelerated significantly. The DCFR, Bhimtal has also done commendable experimental work in trout. Now, the trout farming is also developing in other hill states such as Uttarakhand, Sikkim and Arunachal Pradesh.
- Traditional fish farming is not in regular practice in most of the hill states. Therefore, there is an immense scope for development of the farming to provide a source of employment to the resource poor hill people. Many suitable sites are available in different parts of the hill states, which could be utilized for fish production through aquaculture.

- Owing to simpler farming techniques, low input requirements and possibilities of integration of available resources, culture of Chinese carps in small sized ponds is becoming popular in the region. The carp culture is more profitable by integration of fish culture with dairy, horticulture, agriculture and paddy.
- Most of the capture fishery resources are under severe pressure from habitat alterations and over exploitation. Therefore the riverine fishery is unable to attract full time fishers in the region. Lakes and reservoirs are good source of income generation. Different areas of the reservoir have been earmarked for fishing and fish marketing activities. Likewise, there is need to develop the vast area available under reservoirs for providing livelihood to the peripheral fishers.
- Fishery based eco-tourism is emerging potential area for employment generation. Valuable mahseer and exotic trout 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 Indian Himalayas are an abode for sport fishing. Anglers from all over the world flock to the Indian rivers to try and hook the mighty mahseer or trout. About 3,800 km lengths of river and stream stretches in the upland region of our country are holding sizeable mahseer.
- 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 hills like Mattan in Jammu & Kashmir; Renuka lake in Himachal Pradesh; river stretch of Ganga at Haridwar and Rishikesh, Gomati river at Baijnath, Naldamayanti tal in Uttarakhand are some examples of fish watching spots, which attracts thousands of tourists.
- Collection, propagation and marketing of ornamental fishes are potential ventures in the sector. The global trade of ornamental fishes is estimated about Rs. 1600 Crores. Some very colourful and fascinating species inhabits in the coldwater zones, in which some of these have already recognized as ornamental fishes in other part of the country, where as a few other also have suitable traits. North East region is known as repository of ornamental fish species.
- Lack of proper marketing facility is the biggest hindrance in trout farming. Sale of farmed trout in fresh condition is a big problem faced in the production centers. In this situation, there is need for establishment of Post-Harvest and Value addition units either to preserve the fish for a longer duration or to make value-added by products, so as to attract a wider market within the country and also for augmenting exports. Though the techniques for marine and fresh water fish production have already been developed and practiced in the country, which need to be extended to the coldwater sector too.

Consideration required for further development of fisheries in hill states

At present attention should be directed towards the standardization of technologies suitable to various fish species suitable to hilly cold areas of the region depending on investment potentials of the region. This should also be based on species-based systems, as, a high biodiversity of fish species present in this part of the country. The following points should be considered in order to improve breeding and culture of fish in the hills:

- Imparting training to farmers and entrepreneurs at different levels along with better co-ordination between Extension Functionaries.
- Development of suitable and specific aquaculture system for acidic soil condition of the mid and high altitude areas.
- Regular monitoring of reproductive biology of economically important fish species so as to suggest remedial measures for depleting population.
- Conservation and rational exploitation of resources, which are the backbone of fish and fisheries in the region particularly at the high altitude areas.
- Introduction of research programmes aiming at intensification and diversification of freshwater aquaculture in tune with the geomorphological feature of the region.
- Extensive conservation and bio monitoring of all coldwater resources in time and space to assess threat perspectives in relation to biodiversity.

- It is important to have regular monitoring of reproductive biology of economically important fish species so as to suggest remedial measures for artificial breeding of fishes to restore depleting population

Conclusion

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 DCFR 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.

References

Chauhan, S.K., P. Singh, K.K. Pandey, M.S. Lal, 1994. Studies on some endangered and vulnerable species of the streams of Garhwal Himalaya. In: P.V. Dehadrai, P. Das & SR Verma(eds.) Threatened Fishes of India NA TCON Pub. No.4. pp: 161-164.

Das, P., A.K. Pandey,1998. Current Status of Fish Germplasm Resources of India and Strategies for Conservation of Endengered Species. In: Fish Genetics and Biodiversity Conservation. Ed by A.G. Poonaih, P.Das and S.R. Verma. NATCON, Muzaffarnagar. pp: 253-274.

Joshi.P.C, 1994. Status of fish conservation in river Ramganga. In: P.V.Dehadrai, P.Das and S.R.. Verma (eds.) Threatened Fishes of India. NA TCON Pub.No. 4. pp: 349-353.

Mahanta,P.C., D.Kapoor, A.K. Pandey, S.M. Srivastava, R. Dayal, R.S. Patiyal, K.D. Joshi, A.K. Singh, S.K. Paul,1998. Conservation and Rehabilitation of Mahseer in India. In: Fish Genetics and Biodiversity Conservation. Ed by A.G. Poonaih, P.Das and S.R. Verma. NATCON. pp: 93-106.

Nautiyal, P, 1994. Mahseer the Game Fish: Natural History, Status and Conservation Practices in India and Nepal. Rachna Publication, Srinagar- Garhwal.

Raina, H.S, 1996. Changes in Himalayan upland streams habitats and their impact on coldwater fisheries .Proceedings Symposisum on Fish Genetics and Biodiversity Conservation for Sustainable Production during Sept. 26-27th 1 996. NA TCON. pp:8.

Sehgal, K.L, 1994. State-of-art of endangered, vulnerable and rare coldwater fishes of India. In: P.V. . Dehadrai, P. Dasand S.R. Verma (eds.) Threatened Fishes of India. NATCON Pub. No.4. pp:127-135.

Vass, K.K. and K. Gopakumar (2002) Coldwater Fisheries and Research Status in India. In: Highland Fisheries & Aquatic Resource Management. Ed by K.K. Vass and H.S. Raina. NRCCWF (ICAR), Bhimtal. pp: 3-29.

Vass, K.K, 2005. Status, Constraints, Research Support and Development Action Plan of Hill Fisheries. In: Pros. Nat. Seminar on Aquatic Resource Management in Hills. Ed. by K.K. Vass, S.A.H. abidi and Late V.P. Agarwal. NRCCWF(ICAR), Bhimtal. pp: 198-216.

Coldwater Fisheries sector-Opportunities and challenges

Madan Mohan
Assistant Director General (Fisheries), ICAR, KAB-II
PUSA, New Delhi-12

Introduction

The geographic location of India is blessed with vast and diverse natural aquatic resources that include mainly fresh, brackish and marine ecological systems supporting various forms of aquatic fauna. The immense potential of diverse aquatic resources contributed significantly to the growth and development of Indian fisheries sector over the past few decades. Freshwater aquaculture in India is primarily based on carp culture. The diverse inland fresh water resources consist of 29,000 km of rivers, 0.3 million ha of estuaries, 0.19 million ha of backwaters and lagoons, 3.15 million ha of reservoirs, 0.2 million ha of floodplain wetlands and 0.72 million ha of upland lakes. The aquatic resources of hill regions include quite big size reservoirs namely Govindsagar, Pong and Tehri while few of them are coming up in different hill states.

While producing 5.42% of the world's fish, India trades to the extent of 2.5% in the global fish market. Fisheries sector has registered an overall annual growth rate of 4.5%. During the previous five year plans contribution of fisheries sector is estimated around 1.10% to the national GDP and 5.4% to the agricultural GDP (Ayyappan *et al.*, 2011), thus boosting the agricultural growth since last several years. Capture fishery in the country being almost stagnant since last three decades, freshwater sector has been shouldering the major responsibility to meet the increased demand for fish. Fishing which was a traditional practice of antiquity for centuries transformed into a main livelihood option for more than 15 million people especially in coastal areas in India, besides providing food security, economic returns and major contribution to national foreign exchequer. At present India is third largest producer of fish, second largest producer of fresh water fish and seventh in shrimp production globally. The fish production in India has increased more than ten fold during post-independence period. The significant contribution of fisheries sector encompasses Rs. 29,707 crores to national economy, 1.04% of Gross Domestic Product (GDP) and 5.34% to the agricultural GDP in the last five year plan period. The growth in fish production is noticeable by upsurge from 0.752 million tonnes in 1950 -51 to 8.62 million tonnes in 2011-12. The export of fish and fishery products witnessed a steady growth from Rs. 3.92 crore in 1961-62 to Rs. 16597.23 crore during 2011-12.

The Indian Upland states about ten in number, extending from Northwestern to North-eastern Himalayas, holding fishery of cold waters and sub-temperate species, contribute nearly 3-4% to the total inland fish production in the country. In this total production basket, the combined contribution of Northeastern states is quite significant while among the North-Western Himalayan States the share of Jammu & Kashmir in fish production is highest, followed by Himachal Pradesh and Uttaranchal. The issue that needs attention here, is how in the country scenario, our hill states can contribute to this national growth through fish, and harnessing other aquatic biodiversity as well, as a vehicle of economic growth in our Hill States.

Challenges for Coldwater Sector

According to the 2011 census, India's human population was one billion which stands now as about 1.21 billion. At the present rate of population growth of about 1.5% per year, it may cross 1.5 billion by 2025. Our food grain production is now about 250 million tones and with the addition of more population, India may require 320 million t of food grains by 2025. Now about 40% of Indian population are fish eaters, and with changing life styles every year, it may swell 50-60% in 2025 with its per capita consumption going up from the present 9-10 kg to about 12-15 kg per year. In that case, for our domestic consumption alone, our country may require 7-8 million tones of fish by 2025. The market demand for the processed fish has been increasing over the years.

Table 1 : State-wise area & Human Population and fish production in upland states of India

State	Area (in '000 kms)	Population 2001 (in lakhs)	Population 2011 (In lakhs)	Fish production (in '000 tonnes) 2000-01	Fish production (in '000 tonnes) 2009-10
Jammu & Kashmir	222.24	100.70	125.50	17.15	19.30
Himachal Pradesh	55.60	60.78	68.56	7.02	7.85
Uttarakhand	53.48	84.90	105.40	3.07	3.49
Assam	78.44	266.38	311.69	158.62	218.82
Arunachal Pradesh	83.74	10.98	13.83	2.50	2.65
Meghalaya	22.43	23.18	29.64	6.18	4.21
Manipur	22.33	22.94	27.21	16.05	18.22
Mizoram	21.08	8.91	10.91	2.86	3.75
Tripura	10.50	32.00	36.71	29.42	23.87
Nagaland	16.58	20.00	198.80	5.50	5.50
Sikkim	7.10	5.4	6.08	0.14	0.15
Southern hills	7.00	5.00	5.31	0.50	0.50

Golden mahseer *(Tor putitora)*

Rainbow trout

Coldwater Aquaculture Targets-Real Challenges

The changing life style and affluence of the consuming public are influential in the demands for highly varied types of value added processed fish products. The consumers abroad and the urban elite at home demand new types of value added hygienically prepared, nutritious and attractively packed ready-to-serve and ready-to-cook "convenience foods'.The fish production in Indian upland states in 2009-10 was,105.05 lakh tonnes and about half of it was produced in mountain region which forms about 1.2% of total inland fish production which stood at 4.65 million tones in 2009-10. State-wise area & human population and fish production in upland states of India during the year 2011 and 2011 are given in table 1.

The human population (including Assam) may cross 90 million and more than 52 million excluding Assam in 2025 (Table 2). Most of the population (80-90%) residing in mountains are traditionally fish eaters where per capita consumption is more than plain areas. The per capita availability (including Assam) is 2.34 kg and 1.38 kg without it. With about 70 million of fish eating populations in hills (including Assam) with per capita consumption of fish equal to national average in 2025 which may be 11-12 kg, the Indian uplands may require more than 700,000 tones of fish in 2025. When state of Assam is excluded, the requirement will be 500,000 tones which will be about six times from the present fish production. Even now, most of these hill states are getting fish for consumption from plains. Even in 2025, this region will be heavily dependant on warm water fish supply. If they get about 200,000 tones of fish from plains, even than , they have to produce 500,000 tones (including Assam) and about 300,000 tones excluding Assam in 2025.

Table 2: Projected human population (In lakhs) in Indian uplands in 2025

	Population in 2001	In 2011	Projected population 2025
Including Assam	641.17	760.63	900
Excluding Assam	374.80	448.94	525

Opportunities- Increased Aquatic Resources

Coldwater fishery sector has made significant contribution towards increasing fish productivity at national level, in spite of several constraints. I t raises the question of putting into action new approaches to meet the existing and future needs of the sector.

The expansion of resource base for coldwater fishery is slowly taking place with more and more fishery development programmes being implemented across the hill states involving creation of additional pond areas. The major addition to coldwater fishery resources in the country has been in the State of Uttarakhand with construction of Tehri Dam in Garhwal region. The fishery development in this big water resource (46 km^2) if planned on scientific lines from the beginning will boost the fish production in the state and the surplus can be exported to other states. This will be a big scientific challenge; the fish species combination in the proposed system has to be worked out very carefully so that mistakes committed in other reservoirs across the country especially in Govindsagar (H.P.) are not repeated again. In the hill States viz., Jammu & Kashmir, Himachal Pradesh and Uttarankhand, more power projects involving creation of more impoundments are expected, this will indirectly increase the area for fishery development.

Opportunities- Increased Fish Production

There is good opportunity to increase Fish production from the present 0.90 to 3-5 lakh t in next 13 years- which is going to be A really big task. Which provides offer to produce about 2-3 lakh t from upland aquaculture. It will require to establish more fish seed and feed production units in uplands.

- To establish fish processing units in near future
- To create local and distant markets for fish disposal.
- To create facility for fish & fish products transportation.
- Value addition as canned products for hill produced fish.
- Media exposure for uplands fish and its products

Coldwater Aquaculture Technology Generated by DCFR

- Artificial propagation and hatchery management of Golden mahseer (Tor putitora) and Chocolate mahseer.
- Concept and design of flow-through hatchery system for mahseer seed production.
- The feed formulation for rainbow trout & successful pilot scale production.
- Seed production and hatchery management in case of rainbow trout (Onchorhynchus mykiss)
- Three species exotic carp (common carp, silver carp and grass carp) based aquaculture technology standardized for mid-hill regions, 1000-1500 masl.
- Fish Farming in unutilized Areas like Poly/ Irrigation Tanks

Way forward

The technology of exotic carp-based culture has been standardized and accepted by the farmers but the available pond / tank areas in hills have been limited. This has hindered the horizontal spread of this culture technology to more areas. The respective State Departments should make efforts to create more pond areas and Govt. of India may provide financial support wherever required. This will contribute to generate more fish production in our uplands through aquaculture.

Hatchery support to produce Coldwater Fish Seed especially of Mahseer, Trout and Snow-trout in the country is very limited. There is a need to develop more seed production units of these species.

The rainbow trout culture has been a success in the States of Jammu & Kashmir, Himachal Pradesh and Uttaranchal. But the outbreak of disease in Himachal Pradesh and Uttaranchal affected the stocks significantly. Disease monitoring labs with investigating capabilities need to be established in the country. A beginning has been made at DCFR Bhimtal which will cater the needs of coldwater sector.

Balanced and nutritive diet is very crucial to fish farming activity, especially in coldwater sector, where natural food availability due to low temperature is a limiting factor for growth. Therefore, feed mills need to be set-up to produce feed for coldwater fishes in bulk at a reasonable cost.

Constraints in Hill Aquaculture

The forecasting studies conducted as a part of the World Water Vision, it has been predicted that by 2025 water stress in entire world will increase to more than 60%. The report also indicates that entire India (except Brahmaputra basin) will be under mild to severe water stress. This implies that Himalayas too will face water stress, this is already being felt in some of the hill states, especially Uttarankhand, Himachal Pradesh and Kashmir where large number of underground spring water resources, the best quality of water to raise trout, have either dried-up or flows have drastically diminished with acute crisis being faced during summer. This problem is further aggravated in hills through up-stream water abstraction for other services especially portable water and irrigation use for the foothill agriculture activities. In addition to above concerns the natural lakes in majority of Himalayan regions have become eutrophic with deteriorating water quality resulting in loss in fishery.

Strategy for Freshwater Aquaculture Development in India

P. Jayasankar
Director, Central Institute of Freshwater Aquaculture, Kausalyaganga,
Bhubaneswar - 751 002, Odisha

Introduction

Fish as the cheapest source of animal protein constitutes a major share in the global food basket and world fish production sector faces the challenge to boost the production to meet the protein hunger in the future. According to FAO (2009) global fish production stands at 147.5 million tonnes, of which about 40% is contributed by aquaculture sector. However, global capture fishery being at crossroads with over 70% of the resources exploited, aquaculture is the only option to fill up the gap of much of the future fish demand.

Indian fisheries sector has made great strides in the last five decades showing eleven fold increase, from 0.75 million tonnes in 1950-51 to 8.1 million tonnes in 2009-2010, which is a testimony to the contributions of the sector.Besides providing livelihood security to over 14 million people, the sector has been one of the major foreign exchange earners, with revenue reaching Rs. 10,048 crores in 2010-11 accounting for about 18% of the agricultural export. Producing 5.42% of the world's fish, India trades to the extent of 2.5% in the global fish market. Fisheries sector has registered an overall annual growth rate of 4.5%. During the previous five year plans contribution of fisheries sector is estimated around 1.10% to the national GDP and 5.3% to the agricultural GDP (Ayyappan *et al.*, 2011), thus boosting the agricultural growth since last several years. Capture fishery in the country being almost stagnant since last three decades, freshwater sector has been shouldering the major responsibility to meet the increased demand for fish.

Share of freshwater aquaculture in inland fisheries has gone up from 46% in the 1980s to over 80% in the recent years. The sector, during the past two decades, has shown an overwhelming ten-fold growth from 0.37 million tonnes in 1980 to 4.03 million tonnes in 2010.Freshwater aquaculture has been able to meet the increasing fish requirement of the country when the production from marine capture and other open waters has remained almost stagnant (Ayyappan et al., 2011). It is estimated that only about 40% of the available area of 2.25 million ha of ponds and tanks, 1.3 million ha of beels and derelict waters and 2.3 million ha of paddy fields has been put to use and there exists amble scope for horizontal expansion.

The holistic development of aquaculture over the years has been realized through a series of standardization and development of methods in all fronts of aquaculture, i.e, resource survey, their characterization and effective utilization, production and rearing of seed, grow-out farming technology, nutritional improvement, disease and health management and the extension mechanism to transfer the technology to the field. Further, realized need to improve genetic quality and yield of cultured organism led to up gradation of the broodstock using the tools like selective breeding and cryopreservation techniques. The culture technology itself has undergone several modifications, ramifications and refinements over the years with incorporation of innovations made during scientific evaluations through multi-location trials to evolve to the present day's package of grow-out farming practices to adapt to the varied kind of water bodies. The present article attempts to summarize strategies for the development of freshwater aquaculture in India.

Diversification

Carps are the main stay of aquaculture in India. But being a low valued fish in the domestic and international market, carp farming yields low benefit cost ratio compared to culture of other species elsewhere in the globe and therefore, attracts poor entrepreneurial acceptability. Further, the consumers today with their increased purchasing power looking forward for wide spectrum of fish protein. In this context, diversification of the system and species spectrum forms one of the important strategies for aquaculture development in the coming years. There is a need to bring more and more high valued fish species either under monoculture or polyculture with carps to make aquaculture more remunerative to encourage the entrepreneur investment. However, bringing any new species into the main stream aquaculture practice would require standardization of their breeding, seed production, seed rearing and grow-out technology along with the study on their nutrition, physiology and health management. As the premier research institute of the country, the Central Institute of Freshwater Aquaculture (CIFA) has the Herculean task to shoulder the responsibility of diversification.

Production of quality seed and their assured round the year availability

Controlled breeding after using same population over the years results in poor genetic base leading to retarded growth and low disease resistant variety due to inbreeding depression. Effective strategy should be put in place to minimize such inbreeding depression. While conventional way of replacing the parents in every two years can minimize such risk, gamete exchange programme through development and use of cryo-technology would ensure healthy quality seed effectively. Selective breeding programme with selected traits in fish and prawn can be another efficient way to improve the seed quality. In view of the success achieved in rohu, such programme should be extended to other species of carps and freshwater prawn for increased realization of growth and production. Despite the availability ofsound seed production technology, country faces acute shortage of stocking material, i.e. fingerlings. Such deficit of fingerlings could be overcome by establishing seed bank and encouraging seed-village concept as followed in agriculture. Production practices for fry, fingerling, stunted and advanced stages need to be evolved for different agro-climatic regions of the country. Use of stunted fingerlings not only ensures an extended growth period but also harnesses the compensatory growth capability of the fish resulting in proven success in increasing the grow-out production. Further emphasis on research is needed for effective utilization of the compensatory growth in the fishes to realize their maximum growth potential.

Problems of seed shortage can substantially be reduced if fish can be bred round the year. Although multiple breeding and success in off season breeding through controlled gonadal maturation in few species have been able to extend the breeding period, further effort is needed to bridge the gap and extend such breeding programme for other species. While seed production and culture technologies for some fish species viz. *Clarias batrachus, Heteropneustes fossilis, Ompok pabda,* and *Pangasius pangasius* have already been attempted, perfected and refined,there are still more fish species which need attention for their culture, breeding and seed production technologies.

Freshwater prawn species having high domestic consumer preference as well as export potential need more attention with regard to supply of stocking materials for culture. As such establishment of a chain of prawn hatcheries is the need of the hourfor meetingincreasing demand for seed. Therefore, high priority is to be given for such activity with public-private partnership, if needed, including development of appropriate feeds.

A recent development in the right direction is National Freshwater Fish Broodbank facility (NFFB) in the Kausalyaganga farm of Odisha State Fisheries Department created by the National Fisheries Development Board (NFDB) with technological backstopping from CIFA. This facility is expected to dish out genetically improved fish seed to private hatcheries from next year onwards for multiplying and supply to the farmers.

Increasing grow-out productivity

Fish production in pond is a function of the composition and compatibility of the candidate species, efficient pond management, proper nutrition and effective health management. Since all the above factors need special attention for ensuring healthy fish production, there is a need to intensify the ongoing research in these areas in the face of increased intensification of fish farming. Over the years, it has been observed that market driven forces determine the species composition in grow-out culture. Further, recent years have witnessed introduction of several new species into the culture system. Therefore, impact of such external factors on aquaculture needs periodic assessment for reorienting the grow-out production research.Although carp culture technologies with varied levels of production ranging from 2.0-17.0 t/ha available in the country, there is need to refine these technologies in line with the local condition for effective result. The intensive carp culture technology could make it possible to achieve 17t/ha/yr against the national average 2.9t/ha/yr. Such technology is yet to be transferred through extension service after making proper assessment of cultivable freshwater resources. There exists still enough scope for expansion of aquaculture in horizontal and vertical ways. A perspective plan for aquaculture development is necessary and it is to be implemented with support from state, and at national level with support from NFDB.

The technology of sewage-fed fish culture, though well practiced in east Kolkata wetlands since long and yet to be adopted/practiced in other cities with sewage systems after treatment of water through recycling. This requires region-wise studies as a basis for the quality of the produce for human consumption. It further demands environmental research with particular reference to wastewater utilization and application of bio-filtration in aquaculture.

Culture and breeding technology vis-à-vis seed production is the prime and critical part of aquaculture practice needing both production system and species diversification to augment production by utilizing the pond ecosystem across all agro-climatic regions of the country. Therefore, fish production under low/medium/high input systems as well as culture trials on minor carps, murrels and other miscellaneous fish species needs to be conducted. Species like minor carps and small indigenous fishes need to be studied for their production potential either as the main crop or inter-cropping with the major carp based culture system.

Organic farming

Due to the increased health consciousness and increased purchasing power of the consumers, demand for organic fish has increased in recent years. Though few studies on the organic fish production have revealed quality fish production and good environmental sustainability, efforts in this area need to be intensified to ensure mass scale production in future along with minimal degradation of environmental quality. Further, suitable mechanism should be evolved to establish the organic standards for fish farming and certification of the organic fish as that followed in agricultural and horticultural produces.

Farm mechanization and automation

In view of the impending labour scarcity, aquaculture is going to face major challenge in terms of farm operation in the coming years if timely steps will not be taken in terms of mechanization and automation. Though technology of mechanization and automation for many of the fish farming activities are already in place in other countries, many of such systems may not be cost effective to use in the low valued carp culture. Therefore, there is an urgent need to develop indigenous farm mechanization and automation technology and implements so as to reduce the operational cost and drudgery.

Hi-tech aquaculture with use of automatic pond environment monitoring, oxygenation, monitoring of feeding, water exchange and efficient health management aimed at high fish productionis almost non-existent in the country. Effort is needed in this regard to develop state of the art technology for high scale fish production in controlled environment.

Climate change and aquaculture

Fish being a cold-blooded animal, all stages of aquaculture including reproductive behaviour, breeding, seed production and growth and behaviour of fish are going to be largely affected by the climate change phenomena. Therefore, aquaculture is going to be one of the worst hit sectors by the global warming. Impact of the climate change has already been felt on fisheries and aquaculture in terms of modification of the distribution and productivity of marine and freshwater species, effect on biological processes and alteration in food webs, change in the reproductive behaviour of fishes, shift in the breeding season, shift of the habitat, etc. Therefore, in order to make fish production sustainable and provide the animal protein continuously to the ever growing population of the country, aquaculture has the responsibility not only to evolve itself against the changing climate to remain productive on a sustainable basis, but also has to make simultaneous effort to mitigate the global emission of greenhouse gases. Fortunately, aquaculture offers option for permanent sequestration of the atmospheric CO2 through its incorporation into soil and biomass of plants, crustaceans, shellfish, fish and other organisms and thus, can act as a pro-carbon sink process and an important option for mitigating the global warming process.

Use of large quantity of manure, fertilizer, feed, therapeutics and other inputs, aimed at increasing the fish production, has made the modern fish farming system more energy intensive. In this context, the vast coverage of aquaculture ponds in the country to the extent of 2.35 million hectares could be a significant source of greenhouse gas emission. However, responsible aquaculture practice can alter the trend by making aquaculture a pro-carbon sink process rather than contributing to the global greenhouse gas emission. Life Cycle Assessment tools can be effectively utilized in identifying the potential hot spot in the fish production process so that modified or alternative methods or processes can be evolved which can replace those hot spots so as to mitigate the potential impact of the various products, production systems and the different processes involved in it on the environment. Since this method relies on gathering information on all phases of the 'Life cycle' of product including raw material use, energy of productions, manufacturing, transport, use, etc. efforts should be made to document the input-output flow of the different aquaculture practice.

The Inter-Governmental panel for climate change (IPCC) report indicated that many of the developing countries tend to be vulnerable to extreme climate disturbances and thus may have an adverse impact of a gradual climate change on animal production system including fish farming. Given the importance of climate in the aquaculture production system, it is essential that concerted research efforts be carried out to assess the vulnerability of aquaculture towards the impact of climate change, prioritize the strategies and also to identify the stakeholders' response.

Global warming is likely to create favourable climate conditions for the growth of causative organisms and thus increased ambient water temperature is likely to cause a rise in the responses of disease occurrences spread by vectors. Similarly alterations in other sensitive water quality parameters such as ammonia, air and water temperature may have pronounced effect on feed utilization efficiency, growth and even on the sensory qualities of the cultured fish species. Concerted efforts in aquaculture research to reduce the vulnerability of aquaculture due to the impact of climate change (variables like solar radiation and air temperature) are therefore vital to make aquaculture more resilient.

Water management

A study made by the International Water Management Institute (IWMI) reveals that by 2025 nearly 1/3rd of world's population would live in the regions of severe water scarcity (less than 1,000 m^3 per head per year) and the same proportion of population in India could face absolute water scarcity (less than 500 m^3 per head per year). The common notion that "Water is a free commodity" is no more a reality. Therefore, it is high time to think for judicious management of this natural resource and to develop strategies for its efficient and multiple uses. Since water is the prime requirement for aquaculture activity, maintaining the pace of aquaculture development is possible only through making it available adequately for aquaculture besides satisfying the agricultural, industrial and domestic need. The limited nature of the water resource, therefore, warrants a more holistic approach to water management.

In aquaculture ponds/tanks, possible water sources are regulated inflow either from feeder canal, ground water, precipitation and runoff. Possible causes of water losses may be evaporation, seepage, effluent discharge and overflow and associated factors which are to be carried out to assess the water requirement for aquaculture ponds. Based on the observation attempts may be made to develop a suitable model to predict the water requirement in aquaculture pond. The water budgeting for different species and target of productions may form the practical tools for generating useful information for mitigating the challenges on water for aquatic production.

Development of the re-circulatory system for fish farming is an effective way of fish production while ensuring greater water productivity. There is a need to standardize technology in this area for culture of the Indian species. Productivity of water can be enhanced through integration of fish and other aquatic organisms into existing farming systems in addition to diversification to agri-horticulture crops. This integration is especially important in places where natural aquatic ecosystems have been degraded for production of desired level of protein and other benefits as produced from the system. Fish farming needs to be extended to reservoirs and open waters, the supply canals, and small trenches within rice fields depending on the suitabilityand creating scope for community based aqua farming. Flood-prone ecosystems can also be made use of for additional fish production.

Fish genetics and bio-technology

Genetic upgradation and breed improvement are key areas to be strategized for sustainable aquaculture. Prioritization of species, development of a broad genetic base thereof and subsequent development of improved strains through selective breeding should be prioritized in the coming decades. Controlled breeding after using same population over the years results in poor genetic base leading to retarded growth and low disease resistance due to inbreeding depression. Therefore, replacement of parent fishes should be mandatory once in every two years while in use for commercial purpose. Milt cryopreservation can be used in gamete exchange programmes. Selective breeding programme ofmore number of cultivable fish and prawn species should be taken up. Traditional breeding has to take advantage of biotechnological tools that are available and being developed in each potential species. Fish genomics has been emphasized recently in order to gather basic knowledge as well as application tools and resources for genetic improvement of cultivable species. Development of genomic resources has to be taken up in each prioritized species through multidisciplinary approach in order to address marker assisted breeding, nutrition, health, transgenics, etc. The approaches are as follows:

1. National brood stock upgradation and genetic improvement program conventional selective breeding, DNA marker technology and transgenics.
2. Generation of genomic resources such as marker maps, large insert libraries, DNA constructs and protocols for gene manipulation, cDNA libraries and transcriptome databases of tissues related to various abiotic stresses, developmental stages and disease conditions.
3. Whole genome sequencing of important cultivable species
4. Identification of genes/ proteins underlying different performance traits.
5. Incorporation of DNA chip technology and development of integrated, cost effective marker assisted breeding plans in prioritized fish and shellfish species.
6. Determination of whole genome sequence of a couple of species as reference towards functional and comparative genomics in fishes.
7. Stem cell technology.

Nutrition and feed development

To meet the challenges of feed deficit, identification of locally available feed ingredients and their use in fish feeds would be the suitable solutions. Formulation of on-farm farm-made feeds would be another sustainable approach to narrow the gap of feed deficit. To develop low-cost aquafeeds, studies are required on nutrient requirement of newer commercially important diversified fishes. Similarly, suitable feed processing and manufacturing technology can improve the feeds utilization by the fish, resulting decreased feed requirement with low price. Use of suitable feeding devices is the option for better feed management and reduction of pond bottom sediments. Development of generic feeds and feeds for different life stages of cultivable species are to be relooked. Formulation and use of sustainable aquafeeds to maximise health benefits of farmed fish for consumers is another area of fish nutrition research which needs immediate attention. In order to achieve this goal, suitable aquafeeds need to be developed based on sustainable alternatives to fish meal and fish oil to produce healthy and minimally contaminated fish that are highly nutritious and acceptable to consumers.

The genetic control of different enzymes and metabolic pathways in response to nutrients, the use of nutrients to increase disease resistance in fish, the use of functional food aids in the prevention of health disorders need to be emphasized in future. Enrichment and culture of natural fish food organisms and assessment of their nutrient contributions in fish performance in aquaculture systems needs to be initiated.

Health Management

Health management would play a pivotal role in the coming years for sustainability of semi-intensive or intensive systems of aquaculture. The misuse and drawbacks in antibiotics, problems of emerging pathogens, transboundary diseases, poor quarantine etc. are further adding up to this issues for moving into better health management practices. To meet the challenges of newer and emerging pathogens, there is a need to emphasize on the development of newer molecular-based, specific, sensitive and farmer-friendly disease diagnostics. Exploration of immune system of major cultured candidate species and understanding pathogenesis of important diseases would pave the way in developing suitable immunoprophylaxsis using latest molecular approaches. Diseases like argulosis, edwardsiellosis etc. that pose major threats to the industry would be given priority using novel approaches of prevention or control. The potentiality on use of nanomaterials in diagnostics and vaccine development will also be explored.

Emphasis would be directed to map the diseases in major freshwater aquaculture systems of the country to prioritize the diseases that are causing major economic loss to the sector. Further, targeted active surveillance and health management practices would be taken up to prevent those diseases through development of molecular diagnostics and vaccines.

Processing and post-harvest technology

Processing and post-harvest technology in the field of freshwater aquaculture followed by value addition are absolutely lacking in India. Therefore such field of specialization should receive immediate attention as a part of research in aquaculture.

Database development

Database of freshwater potential resources, their productivity and production from different water bodies namely ponds, tanks, beels and jheels are yet to be updated. Moreover, the national basis network for such purpose is lacking barring few attempts made by CIFRI, Barrackpore and IIM, Ahmedabad. Systematic and periodic survey of freshwater aquaculture resources is required to fill up this void. Therefore electronics, remote searching and computer technology are to be pressed into service for such purpose.

Transfer of technology

Transfer of technology from lab to land or from experimental result to field demonstration is one of the important aspects in extension work which inspires farmers for learning by doing. Therefore viable technologies are to be transmitted to the mass through KVKs, training programme, farmers' meet, farmers' day and published manuals in local languages. A strong foothold is required by making collaborative approaches with different agencies namely FFDA, State Fisheries Departments, NGOs, and SHGs so as to extend all possible useful tips (on aquaculture) which can reach up to grass root level or village level farmers. Such programmes are to be arranged in different agro-climatic zones as well as considering farmers' need and consumers' preferences.

Further emphasis, efforts and attention are to be made so as to make aquaculture an organized activity. Appreciable development and achievement have already been made in this sector in Punjab, Haryana and Andhra Pradesh. In collaboration with CIFA other agencies can take initiative to prepare a blue print on national basis so as to gear up national average fish production through aquaculture to about 5 t/ha/yr from the current production level of 2.6 t/ha/yr. Inputs and financial support are to be provided to those who remain associated with agriculture. In other words,aquaculturists should be at par with agriculturists in terms of facilities and subsidies provided to them.

All proven technologies related to aquaculture development are to be implemented in different agro-climatic zones involving all irrespective of caste, creed or sex. All backward communities, NGOs, women and State Fisheries Departments are to be involved in specific operational and developmental projects.

CIFA can play a pivotal role in planning and guiding a sustainable and economically viable production system in the wake of public private partnership when the entrepreneurs and large farmers of various states could be encouraged to involve themselves in different activities associated with aquaculture industry.

Modeling and forecasting

Research efforts on modeling and forecasting have been limited in aquaculture system particularly in the context of Indian scenario. However, considering the present context of climate change and its subsequent impact on the aquaculture, urgent need of intensifying the effort in this area has been felt in recent years. Such type of research would not only ensure efficient resource and input use but also strengthen our preparedness for the extreme climatic event.

Epilogue

In order to meet the needs and aspirations of stakeholders in freshwater aquaculture and to strengthen this sector further, it is essential to adoptthe frontier research areas including development of production system for efficient use of nutrients and water, enhanced tolerance to biotic and abiotic stress imposed by climate change, achieving rapid growth rate of cultured fish following nutritional principles, development of an integrated, cost effective marker assisted breeding plan through the application of biotechnology, concerted and integrated efforts with effectiveness and efficiency to meet the ever increasing demand. The Way Forward in freshwater aquaculture is sustainable production of about 10 million t of fish with a productivity of 10t/ha/year through responsible farming practices.

References

Ayyappan, S., Moza, U., Gopalakrishnan, A., Meenakumari, B., Jena, J.K. &Pandey, A. K. (Tech. co-ordinators) 2011. Handbook of Fisheries and Aquaculture(2nd edition) Indian Council of Agricultural Research (ICAR), New Delhi, 110012, India, 1116 pages, ISBN: 978-81-7164-106-2.

FAO 2009. The State of World Fisheries and Aquaculture. FAO, Rome. pp. 176.

Fish biodiversity of the Himalayan ecosystem with reference to North Eastern region: Potentials and challenges

J. K. Jena and U. K. Sarkar
National Bureau of Fish Genetic Resources, *Canal Ring Road, P.O. Dilkusha, Lucknow-226 002, India*

Introduction

Biodiversity is commonly referred to as the combination of species present in an ecosystem. Each species within an ecosystem exhibits in addition to other types of diversity, intra-specific genetic diversity. India has very rich aquatic biodiversity spread across different ecosystems. Genetic diversity is thus a crucial component of biodiversity and fundamental to species survival and enabling appearance of new species. It is the basis of reproductive performance, resistance to diseases and capacity of adaptation to environmental changes. Globally, freshwater fish biodiversity has declined faster than either terrestrial or marine biodiversity over the past 30 years (UNESCO, 2003) and are one of the most threatened taxonomic groups because of their high sensitivity to the quantitative and qualitative alteration of aquatic habitats.

The upland Himalayan ecosystem is a kaleidoscope of diverse topography, climate, resources, traditional knowledge and ecology. In upland streams and rivers, the main factors which exert influence on the occurrence and distribution of fish are: temperature, substrate, water flow, gradient and type of microhabitat (pool, riffle, run, rapid etc). The coldwater habitat is characterized by high gradient, high altitude, high transparency, high level of dissolved oxygen, low temperature, rocky substrate and low organic content. However, these habitats are threatened by many threats and as a result, the fish diversity is declining sharply in coldwater ecosystems. Declines in biodiversity are far greater in freshwaters than in the most affected terrestrial ecosystems (Sala *et al.*, 2000). Therefore, conservation of freshwater fish germplasm resources should be given priority taking into consideration the distinct, diverse and fragile nature of aquatic habitat types.

The North Eastern Hill (NEH) Region of India possesses a unique potential of fishery resources and considered as one of the hot spots of freshwater biodiversity in the world. Biodiversity within inland water ecosystems in the Eastern Himalaya region is both highly diverse and of great regional importance to livelihoods and economies. The region comprises the states of Assam, Arunachal Pradesh Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim and lies between Lat. 21.57^0 to 29.3^0 N and Long 84.46^0 to 97.3^0 E, covering elevation of 200-900 m. The region occupies a total geographic area of 2.62 lakh sq. km, which accounts for 7.97% of the total land area of the country. The region has very diverse and distinct agro-climatic and geographical characteristics in relation to the topography, temperature, rainfall and soil types. However, development activities are not always compatible with the conservation of this diversity, and the ecosystem requirements of biodiversity are frequently not considered in the development planning process. One of the main reasons cited for inadequate representation of biodiversity is a lack of readily available information on the status and distribution of inland water taxa. In response to the above, NEH region has been considered a priority area for NBFGR's research programme. In the present communication, the current status and potential of fish biodiversity of the Himalayn region as a whole and NEH region in particular, challenges, NBFGR's efforts, issues, strategies and action plans for sustainable management of biodiversity have been discussed.

Coldwater Resource Potential

The estimated approximate area holding coldwater fisheries in India includes about 10,000 km streams/ rivers, 20,000 ha natural lakes, 50000 ha reservoirs and 2,500 ha brackishwater lakes and impoundments (Sunder and Joshi, 2002). The Greater, lesser 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 Brahmaputra are the largest, each having mountain catchments of about 160,000 km^2. Among the rest of seventeen, five rivers belong to the Indus system (Jhelum, Beas, Sutlej, Chinab and Ravi) of which Beas and Sutlej have a total catchment area of about 80,000 km^2, nine belong to the Ganga system (Gana, Yamuna, Ramganga, Sarda, Karnali, Kosi, Rapti, Gandak and Bagmati) draining nearly 150,000 km^2 and three belong to Brahamaputra system (Tista, Raidak and Manas) draining another 110,000 km^2 (Sehgal, 1999). The Sahyadri, Nilgri, Annamalai, and Cardmom hills in the Western Ghats also harbour many tributaries of the Krishna and Cauvery rivers. Important upland lakes are Wular and Dal in Kashmir; Nainital, Sattal, Bhimtal, Naukuchiatal in Uttarakhand; Ooty and Kodai lakes in Western Ghats. Amongst the fully formed reservoirs in Himalayas, the Gobindsagar and Pong are important. Apart from these, a number of dams and barrages are under construction in Jammu and Kashmir, Himachal Pradesh, Uttarakhand and North Eastern States.

Aquatic resources of the NEH region

Since the NEH Region is a hilly landlocked area, only freshwater resources are available which comprises several rivers, tributaries, streams, floodplains wetlands, lakes, ponds and large areas under rice fish culture system. The hill states are mostly dominated by rheophilic streams followed by slow moving potamogenic courses and stagnant lakes/wetlands The rivers Brahmaputra and Barak form the principal drainage of North East with its numerous tributaries flowing through the different states along with myriads of rivulets and lentic waterbodies. The region is endowed with vast fishery resources with 19,868 km of rivers and streams, 14,338 ha of beels and lakes, 23,792 ha of reservoirs besides about 79,360 ha rice-cum-fish cultivation areas.

Fish diversity

The upland waters of the country are famous for its most prized game fishes like mahseers, snow trout and Indian trout. Although Menon (1962) published a distributional list of 218 species from the Himalayas, Karmakar (2000) reported 276 species from the Himalayan drainage systems adding 58 species. The major coldwater fishes belongs to six different family including Cyprinidae, Cobitiidae, Salmonidae, Sisoridae, Psilorhynchidae and Homalopteridae (Kumar 1996). Sehgal (1999) had listed 241 species from different coldwaters of this country, while Sunder and Joshi (2002) reported 258 fish species belonging to 21 families and 76 genera of which 203 are from Himalaya and 91 from the Deccan plateau. Badola (2009) published a comprehensive list of 96 fish species from Central Himalaya while Uniyal (2010) recorded 132 fishes belonging to 67 families from the Uttarakhand state in which few species (*Glossogobius giuris, Bagarius bagarius, Nandus nandus, Colisa fasciatus*) has been added as a new record. NBFGR, Lucknow has validated 157 species as coldwater fish species. Some of the important coldwater species having food, ornamental and conservation value are: *Tor tor, Tor putitora, T. mosal, T. progeneius, T. khudree, T. mussullah, T. chillinoides, Neiolissochielus hexagonolepis, Schizothoraichthys progastus, S. esocinus, S. longipinnis, Schizothorax richardsonii, S. kumaonensis, Barilius bendelisis, B. vagra, B. shacra, B. (Raiamas) bola, Bangana dero, L. dyocheilus,* *Crossocheilus diplochilus, Garra gotyla gotyla, Glyptosternum pectinopterus* and *G. stoliczkae*. The reports shows that comparatively, the fish diversity of Kumaun Himalaya is more rich (96 species) as compared to Garhwal Himalayas (77 species). Recent studies indicated biogeographical shifting of some warm water fishes to the upper coldwater region of the Ganges which was never reported in the 1950s (Sarkar et al., 2012). The Trans- Himalayas is a fragile biome, characterized by extremes of both climatic and biotic factors. Flora and fauna of this cold desert are adapted themselves to extreme conditions and have low population abundance. The fish diversity of Ladakh have been very inadequately explored and as many as 32 fish species have been documented from Indus, Shyok and Zanskar catchment. Some of the common species are *Diptychus maculatus, Schizothoraichthys stoliczkae, Triplophysa microps, Triplophya tenuicauda, T. ladacensis, T. microps*, *Nemacheilus microps* and *N. stolliczkae*, etc.

The eastern Himalaya drained by the Brahmaputra has a greater diversity of coldwater fish than the western Himalayan drainage. The diversity is attributed to the recent geological history (the collision of Indian, Chinese and Burmese plates) and the Himalayan orogeny which played an important role in the speciation and evolution of groups inhabiting mountain streams (Kottelat, 1989). Molecular phylogenetic studies of the fishes (Guo et al., 2005; Rüber et al., 2004) have indicated that vicariance events in the Miocene (23.0 to 5.3 million years ago) may have played a substantial role in shaping the current distribution pattern of the freshwater fishes of the region. The NEH Region is also characteristic in having several endemic fish genera, viz., *Aborichthys* Chaudhuri, *Akysis* Blyth, *Amblyceps* Blyth, *Badis* Hamilton, *Bangana* Hamilton, Chaca Gray, *Conta* Hora, *Erethistoides Hora, Erethistes* Muller & Troschel, *Exostoma* Blyth, *Meyersglanis* Hora & Silas, Olyra McClelland, *Parachiloglanis* Wu, *Pareuchiloglanis* Regan, *Pseudecheneis* Blyth and *Pseudolaguvia* Misra. A total of 169 are endemic to NEH region. The subsistence and commercial fisheries exploit carps (*Labeo, Neolissichilus* and *Tor* spp.), lesser barils (*Barilius* spp.), schizothoracines (*Schizothorax* and *Schizothoraichthys* spp.), garrids (*Garra* spp.) and sisorids (Glyptothorax and Glyptosternum spp.). Perusal of literature reveals that several scattered information on fish biodiversity is available (Yadav and Chandra, 1994; Sinha 1996; Sen, 2000) from this region. Previous studies reported considerable variation in the distribution and occurrence of fish species. Ghosh and Lipton (1982) reported 172 species while 267 fish species have been reported by Sen (2000). In the recent years a total of 296 species of 110 genera under 35 families have been described, which also reports several new species from this region (Viswanath et al., 2008). In another study, Mahapatra et al. (2004) reported a total of 274 species from the NEH and interestingly almost all fish species were treated as food fish (99.27%) followed by ornamental fish (91.24%), cultivable fish (17.52%) and sport fish (3.28%). Biswas et al. (2007) evaluated the potential ornamental fishes and compiled a list of 92 species. However, the above information on biodiversity is still inadequate to address the critical issues related to the conservation of fishes in the region. There is need to generate more data on species assemblage, distribution and abundance at temporal and spatial scale and identify priority areas of conservation in a holistic way.

New species from the NEH Region

The germplasm exploration from the biodiversity hotspot region is a priority area for NBFGR's research programme. During the last decade several new species have emerged from the NEH region under exploration programme. Some of the new species described from this region includes *Puntius ater, P. khugae, Glyptothorax chindwinica, G. granulus* and *G. ngapang*. Under NBFGR's collaborative programme, *Glytothorax ater, G. patherinus, Batasio mizoramensis* and *Hara koladynensis* have been identified as new to science. Many other species emerged as new species viz., *Gagata gasauyuh* (Roberts & Ferraris, 1998), *Badis chittagongis, B. ferrarisi, B. kanabos* and *Mystus falcarius* (Chakraborty & Ng, 2005), *Sisor chennuah* (Ng and Lahkar, 2003), *Pseudolaguvia ferula* (Ng, 2005), *P. inornata* and *P. muricata* (Ng, 2005), *Batasio spilurus* (Ng, 2005), *Gogangra laevis* (Ng, 2005), *Pseudecheneis crassicauda* and *P. serracula* (Ng and Edds, 2005), *Amblyceps arunachalensis* and *A. apangi* (Nath and Dey, 1986), *Psilorhynchoides arunachalensis* (Nebeshwar et al., 2007), *Pseudecheneis sirenica* and *P. ukhrulensis* (Vishwanath and Darshan, 2007), *Puntius ater, P. khugae* (Linthoingambi & Vishwanath, 2007), *Parambassis bistigmata* (Geetakumari, 2012) and *Badis singenensis* (Geetakumari and Kadu, 2011). Many more new species could be distributed in the drainages of the North-East and therefore, requiring more biodiversity exploration.

Threatened fishes

In keeping with the principles of the Convention on Biological Diversity, biodiversity trends and loss can be monitored by assessing the status of species, which is one of the widely used indicators. It also helps in setting priorities for species conservation. India contains 659 species of animals listed as globally threatened by IUCN (2008) which includes 42 species of Indian fishes have been listed as threatened under categories of endangered and vulnerable. NBFGR, Lucknow in 1992 had identified nine fishes of NEH region (Ompok pabda, *O. pabo, Labeo dyocheilus, Semiplotus semiplotus, Olyra longicaudata, Psilorhynchus homaloptera, Noemacheilus elongatus, Balitora brucci* and *Barbus dukai.)* as most 'threatened'. According to Allen et al. (2010), a total of 70 fish species from Eastern Himalaya are categorized as threatened while 46 have been assessed as near threatened of which fifteen are endangered and five are critically endangered. Among the 15 endangered species, ten are endemic in the Ganga-Brahmaputra and four to the Chindwin. The five critically endangered species are either endemic to hill streams located within the Ganga-Brahmaputra and Chindwin drainages, are restricted to a single lake or to a single cave system within the Ganga-Brahmaputra drainage. However, the conservation assessment (NBFGR, 2010) of the freshwater fishes of India enlisted 120 freshwater fishes of the country under threatened category, of which 57 species are distributed in the waterbodies of NEH region. Out of 57 threatened fishes of this region, 19 have been listed under endangered (EN) while 38 species listed under vulnerable (VU) category. The number of fish species and percentages of Eastern Himalayan fishes under each IUCN Red List category. Focused research on the threatened species, therefore, is required for appropriate conservation planning.

Threats to coldwater biodiversity

Throughout the world, all aquatic environments are experiencing serious threats to both biodiversity and ecosystem stability and many strategies and priorities have been proposed to solve this crisis. Any loss of genetic variation results in erosion of evolutionary flexibility in the adaptation to changing environment and risk of extinction. In the Himalayan ecosystem, the present trend of decline of fish is primarily due to interference of several factors.

Ecological stresses

Habitat destruction and alterations in ecological conditions of aquatic resources cause decline in fish germplasm resources. Deforestation and over-grazing activities along sloppy catchments erode soil structure and cause decline in fish germplasm resources. Siltation from catchment areas of major upland rivers has destructed breeding and feeding grounds of many fishes. In eastern Himalayas, hundreds of multi-purpose reservoirs for water supply, irrigation, hydropower and fisheries have been constructed, as well as numerous barrages for water diversion (Smakhtin and Anputhas 2006). Such alterations of natural flow regimes have a negative effect on the freshwater ichthyofauna of the region, such as the obstruction of fish breeding migrations (Dudgeon, 2005). Construction of dams and barrages hampers spawning migration of mahseers. Therefore, restoration of natural flow regimes should be adopted by dam and river management authorities, and technologies to mitigate the impact of barrages to migratory species. There is need to harmonize biodiversity conservation and river valley projects. The highly sensitive and specialized nature of the upland river habitat and diversity are more sensitive to little environmental change, which may cause the small tributaries of the area to be greatly disturbed resulting in disappearance of species. Pesticide washing from agricultural fields have also been creating detrimental environment for fish life in many water bodies. The activities pertaining to the projects under construction are responsible for increase in the silt load and destruction of fish food organisms due to loss of ecological integrity.

Exotic fish species

NBFGR under its mandate has been working on screening of alien fishes for their invasive characters. It has been found that there is a steady increase in the number of fish species being introduced and becoming established in natural waters in recent years. Many alien species introduced have been found invasive and they have the ability to establish themselves, invade, out-compete native species and take over the new environments. Invasive alien species can cause significant irreversible environmental and socioeconomic damages at the species, genetic and ecosystem levels. Seven risk sectors of illegally introduced fishes have been identified. These are (i) ecological threats (pests and invasives), (ii) general (hybridization with local species), (iii) environmental (alteration in aquatic ecology), (iv) introduction of exotic pathogens, (v) food safety and public health, (iv) financial and (vii) social. Uncontrolled introduction of exotic fishes also exterminated the indigenous fishes in some ecosystems. Common carp introduced into Kashmir valley has almost exterminated the native Schizothoracine fishes in the Kashmir valley. In the Gobindsagar reservoir Indian major carps, especially catla, has already been replaced by the exotic silver carp. The introduction of trouts in almost a virgin niche at high altitude coldwater streams has, however, remained encouraging.

Over-exploitation

The over-exploitation of fishes is a major concern and riverine fisheries can have severe consequences. The fact that the inland fisheries in the Indian subcontinent are largely unregulated is a major cause for concern. Another major obstacle to the sustainable management of the freshwater fisheries resources is the paucity of empirical data regarding levels of exploitation and their effects on the fish populations. Over-exploitation of fishery due to high prices of fish has drastically declined some prized fishes in different ecosystems. Wanton killing by the use of dynamiting and poisoning has affected a number of upland fishes. Victim species of such destructive devices are *Tor putitora, T. tor, Schizothorax spp., Labeo dero, L. dyocheilus* and *Barilius bola*. The use of bleaching powder and even fish toxicants eradicates all the biotic components of the effected waters.

Climate change

The impact of climate change on fish population will result from both biological and abiotic change, as well as shifts in the man-made environment. For coldwater fisheries, changes in water temperature, species distribution and habitat quality are the main direct impacts expected to result from climate change. Changes to water temperature, water levels, extreme events, and climate driven shifts in predator and prey abundances will all impact fish community. However, the limited understanding of the mechanisms controlling the behavioural response of fish to climate, limitations in data to account for the delayed impacts of environmental variability reduce the ability to project net impacts at the moment. The impact of these stresses lead to decline in effective population sizes over a period of time, depending upon original population size and magnitude of the threat. Some potential impacts on fish include shifts in species distributions, reduced or enhanced growth, increased competition from exotic species, greater susceptibility to disease and/or parasites, and altered ecosystem function. These changes could eliminate species from all or part of their present ranges and would affect sustainable harvests of fish. Climate change is likely to produce profound modifications to the structure and functioning of the aquatic ecosystem and has the potential to affect freshwater ecosystem use by fishes through habitat alteration and will result changes in the distribution and abundance of species (James et al., 2008). Model predictions indicate that global climate change will continue even if greenhouse gas emissions decrease or cease. Therefore, proactive management strategies such as removing other stressors from natural systems will be necessary to sustain our freshwater fisheries.

Biodiversity conservation in NEH and involvement of NBFGR

The Convention on Biological Diversity (CBD) in its Sixth Conference of Parties in The Hague, Netherlands, in April 2002 resolved to reduce significantly biodiversity loss by 2010 at the global, regional and national levels in an effort to alleviate poverty and benefit the Earth (CBD, 2002). As human activities continue to alter freshwater ecosystems, a critical conservation goal is to develop dynamic biodiversity conservation management strategies that can adapt to changing environmental conditions while maintaining natural biogeographic patterns in biota. Until recently, comparatively little effort has been devoted to the design and implementation of freshwater conservation management frameworks (Abell et al., 2007). In order to address conservation issues a wide variety of factors must be taken into consideration in developing a comprehensive action plan including information on the taxonomy, biology, stock structure and their distribution, status of the target species in the area concerned. Since the long-term prospects for the conservation of rare and endangered fish species depend on the availability of genetic variation within population, it is therefore important to obtain information on the extent and distribution of such variation. Under the broad mandate of conservation, maintenance and preservation of fish genetic material, collaborative projects were undertaken and considerable achievements were made in inventory and phylogeny using molecular tools, exploration, fish atlas and database, gene banking, captive breeding and artificial propagation of the endangered fishes like chocolate Mahseer *(Neolissichilus hexagonolepis)*, *Osteobraama belangeri*, *Ompok* sp., *Chitala chitala* etc. The other areas include habitat mapping and development of spatial database for Mahseers and documentation of indigenous knowledge and policy issues related to fisheries.

Regional fish live gene bank

Live gene bank contributes to delisting of threatened species by captive breeding and restocking in species-specific recovery programs. Such gene banks can contribute to recovery and utilization of genetic diversity and its use in conservation programs and genetic enhancement. In the NEH region, two small Live Gene Banks have been established at Gwahati in collaboration with Gwahati University and Department of Fisheries, Govt. of Assam with the objectives to explore the habitat of the threatened fish species in wild environment of the North East, their culture and study of the life-history traits and breeding behaviour of prioritized species. Success was observed in captive breeding for *Clarias batrachus, Heteropneustes fossilis, Ompok bimaculatus, Ompok pabda, O. pabo, Sperata seenghala, Chitala chitala, Channa spp. and Notopterus notopterus.*

State Fish Concept

An innovative approach of conservation of some regionally important fish species was envisaged through inviting each of the State Fisheries Department to declare one fish species as state fish. With this process 17 states have become partners with the NBFGR in developing strategies for conservation and enhancement of their selected State Fish to achieve the real time conservation success which also includes five NEH states viz., Manipur for *Osteobrama belangeri* (*Pengba*), Tripura for *Ompok bimaculatus (Pabda)*, Arunachal Pradesh for *Tor putitora* (Golden Mahaseer), Nagaland for *Neolissochilus hexagonolepis* (Chocolate mahseer) and Mizoram for *Semiplotus modestus* (Kingfish).

Human resource development

Keeping in view the need of developing trained manpower and capacity building for biodiversity conservation, the Bureau has taken due consideration that the research achievements developed are disseminated to other agencies including researchers and students. Training programmes were conducted in the field of fish biotechnology, molecular marker development and analysis, DNA barcoding and molecular taxonomy, genotoxicity assays and disease diagnostics and reporting in order to develop capacity building and create specialized human resource in the country that can spearhead research in the frontier areas of science. Detailed knowledge of the habitat ecology and biology of fishes is essential for the conservation and sustainable use of threatened fishes especially.

Strategies and Action plans

The development of coldwater fish biodiversity management strategies will be a challenge and requires concerted efforts by integrating capture, culture fisheries and environmental programmes using latest technological innovations. The conservation policy should promote the management practices that maintain integrity of aquatic ecosystems, prevent endangerment and enhance recovery of the threatened species. Principle elements or tasks in the recovery programmes have been identified as (i) habitat and aquatic biodiversity management, (ii) native fish stocking, (iii) *ex-situ* conservation and gene banking and (iv) research data management, monitoring and capacity building. Prioritization of sites for fish sanctuaries need to be explored and implemented. The harm caused to native fish and habitats need to be compensated through aforestation, eco-restoration, soil conservation, complete ban on deforestation particularly in the fragile mountains and strict implementation of the acts, rules and regulations of Govt. of India. Moreover, data sharing and collaboration between academic institutions and governmental agencies are essential for the effectiveness of fish conservation.

Reference

Abell, R.A., Allan, J.D. and Lehner, B., 2007. Unlocking the potential of protected areas for freshwaters. Biological Conservation, 134: 48–63.

Allen, D.J., Molur, S. and Daniel, B.A. (Compilers), 2010. The Status and Distribution of reshwater Biodiversity in the Eastern Himalaya. Cambridge, UK and Gland, Switzerland: IUCN, and Coimbatore, India: Zoo Outreach Organisation. 978-2-8317-1324-3.

Badola, S.P., 2009. Ichthyology of the central Himalaya. Transmedia Publication, Uttakhand, 206 pp.

Biswas, S.P, Das, J.N. and Sarkar, U.K., 2007. Ornamental fishes of North East India. An Atlas. NBFGR, Lucknow.111 pp.

CAMP, 1998. Conservation assessment and management plan (CAMP) for freshwater fishes of India. Workshop report. Zoo Outreach Organization, Coimbatore/CBSG and NBFGR, Lucknow, India, pp. 1-158.

CBD. 2002. COP 6 Decision VI/26: Strategic Plan for the Convention on Biological Diversity. http://69.90.183.227/doc/publications/gbo/gbo3-final-en.pdf. Accessed on 06 December 2010.

De Silva, S. S. and Abery, N.W., 2007. Endemic Freshwater finfish of Asia: distribution and conservation status. Diversity and Distribution, 13:172-174.

Dudgeon, D. 2005. River rehabilitation for conservation of freshwater biodiversity in monsoonal Asia. Ecology and Society 10: 15. http://wwwecologyandsociety.org/vol10/iss2/art15/. Accessed: 08 December 2010.

Ghosh, S.K. and Lipton, A.P., 1982. Ichthyofauna of the NEH Region with special reference to their economic importance. ICAR Spl. Bulletin No. 1 (ICAR Research Complex, Shillong), pp.119-126.

Guo, X.-G., He, S.P. and Zhang, Y.G., 2005. Phylogeny and biogeography of Chinese sisorid catfishes re-examined using mitochondrial cytochrome b and 16S rRNA gene sequences. Molecular Phylogenetics and Evolution, 35: 344–362.

Karmakar, K.A., 2000. Fish communities and their distribution in Himalayan Drainage System. Rec. zool. Surv. India, 98 (Part-4): 25-37.

Kottelat, M. and Whitten, T., 1996. Freshwater biodiversity in Asia with special reference to fish. World Bank Technical Paper, 343, 59 pp.

Kumar, K., 1996. Biodiversity of ichthyofauna of hill state of Himachal Pradesh. In: Proceedings of the National Symposium on Fish Genetics and Biodiversity Conservation for Sustainable Production. NBFGR, Lucknow, pp. 17-18.

Mahapatra, B.K., Vinod, K., Mandal, B. K., 2004. Fish biodiversity of north eastern India with a note on their sustainable utilization. Environment and Ecology, 22 (1): 56-63.

Menon, A.G.K., 1962. A distributional list of fishes of the Himalayas. J. Zool. Soc. India, 14 (1): 23-32.

Rüber, L., Britz, R., Kullander, S.O. and Zardoya, R., 2004.Evolutionary and biogeographic patterns of the Badidae (Teleostei: Perciformes) inferred from mitochondrial and nuclear DNA sequence data. Molecular Phylogenetics and Evolution, 32: 1010–1022.

Sala, O.E., Chapin, F.S., Armesto, J.J., Berlow, R., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D., Mooney, H., Oesterheld, A.M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M. and Wall, D.H. (2000). Global biodiversity scenarios for the year 2100. Science, 287: 1770–1774.

Sarkar, U.K., Pathak, A.K., Sinha, R.K., Sivakumar, K., Pandian, A.K., Pandey, A., Dubey, V.K. and Lakra, W.S., 2012. Freshwater fish biodiversity in the River Ganga (India):changing pattern, threats and conservation perspectives. Reviews in Fish Biology & Fisheries, 22: 251–272.

Sehgal, K.L., 1999. Coldwater fish and fisheries in the Himalayas: rivers and streams. FAO Fisheries Technical Paper. No. 385: 41-63. Rome, FAO.

Sen, Nibedita, 2000. Occurrence, distribution and status of diversified fish fauna of North East India. pp. 31-38. In: A.G. Ponniah and U.K. Sarkar (eds.). Fish Biodiversity of North East India, NBFGR, Lucknow.

Sen, T. K., 1985. The fish fauna of Assam and the neighbouring Northeastern States of India. Occasional paper No. 64, Records of Zoological Survey of India, 216 pp.

Sinha, M., 1994. Fish Genetic Resources of the Northeastern Region of India. J. Inland Fish. Soc. India, 26(1): 1-19.

Smakhtin, V. and Anputhas, M., 2006. An assessment of environmental flow requirements of Indian river basins. International Water Management Institute Research Report 107. Colombo, Sri Lanka.

Sundar Shyam and Joshi, C.B., 2002. State-of-art of the threatened fishes of Himalayan uplands and strategies for their conservation. In: Coldwater fish genetic resources and their conservation (Eds. Das et al.), Natcon publication 7, Nature conservators. 314 pp.

UNESCO, 2003. The United Nations world water development report: water for people, water for life, UNESCO and Berghann books, Paris.

Uniyal, D.P., 2010. Faunal of Uttarakhand. Zool. Surv. India. 18(part 1): 533-621

Vishwanath, W., Lakra, W.S. and Sarkar, U.K., 2007. Fishes of North East India. NBFGR, Lucknow, India, 290 pp.

Yadava, Y.S. and R. Chandra, 1994. Some threatened carps and catfishes of Brahamaputra river system. pp. 45-55. In: P.V. Dehadrai, P. Das and S.R. Verma (eds.). Threatened Fishes of India, Nature Conservators, Muzaffarnagar, India.

Woman empowerment through Ornamental fish culture in cages: A success story at Dimbhe reservoir, Maharashtra

Kiran Dube and W. S. Lakra
Central Institute of Fisheries Education
Versova, Mumbai - 400 061

Dimbhe reservoir is situated in Pune district on Pune Nasik highway, 100 kms from Pune and 65 kms from Manchar on the way to Bhimashankar. Dimbhe dam Project forms part of the Kukadi irrigation project. It was constructed on Ghod River in Ambegaon tahsil. It is a medium size reservoir (1278 ha), with very low productivity, almost barren in nature, situated in the remote and difficult area. The area receives heavy rainfall during monsoon season.

The community includes hard core, resource poor, displaced tribals who are settled at the fringe of the reservoir. The population is predominantly tribal (97%, Mahadev Koli and Katkari) with a small proportion of scheduled caste. There are now 19 villages around the periphery of this reservoir. Fisherman and fisherwoman both are equally active and participate in all fisheries activities.

How the idea came up?

To cater the need of employment generation during the closed fishing season (June to August), CIFE thought of involving tribal women in growing ornamental fish. Under the ongoing project on reservoir development, a trial for raising gold fish was taken up and the results were an eye opener. In two months' time fish were saleable with very bright golden - orange coloration and in six months time they were all mature and could be used as brooders. During this culture, women were involved for feeding and maintenance of fish and cage both.

Awareness Workshop

Woman participation was initiated through introduction of ornamental fish rearing in cages. Initially, during January 2008 a two days awareness workshop was organized at reservoir site for ornamental fish culture, where more than hundred participants took part.

Formation of SHG

Self Help Group (SHG) were formed and were registered. The total number of SHG at Dimbhe is 32. Initially twenty-two women came forward and shown their keen interest to take up ornamental fish rearing in cages.

Training

A hands - on training programme of one week period was conducted at CIFE on ornamental fish breeding and culture aspects for tribal, tribal fisherwomen of Dimbhe reservoir. The training also included fabrication of glass aquaria, aquarium setting and live feed culture. Once the women were indentified they were exposed to a two days short term training conducted at Dimbhe reservoir on "Ornamental fish culture in cages"

The fisher women were made aware with the identification of live bearers like guppies, mollies, platys and swordtails and egg layers such as goldfish, fighter fish, angels etc. It was followed by the demonstration of artificial feeds preparation. The constituents were rice bran, oilcake, vitamins and mineral mix. The artificial feeds were of different types like flakes, pellets and cakes in dry and wet forms. The demonstration was conducted for the preparation of slurry in turn to have the mass culture of live food organisms.

The two very important water quality parameters like pH and dissolved oxygen were demonstrated. In this regard, they were also made aware with of de-chlorination of municipal water if taken for aquarium keeping. The various measures to control the bio-fouling of cages were discussed. Having covered the above mentioned aspects, how to pack the fishes and transport them were told with live demonstration. The oxygen and water ratio in the packing bags, how to make the bags air-tight, packing density in the context traveling time was also demonstrated.

Exposure to other ornamental fish tradersl Breeders

In the meantime, these women were given exposure to other resources e.g. other entrepreneurs at Ratnagiri, training at Fisheries Department - Pune, training at fisheries department - Bandra, Mumbai. The tribal fisherfolk women of Dimbhe have been able to exhibit samples of the goldfish at the Maharashtra State MatsyaMahotsav 2010 held at Mumbai in Dee 2010 for 3 days. A stall was provided by State Fisheries Dept to exhibit the work of the tribal fisherfolk of Dimbhe by the fisheries co-op. The red-gold shiny goldfish were a big crowd- puller and they had lots of visitors including women and children. Besides, 18 wholesalers expressed interest in placing orders with them. Besides the Taraporewala Marine fish Research Centre Mumbai have also offered to put these women in touch directly with aquarium owners and wholesalers in Mumbai. Many Govt. Officers who have visited them as also supporters of Shashwat have offered to help in marketing aspects. CIFE has continually supported these women in marketing aspects.

Hands on training for cage culture

Seeing women's involvement, CIFE let them use 2 out of the 16 floating cages for growing ornamental fish. Fish seed was regularly provided by CIFE. Women were maintaining the cages and fish. They continued this work for two years and could get very good results out of it. During this period, they could take four crops of gold fish. Most of these fish were sold directly and some of the fish were reared for longer time and were brought to CIFE as brood - stock. This experience was the real hands on training for the women.

Trial in old cages (for learning)

After the training of fisherwomen, initially on trial basis they were given four cages for hands on experience and learning of all activities. For training and practice these cages were stocked with the seed (800 gold fish fry, 25 mm 1.0g, in each cage) provided by CIFE and were fed and maintained by these women. Initially the fish was grown for three and half months and the first lot of fish was harvested (750 nos, 92 mm 86g from each cages). About 250 no of fish were left for growing brood stock, which were reared for another two months and were harvested (121mm, 270.5g) and brought to CIFE's Ornamental fish seed production unit, where they were bred for seed production, for rearing in cages again.

New cages exclusively for fisherwomen

For raising ornamental fishes in cages, sixteen new floating net cages (3m x 3m x 3m) were installed in the reservoir. The cages were made of HOPE knotless webbing. For walking platform saal wood was used. Sealed HOPE barrels were used for floating the cages.

These cages were stocked with 520 numbers of Koi carp, Gold fish and Angel fish where each were stocked for trial. A total of 83200 fish was reared and maintained by the women in cages. After rearing for a period of 2.5 to 3 months, fish were harvested and sold.

Sl. No.	Name of fish	Length range in cm	Weight range in gms
1.	Gold Fish	2.3cm- 3.6cm	0.25gm- 1.40gm
2.	Koi	4.6cm- 5.6cm	1.00gm- 4.05gm
3.	Angel fish	Angel fish	0.35gm- 0.85gm

Empowerment

Having exposure to various activities related to ornamental fish culture, their hands on training with cages and finally harvesting the beautiful fish fetching good price in the market gave tremendous confidence to the fisherwomen. Now, those women who were initially shy and hesitant about their capability now want to do more and more. They want more cages and more fish.

Shifting of cages to three different location

Since the set of cages was placed at one place and most of the women had to travel 15-20 kms every day which was very difficult due to poor transport facilities available at dam area. Therefore, they discussed and decided shift cages operation near their homes at three places viz Phulavade, Ambegoan and Dighad. In January, 2012 overall 10,000 Ornamental fishes (8000 Koi carp and gold fish gold fish and 2000 angel fish) were stocked in 16 cages by the women for growing them to the marketable size.

Revenue generation

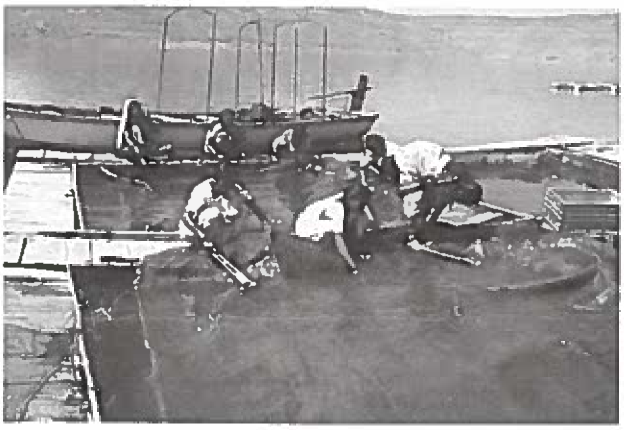
The tribal fisherfolk women have started selling of ornamental fishes reared by them in 16 newly constructed cages. First time they earned Rs. 4025 by sale of 225 numbers of ornamental fish (gold fish 63 nos., Koi carp 154 nos. and Angel 8 nos.) and Rs 9580 by sale of aquariums 62 nos. prepared by them. The trend continued in next year also with much higher quantum.

Today - the Dimbhe women

Today, the Dimbhe women are confident about the technology of "Ornamental fish culture in Cages". They are not only familiar with the operation and maintains of cages, they ar:e aware of the ornamental fish market as well, they are going to the market and select the fish which they want to grow in cages with initial input of 10,000 I. They are able to make a profit of 70,0001- from this business. '

For the sustainable development of the Dimbhe reservoir, Shashwat, an NGO who has been closely associated with these stakeholders along with CIFE won the United Nations Development Programme (UNDP) Equator Prize 2012 in Rio de Janeiro on June 20th. They also won a Special Prize for water and the community also received 3rd prize in the Sitaram Rao Livelihoods Case Study competition, 2011.

Cage aquaculture at Dimbhe reservoir



Fisher women working for growing ornamental fish in floating net cages

Water Requirement for Aquaculture and Inland Fisheries: A Challenge

A.P. Sharma and A. K. Sahoo
Central Inland Fisheries Research Institute
Barrackpore, Kolkata 700120

Introduction

Water is one of the most precious natural resources for sustaining life on the earth. Nearly, 97% of the entire water world is saltwater, and 3% is freshwater. Less than 1% of the world's fresh water (~0.008% of all water on earth) is accessible for direct human uses. This is the water found in rivers, reservoirs, lakes and those underground sources. Only this amount is regularly renewed by rain and snowfall and is therefore available on a sustainable basis. Water from surface and ground resources play a major role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, and recreational activities.

Globally, agriculture is the largest user of water. Water use in agriculture is often highly inefficient with only a fraction of the water is effectively used for plant growth, with the rest drained or lost via evapo-transpiration. With population growth and rising affluence, the need for food and thus agricultural water for irrigation is increasing. At the same time the quantity of water with a sufficient quality is declining. Thus, producing more with less is the only option. Water efficiency in agriculture has been extensively researched for many years. Universally applicable solutions are however difficult to come by, particularly due to different contexts and high specificity of agricultural practices. While, competition for water and aquatic habitat is the most critical challenge facing Inland fisheries majorly rivers in many countries. The need for water to support fish and fisheries can conflict with the needs of other sectors, in particular agriculture, in both water quality and flow requirements for sustaining aquatic habitat. Decisions on water management frequently do not take into account the impact on fish and fisheries and on the rural livelihoods of the populations that depend on them. In part this is because inland fisheries are greatly undervalued in water management at local, national, and basin levels. Equally, there is a lack of knowledge of how to optimize ecosystem services, for example, through environmental flow and water productivity approaches that are needed to guide the allocation of sufficient water to sustain fish and fisheries in river systems. However, in the recent few decades, water availability in the world rivers is diminishing at faster rate due to the growth of population and industrialization. The water availability is further hampered due to the ongoing contamination of the water bodies; some caused by the callous anthropogenic activities while the others due to natural reasons. Therefore, allocation or budgeting of water for a sustainable aquaculture and riverine fisheries is need of the hour.

Water budgeting is known as efficient allocation of water and define as a method of balancing the input and output of a system. The system can represent a basin, stream or groundwater. Water budget can also be defined as an analytical tool whereby the sum of the system inflows equals the sum of the system outflows. A summation of inputs, outputs and net changes to a particular water resource system over a fixed period. Water budget, in its elementary form, can be represented by the equation:

> Total rainfall input = Surface water flows + Groundwater recharge + Evapo-transpiration.

Water sources and budgeting for aquaculture

Water availability has been identified as a key environmental factor that influences the potential for small-scale freshwater pond aquaculture. The water availability for aqua-farm is either from a river or a stream, a lake or a dam, or rain water collected in wells and ponds or pumped up water from underground sources. Commonly, well water is usually the preferred source for aquaculture purposes if the groundwater is abundant, since it is free from undesirable fish, eggs, predators and pollutants. However, it has certain constraints such as

i. expensive

ii. needs pumping from a deep source

iii. dissolved oxygen content is low

iv. Presence of some pollutants such as heavy metals, pesticides, chlorinated hydrocarbons etc., which would kill fish.

Therefore, an analysis of chemical and biological properties of the proposed source of water must be conducted. The quality of that water must support the culture of the desired fish species and should include potential health hazards for both humans and the fish to be cultured. In aquaculture, production usually is done in ponds, cages, net pens, or raceways. Further, depends on the species, therefore water uses are system and species specific in aqua-farming.

Water is the most basic resource in aquaculture, therefore judiciary use and allocation of water is required in terms of inflows, outflows and storage volume in the culture systems. The hydrologic equation in its simplest form can be expressed as

Inflows = Outflows ± Δstorage

In general, inflows to the culture systems are expressed by precipitation, while outflows are represented by evaporation and seepage. Further, the total water flows depends upon the types of the culture practices. The embankment ponds commonly used for commercial aquaculture generally have small watersheds and receive no ground water inflows (Boyd, 1982). In such ponds inflows include precipitation, runoff and regulated inflows, while outflows include evaporation, seepage and regulated discharge. In case of polyethylene lined ponds water loss due to seepage is minimal but all other factors remain same.

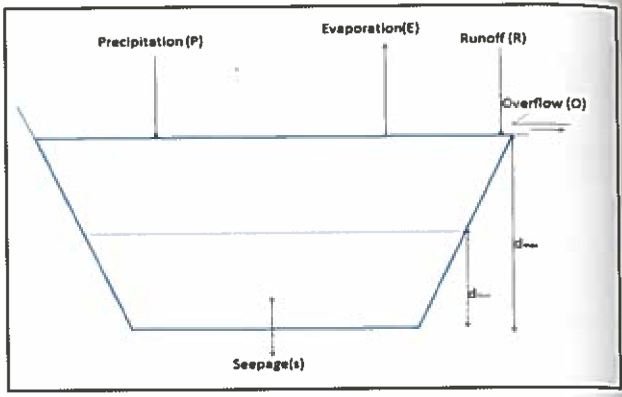


Fig. 1. Schematic diagram showing typical water use in a pond

Water budgets are useful tools for estimating requirements of ponds that rely on rainfall and runoff as primary water sources (Boyd, 1982), and for flow-through pond facilities. Such budgets can also be of use to assess whether a potential or existing source will meet the projected water demand of aquaculture facilities, and in comparing the value of available water for different agricultural purposes. Finally, water budgets can also be used to estimate the likelihood of pond water discharge either by intended release or overflow, and may therefore have applications in evaluating potential environmental effects of pond facilities.

Precipitation

Precipitation exhibits marked variability in time and space and studied in the field of cloud physics. Numerous physical processes are involved in this with a diverse collection of issues ranging from environmental quality to climate change. The different steps include cloud formation are cloud structure, cloud seeding and cloud and climate. The largest precipitation is associated with the monsoon in the form of heavy rainfall during the Asian summer and Asian winter. Rainfall is a major source of water to ponds, as it falls directly into them and generates runoff that enters them. Standard rain gauges are used to determine the amount of rain that falls at a particular location which is for use in aquaculture management.

Fig.2 Standard rain guage (Boyd, 2005)

Standard rain gauges consist of a cylindrical bucket containing a removable inner tube with a cross-sectional area one-tenth that of the bucket (Fig. 2). A funnel at the top of the bucket directs rainfall into the inner tube, where a dipstick measures the depth of rain collected. Because of the larger area of the top of the funnel, rainfall is collected and stored in the inner tube. Thus, the dipstick is calibrated so that 10 cm of length is equal to 1 cm of rainfall. Usually, the gauges are checked and emptied daily. Water gain from rainfall falling on the pond surface can be calculated from precipitation data for a given location as follows:

$$P = \frac{Ap_d}{1000}$$

Where, *pd* is the daily rainfall (mm day_1)

Runoff

Runoff results from short duration highly intense rainfall, long duration low intensity rainfall, snowmelt, failure of levees or combination of these conditions.

Runoff is not a factor in the embankment ponds typical of aquaculture, for their watersheds are restricted to the inside slopes and the tops of the embankments. Watershed ponds usually have catch areas six to12 times greater than their water surface areas. It is difficult to estimate runoff, for it varies with topography, vegetative cover, soil type and moisture content, season, rainstorm characteristics, and other factors. However, on an annual basis, runoff amounts are usually 25-40% of rainfall totals.

Evaporation

Evaporation occurs when water is converted into water vapor. The rate is controlled by the availability of energy at the evaporating surface and the ease with which water vapor can diffuse into the atmosphere. Two standard evaporation rates are defined, potential evaporation and reference crop evaporation, are used as the basis for evaporation estimates. In addition, evaporation rates can also be measured with evaporation pans. Standard, class- A evaporation pans are made of stainless steel 120 cm in diameter and 25 cm deep.

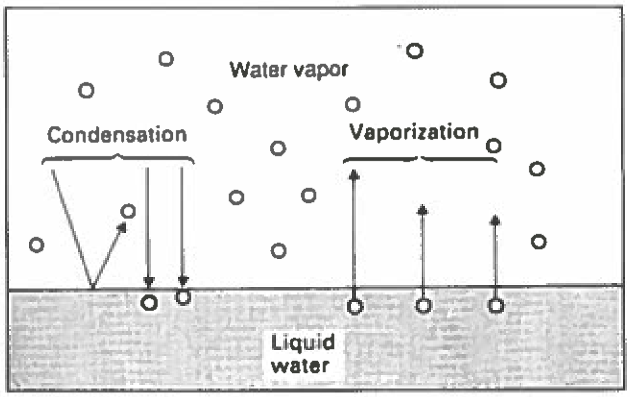


Fig. 3 Molecular exchange between water and vapor

They are filled within 5 cm of the top with clear water and placed on a level platform above the ground in an open, grassy area. A stilling well and hook gauge measure the evaporation loss from day to day. A rain gauge should be placed nearby to correct for rain falling into the pan. Water must occasionally be added to the pan to restore its level. Like rainfall, pan evaporation is measured daily, with monthly and annual totals reported. Spatial variation in evaporation is not nearly as great as for rainfall. Therefore, evaporation data from a weather station in the general area of an aquaculture facility can be used in place of data measured on site.

Evaporation from lake surfaces has been reported to equal 0.7 times pan evaporation. Ponds tend to heat faster than large lakes, which causes greater evaporation. A study at Auburn University found that a factor of 0.81 times pan evaporation provided the best estimate of evaporation from pond surfaces.

Significant amounts of water can be lost from ponds via evaporation (e.g. Szumiec, 1979). Evaporative water loss is primarily a function of ambient air temperature, relative humidity and wind velocity, and can be estimated as follows (Gray, 1970):

$$E = \frac{A\phi_e}{\rho_w L}$$

Where, Øe is evaporative heat loss (kJ m-^{2} day-1), ρw is water density (kg m-^{3}) and *L* is latent heat of vaporization of water (kJ kg-^{1}). Evaporative heat loss has been exhaustively studied in shallow water bodies and several expressions derived from the original work of Dalton (1802) are available to estimate such losses (Henderson-Sellers, 1984). While, Ryan et al. (1974) estimated accurate evaporative heat loss by using equation as below

$$\phi_e = (e_s - e_a)[\lambda(T_{wv} - T_{av})^{1/3} + b_0 u_2]$$

Where, *es* is saturated vapor pressure at the current water temperature (mmHg), *ea* is water vapor pressure immediately above the pond surface (mmHg), *Twv* and Tav are the virtual water and air temperatures respectively. λ and *bo* are constants with values of 311.02 kJ m-^{2} day-^{1} mmHg-^{1} and 368.61 kJ m-^{2} day-^{1} mmHg-^{1} (m s-^{1}) 1, respectively, and u_2 is wind velocity (m s-^{1}) at a reference height of 2 m.

Seepage

Seepage from ponds is a complex variable for which accurate, direct measurements are impossible. It is possible, however, to obtain indirect estimates of seepage. A staff gauge or meter stick can be mounted vertically in a pond to read changes in the water depth. During periods when there is no rainfall and water is not added to or discharged from the pond, water level declines must equal seepage plus evaporation. Pan evaporation measurements during the period of water loss can help estimate the portion of the decrease in water level that resulted from seepage. Pond water loss or gain by seepage depends primarily on the soil porosity, methods used for pond construction, structural changes that have occurred to the pond basin over time, and pond management practices (Boyd, 1982; Teichert-Coddington et al., 1989). If the daily seepage rate (sr; mm day-1) is known, S can be calculated as:

$$S = \frac{As_r}{1000}$$

The surface area of the pond at the current water level is used to estimate seepage. This is a simplified assumption to avoid estimation of the actual area (i.e. pond bottoms and sides) from which seepage may occur. The use of a constant sr value for long-term simulations is somewhat questionable because pond seepage rates may vary substantially over time, particularly during rainy seasons when rainwater infiltrates ponds via the dikes resulting in lower net seepage rates (Boyd, 1982)

Fish production uses no more water and in many cases much less than the production of other animal foods (Brummett 1997, 2006; Verdegem, Bosma, and Verreth 2006) and, for the case of rainfed systems, the periodicity of water supply is also much less critical for fish than for crops. A comparative use of water for fish, crops and other animals is indicated in Table 1.

Table 1. Water requirement for various food production systems (Brummett, 2006)

Food Production systems	Water requirement (metric ton /cubic meter)
Potatoes	500
Wheat	900
Rice	1912
Beef	100,000
Chickens	3500
Tilapia (intensive)	21000
Carp (intensive)	740,000
Salmon: Cages	2,260,000

Water requirement for riverine fisheries: Environmental flows

Freshwater fish resources are probably among the most resilient harvestable natural resources, provided their habitat, including the quantity, timing, and variability of river flow, is maintained (Welcomme and Petr, 2004). Their management and conservation can be approached only at the ecosystem level, as changes in flow and water quality in rivers and river dependent water bodies can have major impacts on fisheries production there and downstream. These changes may arise naturally, due to climatic variability, as in Sahelian rivers (Lae *et al.*, 2004). More commonly, they result from human modifications to the flow regime and the functioning of the ecosystem, in particular from reduced extent and duration of flooding that undermine biological production and reduce the potential for fisheries.

Rivers constitute a sizeable part of the total freshwater resource, virtually supporting a range of ecosystem services, fish diversity and livelihood concerns of millions, especially the Inland fishers. Fish and fish related livelihoods constitute a prominent component of ecosystem goods and services that river water provides. About 250 million people in the developing world depend on the 12 million tons of fish caught from inland water bodies every year for their food, employment and income. However, over 70% of all temperate rivers are known to be heavily regulated and a similar trend is evident also in tropical, sub-tropical and arid-zone systems. In fact, changes to the morphology, hydrology and functioning of river ecosystems owe directly or indirectly to hydraulic interventions beyond a reasonable limit. It is not uncommon to see that in order to meet the growing demands of society, excessive amount of water is abstracted from rivers for agriculture and several other purposes, by installing a large number of small and large dams which cause irretrievable changes to the natural hydrographs of rivers. In this water control regimen, the adverse impact on riverine fish stocks and aquatic biodiversity is substantially high. Furthermore, the combined effect of irrational use of fishing gears, loss of breeding grounds and indiscriminately large scale exploitation of brooders and juveniles etc. emerges as the conspicuous cause for decline in riverine stocks. Therefore, generation of reliable data base is perceived to be so vital to have a realistic estimate of the exact flow needs for open-water systems of riverine fisheries. As a first move in this direction, it is imperative to calculate the amount of water that can reasonably be withdrawn without affecting ecosystem functions, and then to assess the impact of new dams, barrages and river control structures on future flow patterns, which may provide the basic frame work to further estimate the discharges from these impoundments for conserving the aquatic environment downstream. Reduced water flow in the rivers not only causes loss of fish habitat but also aggravates aquatic pollution. As a result of huge water abstraction for agriculture, domestic, industries, and for electricity generation, it practically leaves very little water in rivers for most part of the year. The natural resilience of rivers in abating pollution by flushing and dilution is therefore lost. This underlines the research need for environmental flow assessment (EFA) in rivers, which explains the river inflow requirements necessary to sustain a complex and essential habitats and ecosystem processes.

In principle, Environmental flow refers to the water considered sufficient for protecting the structure and function of an ecosystem and its dependent species. Environmental flows are required to be maintained through a river reach for sustaining its ecosystem and dependent species. It means enough water is to be released in the downstream of the river system after utilizing the water for the development projects in order to ensure downstream environmental, social and economic benefits. Realizing its importance, several countries have made ensuring environmental flows mandatory. For example, The Mekong River Agreement, 1995; South Africa's National Water Act, 1998 and the Swiss Water Protection Act, 108. These legislations attempt to ensure required minimum flow in the river system to sustain ecosystem services. Realizing the value and urgency of sustainability of riverine ecosystem, the environmental flows have been made mandatory in several countries; e.g, the Mekong River Agreement, 1995; South Africa's National Water Act, 1998 and the Swiss Water Protection Act, 108. These legislations could be viewed as an attempt to ensure required minimum flow in the river system to sustain ecosystem services (Dyson, 2000; King et al., 2003). As of now, over half (52%) of developed countries in the world are keenly involved in environmental flow initiatives at various levels of advancement (Tharme, 2003). In developing countries, however, the initiatives on environmental flow assessment (EFA) is either nascent, sporadic or limited only to restricted local attention, as evident from the fact that merely 11% of such counties are reportedly emphasizing on EFAs. Contextually it is imperative, therefore, to move forward proactively in managing Indian rivers ecosystem and fisheries, based on the environmental flow requirements, especially at a time when the demand for dams and barrages for hydropower generation rising over time. In India, very limited efforts have been given to assess the environmental flows in river systems. However, in the past five years CIFRI has been intensively working on this concept focusing on the water requirement for sustainable fisheries in different river systems (fig. 4)

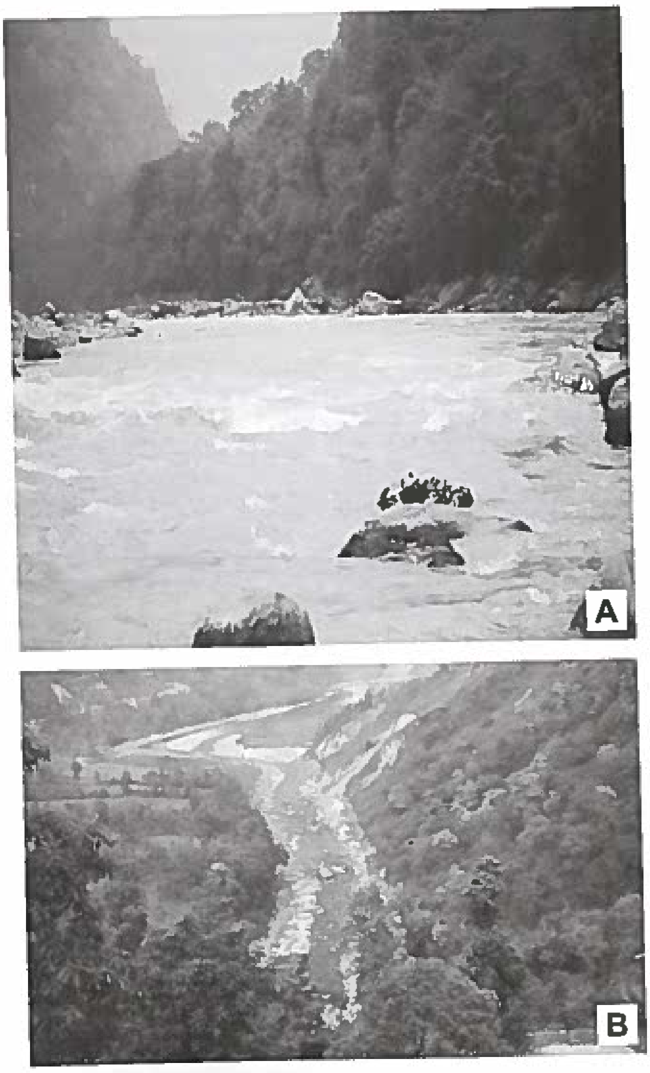


Fig. 4. Upstream (A) and Downstream (B) of Teesta HEP, Sikkim

As mentioned above, there are number of methods for the computation of environmental flows. It has been observed from the literature that different methods are used in different countries considering the various flow regimes. There are four main group of methods: Those are

A) Hydrological methods
B) Hydraulic rate methods
C) Habitat simulation methods
D) Holistic methods

In hydrological methods, the daily or monthly flow data series are analysed to provide the information about environmental flows. In addition, this method can be used to calculate a minimum flows for the gauged as well as un-gauged streams. Furthermore, it is easier to apply the hydrological method in the planning stage itself of the water resources development project. Hydraulic, habitat and holistic methods are capable of providing more detailed knowledge for the environmental flows in the streams. However, the requirement of extensive data base and efforts needed for collective the detailed information about the flow regimes, streams and the catchment restricts the applications of those methods. By using hydrological desktop method an attempt has been taken to quantify the environmental flow requirements of major river basins including Cauvery, Krishna, Godavari, Narmada, Mahanadi, Brahmani and Baitarani and some others. During 2005 to 2007 CIFRI conducted a survey on impact of dams in Krishna estuary across 80 kms from Srikakulam to Hamsala (sea face) indicates that dams constructed in the upstream and the Prakassam Barrage in Andhra Pradesh have diverted all the water away from the river for irrigation, industrial and urban uses. Upper part of the estuary is dry in summers and the estuary has now reached hyper saline conditions due to absence of freshwater. This has lead to near disappearance of oligohaline and freshwater species of carps, catfishes, murrels, feather backs. Low run off from the catchments, seawater intrusions due to absence of freshwater, increased salinity (20-35ppt) and drying up of one third of the estuary in non monsoon months leading to inadequate nutrient supply and sub normal productivity of fisheries. Based on this study CIFRI has recommended that productivity of estuary may be improved by discharging at least 1300-1500 TMC water from Prakassam Barrage annually in seasonal cycles.

While, a reduction on fish abundance, due to blocking migrations and due to changing the river into reservoirs, eliminating riverine spawning and non-spawning habitats, causes extirpation of populations has been reported by Godinho *et al.*, 2007. It has also been reported that in river floodplain area, interrupted fish migration routes and altered hydrological dynamics, interrupting floods in some periods are leading to severe decreases in flood intensity, duration and amplitude. Impacts related to its operation have affected floodplain assemblages and have been documented in some recent studies (Agostinho *et al.* 2004).

Based on the fish requirement in rivers, the flows can be classified as population, critical, stress, and habitat flows. Population flows regulate the volume of water in a system influencing the availability of fish biomass through density-dependent interactions. The main hydrological features arising from population flows that influence fish populations are volume, depth or area of water. They also change the relative areas of different types of habitat in the channel, as well as accessibility to floodplains, backwaters and off-channel structures. The main features of critical flows are flow velocity, and timing coupled with season, temperature regimes and sometimes, lunar phase, triggering events such as migration and reproduction. Stress flows occur during exceptionally high or low water events that endanger fish because of excess velocity or desiccation. These are catastrophic rare events occurring far apart and characterized by profound impacts on fish communities.

Challenges for River researchers

There are various critical issues such as aquatic pollution including industry, domestic and agricultural runoff, anthropogenic activities and use of destructive fishing gears that kill the juveniles and fish seeds. In addition to the climate change, the major issues in the riverine ecosystem is alteration hydrological regimes by construction of dams and barrages. Some extent this issue has become a treat for sustenance of river ecosystem by declining fish catch and native fish species, resulting loss of riverine fish germplam. The causes for loss of riverine biota are also attributed to changes in the hydrological regimes along with many other natural and human influences viz., changing pattern of water discharge, variations in sediment load, non judicious-irrational fishing, increased water abstraction, river course modifications, population growth, deforestation, agricultural activities, urbanization, fertilizer and fossil fuel consumption etc. Presence of heavy metals and organochlorine pesticide residues in water and sediments derived from the industrial and agricultural effluents are also found to affect the fishery. In addition the major challenge before us is climate change and their impact on riverine fisheries. The climate is changing at an alarming rate, causing temperature rise, shifting pat¬terns of precipitation, and more extreme events. It is predicted that agriculture and fisheries in the subtropics where most poor countries are situated will be affected most. All these have inconceivable adverse impact on the health and natural regeneration capacity of the river systems making major challenges before river researchers.

References

Agostinho, A.A., Thomaz, S.M., Gomes, L.C., 2004. Threats for biodiversity in the floodplain of the upper Paraná River: effects of hydrological regulation by dams. *Ecohydrology and Hydrobiology* 4, 267-280.

Boyd, C.E., 1982. Hydrology of small experimental ponds at Auburn, Alabama. Trans. Am. Fish. Soc. 111, 638–644.

Boyd, C.E., 2005. Estimating water volumes in aquaculture. *Global Aquaculture Advocate*,70-71.

Brummett, R. E. 1997. Farming Fish to Save Water. *Bioscience* 47 (7): 402.

Brummett, R. E. 2006. Comparative Analysis of the Environmental Costs of Fish Farming and Crop Production in Arid Areas: A Materials Flow Analysis. Paper presented to the International Workshop on the Environmental Costs of Aquaculture, April 25–28, Vancouver, Canada.

Dalton, J., 1802. Experimental essays on the constitution of mixed gases; on the force of steam or vapour from waters and other liquids in different temperatures, both in a Torricellian vacuum and in air; on evaporation; and on the expansion of gases by heat. Mem. Proc. Manchester Lit. Philos. Soc. 5, 535–602.

Dyson, M., 2000. Flow. In: Bergkamp,G & Scanlon, J. [Eds]. The Essentials of Environmental Flows. IUCN, Gland, Switzerland and Cambridge, UK. 118 pp.

Godinho, A.L., Kynard, B., Godinho, H.P. 2007. Migration and spawning of female surubim (Pseudoplatystoma corruscans, Pimelodidae) in the São Francisco River, Brazil. Environmental Biologyof Fishes 80, 421-433.

Gray, D.M., 1970. Handbook on the principles of hydrology; with special emphasis directed to Canadian conditions in the discussions, applications, and presentation of data. Water Information Center, Port Washington, NY.

Henderson-Sellers, B., 1984. Engineering Limnology. Pitman, London.

Lae, R., S. Williams, A. Malam Massou, P. Morand, and O. Mikolasek. 2004. Review of the Present State of the Environment, Fish Stocks and Fisheries of the River Niger (West Africa). In R. Welcomme and T. Petr, eds., *Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries* Vol. I. RAP Publication 2004/16. Bangkok: Food and Agriculture Organization, Regional Office for Asia and the Pacific.

King, J., Brown, C. & Sabet, H., 2003. A scenario-based holistic approach to environmental flow assessments for rivers. *River Research and Applications* 19: 619-639.

Ryan, P.J., Harleman, D.R.F., Stolzenbach, K.D., 1974. Surface heat loss from cooling ponds. *Water Resour. Res.* 10, 930–938.

Szumiec, M., 1979. Hydrometerology in pond fish culture. In: Pillay, T.V.R. (Ed.), Advances in Aquaculture. FAO, Fishing News Books, London, pp. 117–120.

Teichert-Coddington, D.R., Peralta, M., Phelps, R.P., 1989. Seepage reduction in tropical fish ponds using chicken litter. *Aquacult. Eng.* 8, 147–154.

Tharme R.E. 2003. A Global Perspective On Environmental Flow Assessment: Emerging Trends In The Development And Application Of Environmental Flow Methodologies For Rivers. River Research and Applications, 19, 397–441.

Verdegem, M.C.J., R.H. Bosma, and J.A.V. Verreth. 2006. "Reducing Water Use for Animal Production through Aquaculture." *Water Resources Development* 22 (1): 101–13.

Welcomme, R.L., and T. Petr, eds. 2004. *Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries Volume I.* RAP Publication 2004/16/17. Bangkok: Food and Agriculture Organization, Regional Office for Asia and the Pacific.

Recreational Fishing in India: Prospects and Management

T.K.Srinivasa Gopal and Saly N.Thomas
Central Institute of Fisheries Technology
Cochin-682 029

Introduction

Recreational fishing is important as it gives immense pleasure and mental peace to the angler without involving any risk factor associated with many other recreational activities like diving, kayaking and swimming with wild dolphins. Thus this is an ideal leisure time activity for the young as well as senior citizens. Recreational fishing methods range from fly fishing to the modern high-tech fishing from modern vessels targeting marlin and tuna. Recreational fishing can be both fresh water and marine. Fresh water angling is mostly targeted on mahseer, trout, snow-trout, carp and catfish. Sea angling started in late 1800 along with the invention of motor boat. USA, Australia, New Zealand, Hawaii etc. were the countries where this game started initially. Later, as more powerful and large vessels were made available the endeavour grew up and spread to Asian maritime countries where fishery close to shores was available.

Ecotourism is defined as "responsible travel to natural areas that conserves the environment and improves the well-being of local people" (TIES, 1990). Ecotourism envisages minimum impact to the environment, conservation of biodiversity, positive experience for both the guests and hosts and direct financial benefits for conservation of resources and for empowerment of local people. In this context, recreational fishing is an ideal activity coming under ecotourism.

Recreational fishing is diverse in terms of the diverse catching implements used like spear, rod and line, pots, small nets or bare hands. However, it mostly refers to angling, the activity of catching fish on hooks using rod and line or hand held line. This is due to the challenge of finding and catching the fish associated with angling. Thus often recreational fishing is termed as 'angling'

The main difference between recreational fishing and commercial fishing is that while recreational fishing is mainly for enjoyment or adventure, commercial fishing is for monentary benefits, production of food and for employment. Besides, recreational fishing does not include sale of fish.

Recreational fishing is the most attractive outdoor physical activity for amusement, outdoor recreation and for relaxation. Due to absence of competition, there does not arise the question of stress or strain. Unlike many commercial fishing activity recreational fishing does not disturb the biodiversity or adversely affect the ecological balance. Recreational fishing normally does not produce noise or disturb the ecosystem.

The economic benefits of sports fishing are both direct and direct. The direct benefit refers to the money directly spent by the sport fishers while the indirect benefits can be the employment and the number of personnel engaged in it. The money sport fishers spend result in a sizeable employment viz., employment in fishing unit, agents, managers, fishing implement supplier and manufactures and travel and food sector associated with it.

There are 118 maritime countries around the world where recreational fishing takes place (Montemayor and Sumaila, 2010). The highest participation rate was estimated for Oceania (17% of the population) followed by Europe (3.7%), North America (2%) Africa (0.3%) while Asia had the lowest participation rate (0.2%) (Montemayor and Sumaila, 2010). Though European and North Americans engage in recreational fishing at a very high level, 80% of it takes place in fresh water. The estimated recreational anglers around the world in 2003 was 58 million spending a total of 39.7 billion US generating 0.954 million jobs. There is no authentic data on the number of people engaged in recreational fishing worldwide. Nearly 20 million anglers are there in USA while another 3 and 5 millions are there in Japan and UK respectively (Borgohain, 2000). The total annual catch by recreational fisheries was estimated at 47 billion fish in 2004, which comes to 12% of total world catch (SOFIA, 2012).

Types of recreational fishing

Recreational fishing is broadly divided in to two, fresh water and marine. Fresh water recreational fishing is mainly conducted in rivers, pools, bays and cold water streams. The main target species are carps, trouts and mahseers. Marine recreational fishing is conducted in open seas and beaches. Marine recreational fishing is present in 76% of the worlds Exclusive Economic Zones (EEZ).The target group of fishes are snappers, groupers, tunas, marlins and marine cat fishes.

Based on the fishing equipment and methods there are four basic types of recreational fishing practices. They are spin fishing, fly casting, bait casting and jigging. Spin fishing is an angling technique where a spinning lure is used to entice the fish to bite. Spin fishing is used in both freshwater and marine environments. Two types of reels are used in spin fishing viz., open faced reel and closed faced reel. In spin fishing rod there is no trigger attached to the base of the fishing rod unlike in bait casting fishing rod. The effectiveness of spinner and lure are governed by weight, colour, and actions of the lure and the speed of retrieval by the angler. The common freshwater target species are trout, salmon, perch and bream. In fly fishing an artificial 'fly' is used to catch fish. The fly is thrown into water, using a fly rod, reel, and specialized weighted line. Fly fishermen use hand tied flies that resemble natural invertebrates or other food organisms, or 'lures' to attract the fish to strike. Fly fishing can be done in fresh or salt water. Techniques for fly fishing also differ with habitat like lakes and ponds, small streams, large rivers, bays and estuaries and open ocean. Bait casting involves presenting live or dead baits in a variety of ways to attract and catch fresh water or marine fishes. The bait, cut into pieces is attached on hook. The main baits used are small fishes, shrimps and crabs. The bait rigs are used in various combinations of terminal tackle - hooks, leaders, swivel, beads, sinkers etc. A single hook attached to the main fishing line is the simplest rig of all and is normally quite effective. Jigging is a fishing technique, which involves fishing with a special type of lure to attract the fish or prey. A jig consists of a lead sinker with a hook molded into it and usually covered by a soft body to attract fish. Jigs are intended to create a jerky, vertical motion. The jig is very versatile and can be used in both salt and fresh water. Many species are attracted to the lure which has made it popular amongst anglers.

Indian Scenario

With the fast improving Indian economy and the changing life style of 'young India' there is ample scope for establishing recreational fishing to the status of tourism industry. India has ample scope for recreational fishing with about 40 indigenous and exotic fresh and saltwater fishes, which are some of the finest game fishes in the world and with a vast stretch of fresh, brackish and marine waters. The country has about 50000 km of fresh water bodies viz., river, streams and lakes. All major rivers are easily accessible and are near major cities. In addition, India has 8000 km of coastal area inclusive of two beautiful groups of islands, Andaman and Nicobar islands and Lakshadweep on the west and east coasts. Besides, India has the advantage of having different climatic conditions across the country enabling fishing throughout the year. Many of the hot spots for angling are the best tourist destinations of the country. Despite having such advantages, Indian recreational fishing is still considered as an insignificant sector. There is no authentic data on the number of people engaged, employment generated and the financial benefits of recreational fishing.

The most sought after marine game fishes are tuna species, mackerel, seer species, snapper, giant travelly, grouper, barracuda and marlins. The fresh water game fishes of India are mahseers, trouts, snow-trout and carps.

The Himalayas and the Western Ghats are the two important world class sports fishing destinations in India. The endemic species *Tor khudree, T. mussullah* and the exotic rainbow trout of Western Ghats are much sought after game fishes.

The Western Ghats have a number of lakes and reservoirs, the important ones being Ootty (34 ha) at 2500 m altitude in Nilgiris and Kodaikanal (26 ha) at 2285 ha both natural lakes. Two smaller lakes are Devikulam (6 ha) and Letchmi elephant (2.0 ha) in Munnar High range and Yercad (8 ha) at 1340 m altitude in Shevaroy hills. Of the 102 fish species listed in Western Ghats between 750 and 2000 m altitude very few are suitable as game fishes. Kashmir, Himachal Pradesh, Uttrakhand, Arunachal Pradesh, Assam, north west Bengal, Sikkim, Tamilnadu, Karnataka and Kerala have potential sports fishing destinations for mahseers, trouts and carps.

All ports towns where facilitates for coastal fishing are available, this practice has a prospect to be developed. Andamans, Lakshadweep, Orissa, Goa and Kerala coasts this can be undertaken. Presently an organized marine recreational fishing is practiced only in Andamans. With the presence of coral reefs and underwater canyons, Andaman warters offer a wide species of fishes suitable for game fishing.

Sea angling was started as an established enterprise in Andamans by 2005. Twelve sports fishing companies are registered with Dept of Fisheries, Andamans. Altogether 26 vessels are registered under these 12 companies out of which 11 vessels are based at Port Blair and 15 are at Havlock island. Popping, jigging and trolling are the main types of recreational fishing techniques carried out at Andaman waters. Circle hooks or barbless hooks are used in the lines to have minimum injury to the fishes caught. The angling activity exclusively is of the 'catch and release' type viz., the catch is released back in to the sea and is not retained unless injured severely. Proper care is taken during handling of the catch so that fishes have minimum injury. Season starts by mid October and lasts till May end. Mid January to end of May is the best season. Area of operation is as per the license but normally ranges between 10 and 200 m depth. The main game fishes targeted are giant trevally, dog toothed tuna, yellow fin tuna, Spanish mackerel, grouper and barracuda.

Legal framework in India

In many European countries and US, recreational fishing is regularized in terms of minimum landing size, prohibited species, closed seasons, area and gear specifications. The growth of tourism industry in India gives an indication that the interest in angling is on the rise. Unless properly regulated, the industry would harm the ecosystem and be a threat to the resources. The sector is not sufficiently regulated except in centres like Himachal Pradesh, Kashmir, Assam, Arunachal Pradesh and Andamans.

The tourism and fisheries departments are giving licenses to fish a specific stretch of river and there are restrictions on the number of fishes that can be caught. In Andamans, the foreign clients are required to take special permits. Besides, the sports fishing vessels have to be registered with the Department of Fisheries by paying registration fee and annual license fee. The minimum crew requirement is to be followed and it is mandatory for the crew to have identity cards. The boat license and the identity card have to be renewed annually.

In Kashmir, permits are issued to tourists for trout fishing for a day to a week. With each permit 6 fishes of 7.5 cm and above within a beat of 2 km are permitted to fish. Fishes of length below 7.5 cm should be released back.

In Himachal Pradesh sports fishing banned from 1st June to 31st July while in trout fishing the ban is from 1st November to 28th February. In Assam and Arunachal Pradesh angling is banned during closed seasons. License is given for specified stretch in Arunachal Pradesh while in Assam catch limit is observed.

In Lakshadweep islands, only in Agati and Bengaram Islands sports fishing is allowed and that for using pole and line only so that only big fish be caught. In Andaman, 'catch and release' policy is adopted.

Problems

Absence of clear cut policies is a major problem facing the recreational fishing sector of India. For any management interventions, data base on the sector viz., number of participants, employment opportunities, financial benefits, fishing implements used, treatment of the catch etc. are required. This is lacking in the Indian sector. The fresh water angling destinations lack comfortable camping facilities, approach roads and anglers hut. In the marine angling sector, the problems are lack of infrastructure for out board motor servicing, vessel dry-docking and also absence of provision for fresh water and bunkering facilities at the jetty. Fresh water and fuel have to be carried to the jetty. There is a huge untapped marline resource around Anadaman islands. This species has the maximum attraction from foreign clients. However, India is not able to capture this market due to the absence of dedicated fishing boats and experienced crew with good communication skills. The local fishermen who work on sports fishing vessels in Andamans lack language command to deal with foreign clients.

There are instances of recreational fishers having negative impact on commercial fishers. The increased fishing pressure for masher *Tor khudree* in the Western Ghats led to their decline

Anglers mostly target large individuals, which can have a negative impact on the ecosystem. Removal of larger individuals adversely affects the balance of the food web. The European Inland Fishery Advisory Commission (EIFAC) developed the Code of Practice for Recreational Fisheries in 2007-08, which stipulated standards for responsible environmentally friendly recreational fishing. FAO is developing technical guidelines censoring all types of recreational fisheries viz., harvest oriented angling, catch and release fishing, trapping and spear fishing in marine, coastal and inland waters. Such guidelines are meant for sustenance of the system ensuring a balanced development of recreational and commercial fishing.

Management Measures

The use of sophisticated fishing vessels with advanced navigational aids, efficient fishing implements and improving economic status of developing countries result in recreational fishing rapidly expanding across the world. Many recreational fishers is characterized by open-access scenario which is giving intense fishing pressure on certain pockets. Hence, the catch quota system is to be implemented to avoid unhealthy fishing pressure on the resources. Monitoring of the recreational fishers is to be done through registration and licensing.

The management measures that can be adopted in recreational fisheries are size limits, imposing licenses and fees, stocking of fish, closed fishing seasons, harvest regulations, 'catch and release', habitat management, human interference and control of predatory or unwanted species. Closed fishing season, closed areas, gear restrictions, catch limits, size restrictions on species caught and regulation of fishing effort are regulatory measures imposed for sustainability of the system.

The Authorities should ensure that fishing licenses are not issued during the breeding season of fishes (mostly monsoon). Besides, while issuing licenses the condition of 'catch and release' should be ensured. 'Catch and release' is a system in where the caught species are released back into the water body from where they are fished. In catch and release process use of barbless hooks and circle hooks reduces the chance of deep hooking and severe wounds giving a better chance for the survival of the released fish.

Recreational fisheries, important in most of the developed and developing countries of the world is a growing sector which attract people from all walks of life. For conducting recreational fishing judiciously, government has to implement strict regulations and management plans. In addition, the authorities or local bodies should conduct awareness campaign among the people about the importance and conservation aspects of recreational fisheries. In Indian scenario, very less research works are reported so far and more study is needed in this sector.

Reference

Borgohain, A. (2010) sport fisheries in north east India for encouraging eco-tourism, In: Cold water fisheries management (Mahanta, P.C and Saram, D.Eds) pp 275-284 Directorate of cold water fisheries research, India

Montemayor, A.M.C. and sumaila, U.R. (2010) A global estimate of benefits from ecosystem-based marine recreation: potential impacts and implications for management, J. Bioecon, DOI 10.1007/s10818-010-9092-7

TIES (1990) TIES Overview, http://www.ecotourism.org/ties-overview (Accessed October 2, 2012

SOFIA (2012) The state of world fisheries and aquaculture 2012, http://www.fao.org/docrep/016/i2727e/i2727e00.htm (Accessed September 30, 2012)

Sport Fishery and Ecotourism

Anju Agrawal[1] *and Krishna Gopal*[2]
[1]Department of Zoology, S N Sen B V P G College, CSJM University, Kanpur
[2]Aquatic Toxicology Laboratory, Indian Toxicological Research Centre, Lucknow

Recreational fishing, also called sport fishing, is fishing for pleasure or competition. It can be contrasted with commercial fishing, which is fishing for profit, or subsistence fishing, which is fishing for survival. The most common form of recreational fishing is done with a rod, reel, line, hooks and any one of a wide range of baits. Other devices, commonly referred to as terminal tackle, are also used to affect or complement the presentation of the bait to the targeted fish. Some examples of terminal tackle include weights, floats, and swivels. Lures are frequently used in place of bait. Some hobbyists make handmade tackle themselves, including plastic lures and artificial flies. The practice of catching or attempting to catch fish with a hook is known as angling.

Big-game fishing is conducted from boats to catch large open-water species such as tuna, sharks and marlin. Noodling and trout tickling are also recreational activities. One method of growing popularity is kayak fishing. Kayaks are stealthy and allow anglers to reach areas not fishable from land or by conventional boat. In addition, fishing from kayaks is regarded by some as an effort to level the playing field, to a degree, with their quarry and/or to challenge their angling abilities further by bringing an additional level of complexity to their sport. Historically, sport fishing has attracted greater interest among males. Women and girls represent barely 10% of the angling community, yet those who do enter the sport are often extremely successful, and at the highest levels of competitive angling, their results are comparable to those of their male counterparts.

Recreational fishing, also called sport fishing, is fishing for pleasure or competition. It can be contrasted with commercial fishing, which is fishing for profit, or subsistence fishing, which is fishing for survival. The most common form of recreational fishing is done with a rod, reel, line, hooks and any one of a wide range of baits. Other devices, commonly referred to as terminal tackle, are also used to affect or complement the presentation of the bait to the targeted fish. Some examples of terminal tackle include weights, floats, and swivels. Lures are frequently used in place of bait. Some hobbyists make handmade tackle themselves, including plastic lures and artificial flies. The practice of catching or attempting to catch fish with a hook is known as angling.

Big-game fishing is conducted from boats to catch large open-water species such as tuna, sharks and marlin. Noodling and trout tickling are also recreational activities. One method of growing popularity is kayak fishing. Kayaks are stealthy and allow anglers to reach areas not fishable from land or by conventional boat. In addition, fishing from kayaks is regarded by some as an effort to level the playing field, to a degree, with their quarry and/or to challenge their angling abilities further by bringing an additional level of complexity to their sport. Historically, sport fishing has attracted greater interest among males. Women and girls represent barely 10% of the angling community, yet those who do enter the sport are often extremely successful, and at the highest levels of competitive angling, their results are comparable to those of their male counterparts.

Sport fishing methods vary according to the area fished, the species targeted, the personal strategies of the angler, and the resources available. It ranges from the aristocratic art of fly fishing elaborated in Great Britain, to the high-tech methods used to chase marlin and tuna. Sport fishing is usually done with hook, line, rod and reel rather than with nets or other aids. The most common salt water game fish are marlin, tuna, tarpon, sailfish, shark, and mackerel.

In North America, freshwater fish include snook, redfish, salmon, trout, bass, pike, catfish, walleye and muskellunge. The smallest fish are called panfish, because they can fit whole in a normal cooking pan. Examples are perch and sunfish. In the past, sport fishers, even if they did not eat their catch, almost always killed them to bring them to shore to be weighed or for preservation as trophies. In order to protect recreational fisheries, sport fishermen now often catch and release, and sometimes tag and release, which involves fitting the fish with identity tags, recording vital statistics, and sending a record to a government agency.

Ecotourism operations occasionally fail to live up to conservation ideals. It is sometimes overlooked that ecotourism is a highly consumer-centered activity, and that environmental conservation is a means to further economic growth. Although ecotourism is intended for small groups, even a modest increase in population, however temporary, puts extra pressure on the local environment and necessitates the development of additional infrastructure and amenities. The construction of water treatment plants, sanitation facilities, and lodges come with the exploitation of non-renewable energy sources and the utilization of already limited local resources. The conversion of natural land to such tourist infrastructure is implicated in deforestation and habitat deterioration of butterflies in Mexico and squirrel monkeys in Costa Rica. In other cases, the environment suffers because local communities are unable to meet the infrastructure demands of ecotourism. The lack of adequate sanitation facilities in many East African parks results in the disposal of campsite sewage in rivers, contaminating the wildlife, livestock, and people who draw drinking water from it.

Aside from environmental degradation with tourist infrastructure, population pressures from ecotourism also leaves behind garbage and pollution associated with the Western lifestyle. Although ecotourists claim to be educationally sophisticated and environmentally concerned, they rarely understand the ecological consequences of their visits and how their day-to-day activities append physical impacts on the environment. As one scientist observes, they "rarely acknowledge how the meals they eat, the toilets they flush, the water they drink, and so on, are all part of broader regional economic and ecological systems they are helping to reconfigure with their very activities." Nor do ecotourists recognize the great consumption of non-renewable energy required to arrive at their destination, which is typically more remote than conventional tourism destinations. For instance, an exotic journey to a place 10,000 kilometers away consumes about 700 liters of fuel per person.

Ecotourism activities are, in and of themselves, issues in environmental impact because they may disturb fauna and flora. Ecotourists believe that because they are only taking pictures and leaving footprints, they keep ecotourism sites pristine, but even harmless-sounding activities such as nature hikes can be ecologically destructive. In the Annapurna Circuit in Nepal, ecotourists have worn down the marked trails and created alternate routes, contributing to soil impaction, erosion, and plant damage. Where the ecotourism activity involves wildlife viewing, it can scare away animals, disrupt their feeding and nesting sites, or acclimate them to the presence of people. In Kenya, wildlife-observer disruption drives cheetahs off their reserves, increasing the risk of inbreeding and further endangering the species.

The main target species for hunting tourism include larger ungulates (mostly cervids and bovids), rodents (rabbits, marmosets), and waterfowl (ducks, geese), but also incorporate carnivorous species such as bears, wolves, foxes, felids (wild felines), mustelids (weasels), and crocodiles. Fishing focuses on a wide range of marine/estuarine fish, molluscs, crustaceans, and a variety of freshwater species in rivers and lakes. Not all hunting/fishing falls under tourism, but much of it incorporates the following defining elements of tourism:

- Travel to and from a particular destination
- The presence of a tourism service industry (outfitters, tour guides, hunting farms)
- The exchange of money for services
- Overnight, to several months, stays at destinations

- A service industry
- Aspects of leisure and recreation

International hunting tourism, as an industry, has developed in the wake of the European expansion. The affluent British gentleman-adventurer, often also a naturalist, travelled to remote places, to explore first-hand the wonders of the tropics, the confronting dangers of a tiger or elephant hunt, the thrill of a safari, or the quiet pastime of the insect collector. It is not surprising that such a person would take home a trophy, such as skins, horns, teeth, dried penises, skulls or tails, in order to verify their adventures. Although, in later years, photographic evidence could have replaced this method of verification, tiger skins and elephant tusks had, by that time, become such an essential part of a residential display that its waste would have been unthinkable. Much of this would have occurred during the 19th Century in Africa and Asia, and thus international trophy hunting was born. Trophy hunting was never restricted to the European gentry. In the 1960s, for example, the King of Bhutan, a Buddhist, succumbed to a heart attack while enjoying a hunting-safari in the heart of Africa. In 2003, there is a wide, and increasing, range of potential destinations for hunters and fishers depending on their interests in prey and costs. There are fishers and hunters in all parts of the world, however there are distinct places where the supply outweighs the demand. It is to these destinations that most fishers and hunters travel. Hunting and fishing, including in their tourism form, are important land uses and are a part of the essential cultural heritage for many societies In Europe hunting remains of great cultural significance as it does in many other parts of the world (eg. Africa and North America), particularly for indigenous people. The hunting language in Germany and Scandinavia forms an essential part of the Germanic cultural heritage; even music has its own hunting history.

Hunting and Fishing Tourism

Although not required for subsistence, hunting and fishing for recreation play an important role in the economy of western countries, and may even bring significant commercial benefits. Recreational hunting is a multibillion dollar industry in the US and in Europe Statistics suggest that in Australia every third person goes fishing, and in the state of New South Wales 27 per cent of estuarine waters are now "free of commercial fishing."

At present around 6 million wild ungulates are harvested in the northern hemisphere every year, instigated by a complex framework of tradition, commerce, and social values. In Germany, one of the most industrialised countries in the world, hunting remains an important land use and tradition. The result is a harvest of nearly 1.2 million ungulates, equalling approximately 500,000 tons of venison every year. Fishing, more so than hunting, has been an important aspect of the lives of a large part of society. Its origins and pursuit have been much less questioned, and there has been generally little controversy surrounding its practice. Many people holiday on the coast, on islands, or by the riverside so that they can take their fishing rod, hand line, or crab basket. Whilst this may not be an independent industry, it is an essential part of holiday making. The emergence of a more specific and targeted fishing-tourism sector was probably connected to a rise in mobility, an increase in the number of recreational fishers, and the emergence of service providers (such as guides, boat owners, land owners, and resort owners) who could take advantage of the increase in fishers by offering special experiences, locations, and species, and constructing a price for it. We suspect this industry was a response to declining fish resources. The more expensive end of the market, big game fishing, which targets species such as sharks, marlin, and tuna, started as an elite industry in the US but has spread from there to many other countries.

By combining hunting and fishing we also want to overcome the contrasts between the relative social indifference towards fishing, and the frequently negative public attitude towards hunting. Hunting and fishing both use wildlife, both can be humane and professional, or cruel and destructive, and both can only be justified. From an ecological viewpoint, the sustainability of hunting and fishing relies on the principles of wildlife harvesting. Well-managed hunting can have a wide range of benefits for conservation which by its very nature is opposed to modern and intensive agriculture and forestry. There is emerging support from those formerly subscribing to the protectionist-conservationist attitude, who now proclaim that rich trophy-hunting tourists might be the saviour of Africa's wildlife. Hunting tourism seems to have become acceptable again, after many years of discredit by the conservation movement

Recreational hunting and fishing, a vast industry in the "rich countries", may provide increasingly important income to the poorer countries as consumptive wildlife tourism. This industry, however, still raises many questions for conservationists from western countries, while many non-western societies simply view it as an opportunity for income through consumptive wildlife use.

Ecotourism

The industrialization, urbanization, and unsustainable agriculture practices of human society are considered to be having a serious effect on the environment. Ecotourism is now also considered to be playing a role in this depletion. While the term ecotourism may sound relatively benign, one of its most serious impacts is its consumption of virgin territories. These invasions often include deforestation, disruption of ecological life systems and various forms of pollution, all of which contribute to environmental degradation. The number of motor vehicles crossing the park increases as tour drivers search for rare species. The number of roads has disrupted the grass cover which has serious effects on plant and animal species. These areas also have a higher rate of disturbances and invasive species because of all the traffic moving off the beaten path into new undiscovered areas. Ecotourism also has an effect on species through the value placed on them. "Certain species have gone from being little known or valued by local people to being highly valued commodities. The commodification of plants may erase their social value and lead to overproduction within protected areas. Local people and their images can also be turned into commodities". Kamuaro brings up a relatively obvious contradiction, any commercial venture into unspoiled, pristine land with or without the "eco" prefix as a contradiction in terms. To generate revenue you have to have a high number of traffic, tourists, which inevitably means a higher pressure on the environment.

Local people

Most forms of ecotourism are owned by foreign investors and corporations that provide few benefits to local communities. An overwhelming majority of profits are put into the pockets of investors instead of reinvestment into the local economy or environmental protection. The limited numbers of local people who are employed in the economy enter at its lowest level, and are unable to live in tourist areas because of meagre wages and a two market system.

In some cases, the resentment by local people results in environmental degradation. As a highly publicized case, the Maasai nomads in Kenya killed wildlife in national parks to show aversion to unfair compensation terms and displacement from traditional lands. The lack of economic opportunities for local people also constrains them to degrade the environment as a means of sustenance. The presence of affluent ecotourists encourage the development of destructive markets in wildlife souvenirs, such as the sale of coral trinkets on tropical islands and animal products in Asia, contributing to illegal harvesting and poaching from the environment. In Suriname, sea turtle reserves use a very large portion of their budget to guard against these destructive activities.

Displacement of people

One of the most powerful examples of communities being moved in order to create a park is the story of the Maasai. About 70% of national parks and game reserves in East Africa are on Maasai land. The first undesirable impact of tourism was that of the extent of land lost from the Maasai culture. Local and national governments took advantage of the Maasai's ignorance on the situation and robbed them of huge chunks of grazing land, putting to risk their only socio-economic livelihood. In Kenya the Maasai also have not gained any economic benefits. Despite the loss of their land, employment favours better educated workers. Furthermore the investors in this area are not local and have not put profits back into local economy. In some cases game reserves can be created without informing or consulting local people, who come to find out about the situation when an eviction notice is delivered. Another source of resentment is the manipulation of the local people by their government. "Eco-tourism works to create simplistic images of local people and their uses and understandings of their surroundings. Through the lens of these simplified images, officials direct policies and projects towards the local people and the local people are blamed if the projects fail". Clearly tourism as a trade is not empowering the local people who make it rich and satisfying. Instead ecotourism exploits and depletes, particularly in African Maasai tribes. It has to be reoriented if it is to be useful to local communities and to become sustainable.

Threats to indigenous cultures

Ecotourism often claims that it preserves and "enhances" local cultures. However, evidence shows that with the establishment of protected areas local people have illegally lost their homes, and most often with no compensation. Pushing people onto marginal lands with harsh climates, poor soils, lack of water, and infested with livestock and disease does little to enhance livelihoods even when a proportion of ecotourism profits are directed back into the community. The establishment of parks can create harsh survival realities and deprive the people of their traditional use of land and natural resources. Ethnic groups are increasingly being seen as a "backdrop" to the scenery and wildlife. The local people struggle for cultural survival and freedom of cultural expression while being "observed" by tourists. Local indigenous people also have strong resentment towards the change, "Tourism has been allowed to develop with virtually no controls. Too many lodges have been built, too much firewood is being used and no limits are being placed on tourism vehicles. They regularly drive off-track and harass the wildlife. Their vehicle tracks cris-cross the entire Masai Mara. Inevitably the bush is becoming eroded and degraded".

Mismanagement

While governments are typically entrusted with the administration and enforcement of environmental protection, they often lack the commitment or capability to manage ecotourism sites effectively. The regulations for environmental protection may be vaguely defined, costly to implement, hard to enforce, and uncertain in effectiveness. Government regulatory agencies, as political bodies, are susceptible to making decisions that spend budget on politically beneficial but environmentally unproductive projects. Because of prestige and conspicuousness, the construction of an attractive visitor's center at an ecotourism site may take precedence over more pressing environmental concerns like acquiring habitat, protecting endemic species, and removing invasive ones. Finally, vinfluential groups can pressure and sway the interests of the government to their favour. The government and its regulators can become vested in the benefits of the ecotourism industry which they are supposed to regulate, causing restrictive environmental regulations and enforcement to become more lenient.

Management of ecotourism sites by private ecotourism companies offers an alternative to the cost of regulation and deficiency of government agencies. It is believed that these companies have a self-interest in limited environmental degradation, because tourists will pay more for pristine environments, which translates to higher profit. However, theory indicates that this practice is not economically feasible and will fail to manage the environment.

The model of monopolistic competition states that distinctiveness will entail profits, but profits will promote imitation. A company that protects its ecotourism sites is able to charge a premium for the novel experience and pristine environment. But when other companies view the success of this approach, they also enter the market with similar practices, increasing competition and reducing demand. Eventually, the demand will be reduced until the economic profit is zero. A cost-benefit analysis shows that the company bears the cost of environmental protection without receiving the gains. Without economic incentive, the whole premise of self-interest through environmental protection is quashed; instead, ecotourism companies will minimize environment related expenses and maximize tourism demand.

The tragedy of the commons offers another model for economic unsustainability from environmental protection, in ecotourism sites utilized by many companies. Although there is a communal incentive to protect the environment, maximizing the benefits in the long run, a company will conclude that it is in their best interest to utilize the ecotourism site beyond its sustainable level. By increasing the number of ecotourists, for instance, a company gains all the economic benefit while paying only a part of the environmental cost. In the same way, a company recognizes that there is no incentive to actively protect the environment; they bear all the costs, while the benefits are shared by all other companies. The result, again, is mismanagement.

Taken together, the mobility of foreign investment and lack of economic incentive for environmental protection means that ecotourism companies are disposed to establishing themselves in new sites once their existing one is sufficiently degraded.

Success story of first introduction, rearing and breeding of Rainbow trout *(Oncorhynchus mykiss)* in Kumaun Hills

K.D. Joshi
Allahabad Regional Centre, Central Inland Fisheries Research Institute (ICAR),
Allahabad-211 002, Uttar Pradesh
Emai: kdjoshi.cifri@gmail.com

Introduction

Rainbow trout is native to the Pacific drainages of North America, ranging from Alaska to Mexico. Since 1874 it has been introduced to waters on all continents except Antarctica, for recreational angling and aquaculture purposes. A total of about 65 countries were reportedly farming and producing rainbow trout globally, by 2006. Though, many have relatively insignificant output in comparison to the production from the larger systems that are located in the primary producing countries in Europe, North America, Chile, Japan and Australia. Trout production greatly expanding globally since 1950s after development of pellet feeds. Trout fisheries are maintained, or culture practiced, in the upland catchments of many tropical and sub-tropical countries of Asia, East Africa and South America including India.

Efforts for trout culture in the upland region of India had been initiated since 1863. Sir Francis Day made an unsuccessful attempt in the year to introduce eyed eggs and fry of brown and lock-leven trouts in the Nilgiri hills. Later on Mr. F.J. Mitchell succeeded in introduction of eyed eggs of brown trout in the Harwan hatchery in Jammu and Kashmir in the year 1900. Then rulers of the a few princely states started efforts to establish trout farms and culture & breeding of exotic trouts for stocking in the adjoining streams and rivers to build trout stock for sport fishery. Eyed eggs of brown and rainbow trouts were brought, incubated and reared in some hatcheries located in upland regions.

Trout farming needs high investment in the form of pond construction, procurement of seed, feed, maintenance of fish health and quality water requirement. So, its expansion has limitations due to these barriers coupled with limited markets. Even though, successful collaboration with European Economic Community (EEC) and Norwegian Government in last 2 decades has accelerated rainbow trout (*Oncorhynchus mykiss*) farming in the states of Jammu and Kashmir and Himachal Pradesh, respectively. This included supply of quality trout seed, setting up of modern raceways, hatcheries, feed mills, disease control measures and human resource development. Now, the trout farming is also developing in other hill states-Uttarakhand, Sikkim and Arunachal Pradesh. At present above 25 trout hatcheries established under government sector (Joshi, 2010) are engaged in breeding and rearing of rainbow and brown trout in different region with an estimated production of about 500 t yearlings and capacity of 1.5 to 2.0 million seed every year.

Trial for transplantation of trouts in the territory of Uttarakhand state dates back to 1910 with the transplantation of eyed-eggs of brown trout from Kashmir to Bhowali hatchery (District Nainital). Later on another consignment was received in 1912 and trout fingerlings were stocked in Kumaun lakes (Jones and Sarojini 1952). The trout eggs were also procured from Kashmir to Kaldyani and Talwari hatcheries in Garhwal region in the year 1910. The trout thrived in the hatcheries and some tributaries in the Garhwal but could not survive in Kumaun hills, due to comparatively high summer temperature.

Later, the efforts were further initiated by National Research Centre on Cold Water Fisheries (now DCFR), Bhimtal during 1992-95 for introduction of the trout in Chhirapani farm Champawat, located in Kumaun hills. However, the trials to raise trout did not met initially. Later the rainbow trout (*Oncorhynchus mykiss*) was successfully introduced in the farm in the year 1999 (Joshi *et al*, 2005). Studies on rainbow trout culture have been conducted in Western countries particularly in United States are well documented (Gempesaw *et al* 1995; Bacon *et. al.*1996). However, barring a few scattered communications (Sunder et al 1986, Anon 1993) there is complete dearth of documented information on transplantation and rearing of rainbow trout in Indian uplands. The present paper deals with all the steps lead to successful transplantation and breeding of rainbow trout from Patlikuhal, Himachal Pradesh. to Chhirapani Experimental Fish Farm Champawat in Kumaon hills, Uttarakhand.

Successful introduction of rainbow trout at Champawat farm

The eyed eggs of Norwegian rainbow trout (*Oncorhynchus mykiss*) were brought from Patlikuhal, Himachal Pradesh to the Chhirapani Experimental Fish Farm, Champawat located at an altitude of 1620 m. from asl. in Central Himalaya (Long. 80⁰ 07' N., Lat. 29⁰ 30' E.) on January 26th 1999. The stripping was conducted at Patlikuhal (H.P.) on December 24th 1998. The development stages starting from incubation of eyed eggs, rearing of alevins, fry, fingerlings up to attaining 4 years in age, were studied at the farm. The eyed-eggs were brought in indoor hatchery and incubated in floating hatching trays (54x28x12 cm.), with nylon netted bottom, at the rate of 1000 eggs / tray in a single layer. The trays were fixed in fibre-glass hatching troughs. Continuous water flow was maintained @ 15-20 l/ minutes in the troughs. The water is supplied to the farm from the adjacent perennial stream – the Gandaki, through gravitational flow by a 200m long pipeline. The dead eggs were picked up regularly without disturbing neighboring eggs. The hatching troughs and trays were treated occasionally with 0.2 ppm malachite green for about half an hour as prophylactic measures against fungal attack.

The fry after complete absorption of the yolk sac were reared in feeding troughs up to 1 month. The fry were later shifted to nursery pond (10x3x1.25 m) at the stocking density of 100 /m2. The water flow was maintained at the rate of 15-20 l/minutes. After one year the trout stock was shifted to the Raceway ponds (30x5x1.25 m). The Raceway and Nursery ponds were repeatedly cleaned at an interval of 10-15 days for complete removal of fecal material and waste feed. The fry were fed initially with finely powdered dry starter feed @ 3 - 6 % of the body weight. The feed was broadcasted 6-8 times a day. The feed is later replaced with floating starter crumbles to pellets upto 3 years in age @ 2-1% of the body weight. The proximate composition of the NRC-CWF formulated trout feed was - crude protein 47.10%, ether extract 12.85 %, N.F.E 26.50 %, carbohydrate 4.65 % and rest is moisture. Due to low water availability from the stream particularly during lean period (April-June) the water supply to the stock was merely between 0.2-1.0 l/kg/ minute. The stock was sampled in regular interval for observation of gain in body weight. The water quality parameters were recorded at regular interval as per standard methods (APHA 1990).

Hatching and rearing

The hatching of the eggs started since February 2nd 1999 and completed up to February 26th 1999 with a survival rate of 83.27 %. The salient features of the incubation experiment are detailed in the Table-1. The water quality during incubation period was recorded as- water temperature 4.5 – 9.5 0 C; pH 8.2; dissolved oxygen 9.2 –10.0 mg./l; free carbon di –oxide 0.4 –1.0 mg/l; total alkalinity 14.0 – 18.0 mg./l; total dissolved solids 11.9 –14.3 mg./l. and specific conductance 23.0 – 29.0 µmho's. The feeding was started after 3/4th absorption of the yolk sac. The details about month wise increment in growth of the rainbow trout at Champawat Farm during 1st Year are shown in the Table-2.

Table -1. Salient features of the transplantation and incubation experiment

Number of eggs brought	20,000
Date of stripping at Patlikuhal (H.P.)	December 24, 1998
Eyed eggs brought at Champawat	January 26, 1999
Hatching started	February 2, 1999
Hatching completed	February 26, 1999
Mortality during incubation	3,346 (16.73 %)
Survival after incubation	16,654 (83.27 %)

Table - 2. Monthly growth increment of the rainbow trout at Champawat Farm during 1st Year

S. No.	Month	Average weight (gms.)	Weight Range (gm)
1.	January, 2000	84.0	49.8 – 178.0
2.	February, 2000	95.0	56.0 - 200.0
3.	March, 1999	1.1	0.4 – 1.7
4.	April, 1999	3.4	1.2 – 4.8
5.	May, 1999	7.0	2.1 – 11.0
6.	June, 1999	15.0	5.6 – 31.0
7.	July, 1999	26.0	8.9 – 45.0
8.	August, 1999	34.0	14.6 – 59.0
9.	September, 1999	46.0	23.4 – 86.0
10.	October, 1999	57.0	31.8 – 101.0
11	November, 1999	64.0	38.4 – 131.0
12.	December, 1999	72.0	43.4 – 152.0

The stock attained an average weight of 95.0 gm and maximum of 200.0 gm upto February 2000. Whereas the fish takes approximately 8 months to reach a market size of 300-350 gm in trout farms of Idaho, U.S.A after being stocked in the raceways as a 4 inch long fingerling (Gempesaw et.al.1995). The expected growth in the trout farms located in Himachal Pradesh is about 260 gm (Anon 1993). At Chhirapani, Champawat farm the stock attained average weight of 225.0 gm and maximum weight of 1100 gm after 2nd year and 940.0 gm and 2100.0 gm respectively, after 3rd year (Table-3). The feed conversion ratio (F.C.R.) was observed as 1:1.65 during the study period at Champawat farm whereas in the commercial farms of Idaho in U. S. A. (Brannon and Klontz, 1989) it was approximately 1:1.5.

Table -3. Growth pattern of rainbow trout at the Farm during 1st-4th year period

Year	Duration (up to)	Average weight (gms.)	Weight Range (gm)
1st	February 2000	95.0	56.0 – 200.0
2nd	February 2001	225.0	180.0 – 1100.0
3rd	February 2002	940.0	650.0 – 2100.0
4th	February 2003	1500.0	950.0-3000.0

Table-4. Water quality parameters in trout ponds

S.N.	Month	Water supply (lpm)	Water temperature (°C)	Dissolved oxygen (mg/l)	Free carbon-di-oxide (mg/l)	pH
1.	January	250-400	4.5-6.5	8.2-10.0	0.0-1.0	8.0-8.2
2.	February	200-350	4.5-8.5	8.4-10.2	0.0-0.8	8.0-8.2
3.	March	220-300	7.0-14.5	7.6-9.0	0.6-1.2	8.0-8.2
4.	April	200-300	13.0-17.5	5.4-8.6	1.8-2.4	8.0-8.2
5.	May	180-250	15.5-22.5	5.4-8.2	1.8-2.8	8.0-8.2
6.	June	150-1000	18.5-21.5	5.4-8.2	2.0-2.6	8.0-8.4
7.	July	1000-1200	18.0-20.5	6.2-8.8	1.4-1.8	8.0-8.2

S.N.	Month	Water supply (lpm)	Water temperature (°C)	Dissolved oxygen (mg/l)	Free carbon-di-oxide (mg/l)	pH
8.	August	150-1200	18.0-21.5	5.0-8.8	2.0-2.2	8.0-8.2
9.	September	800-1200	18.5-20.5	6.8-9.2	0.6-1.2	8.0-8.2
10.	October	450-740	15.5-20.0	6.8-8.8	0.8-1.6	8.0-8.2
11.	November	360-600	9.5-12.5	8.0-9.6	0.0-1.0	8.0-8.2
12.	December	300-500	6.5-10.0	8.0-9.6	0.0-1.0	8.0-8.2

The variation in total water supply and relevant water quality parameters in the trout ponds are detailed in Table-4. The range of total alkalinity, total dissolved solids and specific conductance of the pond water varied between 17.0-40.0 mg/l, 11.8-37.6 mg/l and 23.0-75.0 mho's during the period under report. The total biomass at the farm was recorded 500 kg. during February 2001. The total water supply to the stock remained a prominent limiting factor particularly during summer months, in culture of rainbow trout at Champawat farm. The water supply was drastically dropped to 0.2 l /kg/mt during lean period whereas the universally followed Leger formula, the supply of good quality water for rainbow trout should be 1 l/kg/mts (Huet, M.1994) as a result mortality in trout stock occurred in the farm. Sale of table size trout also started at farm since February 2001.

Successful breeding of introduced trout

Brood stock maturity

After successful introduction, the stocked rainbow trout, Oncorhynchus mykiss (Walbaum) was successfully bred for the first time at the farm. Male attained full sexual maturity after completion of 2nd year (average body weight: 180.0-820.0 g) and many were observed in oozing condition, during winters (December 2000- February 2001. In the males, colours of the fishes become brighter and lower jaw turned up into a spoon shaped structure-"kype". The mature male has an iridescent, rose coloured band on their flanks. The female attained full sexual maturity after completion of 3 years (average body weight: 800.0-1850.0 g). The females are also easily recognized due to their extended bellies and prominent reddish round anus. The potential male and female brooders were segregated and stocked in separate ponds in November 2001 (prior to attaining maturity) and fed @ of 0.5-1.0 % of the body weight. These were sampled regularly to find fully mature oozing specimens of both the sexes. Sehgal (1990) observed that rainbow trout in Himalayan region attains sexual maturity during mid-February to March. Whereas in USA, the trout mature during January-May. In the present investigation, the fish attained maturity during December to February (1st week). This deviation in maturity period (December) could be due to fluctuating nature of water temperature influenced by rain and snowfall in the stream catchments and related climatic factors. The rainbow trout is reported to breed after 2-3 years of age in U.S.A (Bacon et al, 1996). In Indian environments also, the rainbow trout breeds after attaining 2-3 years of age similar to its counterparts in U.S.A.

After completion of 3 years, the male fish in 800 - 1200 gm. body weight range were observed in oozing condition since January 20th 2002. Thereafter, fully mature female in 900.0 - 1850.0 gm weight were also caught from the pond. The ready female and male brooders in the ratio of 2:1 were stripped and fertilized following "dry method" during first week of February 2002. Two-man method (Jhingran and Sehgal, 1978) of stripping was followed. In the next breeding season, fully mature females (4 year old) in 1350-2500 gm weight were further stripped and fertilized during 11-13 December 2002 (Table-5).

Table-5. Salient features of trout breeding (stripping) experiments conducted at Champawat farm during 2002-03.

Particulars	Details of breeding experiments	
	1st season (Feb. 02)	2nd season (Dec. 02)
Age of the brooders (yr)	3	4
Size of stripped females (g)	900-1850	1350-2500
Size of stripped males (g)	800-1200	1000-1800
Dates of stripping	1-2, February 2002	11-13, December 2002
Fecundity rate (eggs kg-1)	547	1402
Eyed-egg condition appeared on	February 24th 2002	January 23rd 2003
Survival (%) up to eyed-egg stage	92.6	74.3
Hatching started on	March 10th 2002	February 6th 2003
Hatching completed	March 14th 2002	February 12th 2003
Hatching period post fertilization (days)	37-44	57-68
Cumulative survival (Fertilization to hatching) (%)	88.9	42.2
Water temperature during hatching (0C)	6.5-12.0	4.5 -7.5

Fecundity

In the present investigation, fecundity in the 1st (February 2002) and 2nd (December 2002) breeding seasons has been recorded as 547 and 1402 eggs kg^{-1}, respectively. While, Ingram (1988) and Bacon *et al* (1996) observed that the female rainbow trout, depending upon age, size and strain can produce 1000-2000 eggs kg^{-1} body weight. In the present study, the number of eggs produced during 1st breeding season were quite low (547 eggs kg^{-1}), but the fecundity (1402 eggs kg^{-1}) in the second season was within the above range. The low fecundity during 1st breeding season could be attributed to its first time maturity coupled with eco-climatic condition of the region. The fresh extruded eggs were flaccid, spherical in shape and 4.0-6.0 mm. in diameter.

Incubation period and survival

During incubation, ambient water temperature in the troughs ranged between 6.5-12.0 ^{0}C in the 1st breeding season and 4.5-7.5 in the 2nd. Brown and Gratzek (1980) observed that the water temperature has much effect on the development of eggs or growth of the fish. The present experiment on incubation strongly support the statement, because in this study the incubation of the fertilized eggs completed within 51-58 days, at the water temperature between 6.5-12.0 ^{0}C, while took 86-100 days at lower temperature (4.5-7.5 ^{0}C). The embryonic developmental stages: green-egg, eyed-egg and alevin stage lasted for 23-24, 14-18, 14-16 days during the 1st season (February 2002) and 42-46, 14-20 and 30-34 days in the 2nd (December 2002) in different temperatures (Table-6). Hatching of the eggs in both the experiments, completed after 37-66 days post fertilization, at ambient water temperature between 4.5 - 11.5 0C. The size of resultant yolk-laden alevin (early fry) ranged from 14-17 mm. Later, feeding of the advance alevins (fry) started after 3/4th absorption of the yolk sac, since March 25th 2002 (15th day, post-incubation). The fry attained average length of 26.0 mm with corresponding weight 0.45 g at the end of March 2002.

Table-6. Details of incubation experiments conducted at different temperatures.

Incubation stage	1st season (February 2002)		2nd season (December 2002)	
	Duration (days)	Temperature (° C)	Duration (days)	Temperature (° C)
Green-egg stage	23-24	6.5-8.5	42-46	4.5-5.5
Eyed-egg stage	14-18	8.0-11.5	14-20	5.0-6.5
Alevin stage	14-16	10.0-12.0	30-34	6.0-7.5
Incubation duration	51-58	6.5-12.0	86-100	4.5-7.5

In the hatching troughs, the volume of dissolved oxygen in the inlet and outlet water recorded as 10.0 and 9.6 mg l^{-1}, respectively. Similarly the volume of free carbon di-oxide in the water was 1.4 and 2.0 mg l -1, respectively.

In this study, the survival during hatching and cumulative survival of the fertilized eggs in first breeding attempt was remarkably high (92.6 & 88.9%), but it was very low (74.3 & 42.2%) during 2nd season. Whereas, the survival rate in some commercial trout farms of United States was reported 65.0-95.0 % (Branon, 1991). In the present study, the higher mortality during 2nd breeding season could be attributed to the stress faced by the brood stock due to poor water supply and low dissolved oxygen in the pond water at farm, during summer months (April-June 2002).

The results obtained during the study indicates that the rainbow trout could be incubated and reared successfully to produce table size as well as bloodstock in comparatively warmer agro-climatic conditions prevailing in Lesser Himalayan region, provided sufficient quantity of quality water and suitable feed is available. However, increase in water temperature beyond 21.50 C coupled with drastic decrease in quantity of water supply in the trout ponds could increase incidences of disease and mortality. Thus, the present study would pave the way for large-scale seed production of the trout in the region with establishment of better facilities and improvement in husbandry practices.

References

APHA, 1990. *Standard Methods for the Examination of Water and Waste Water.* American Public Health Association. New York. 1193pp.

Anonymous, 1993. Norwegian assistance for the state of Himachal Pradesh: trout culture. *Fishing Chimes*, August 1993: 23-27.

Bacon, J.R.; C.M.Gempsaw II; W.W.Lussier and J.W.Dunn. 1996. Economic viability and animal health regulation effects on a large scale trout hatchery. *Aquaculture*, 143: 245-255.

Brannon, E. and G.Klontz. 1989. The Idaho Aquaculture industry. *North West Environ. J.* 5:23-35.

Brown, E. Evam and Gratzek, J.B. 1980. *Fish Farming Hand Book:* Food, Bait, Tropical, Goldfish. The Avi Publishing Co. Inc. Westport, Conneticut, USA, 391p.

Gempesaw, C.M.; J.R.Bacon; I. Supitaningsih and J.Hankins. 1995. The economic potential of a small-scale flow-through tank system for trout production. *Agric. Syst.* 47: 59-72.

Holliman, A. 1993. The veterinary approach to trout. In : Aquaculture for Veterinarian: Fish husbandry and medicine. (ed. L.Brown).. Pergaman Press, London. pp. 155-189.

Huet, M.1994. Text Book of Fish Culture: Breeding and Cultivation of Fish. Fishing News Book Ltd. Farnham, Surry, England. 438 p.

Ingram, M. 1988. Farming rainbow trout in fresh water tanks and ponds. In: Salmon and Trout Farming (eds. L. Laird and T. Needham). Ellis Horwood, Chiester, U.K. pp155-189.

Jhingran, V.G. and K.L.Sehgal, 1978. Coldwater Fisheries of India. Inland Fisheries Society of India, Barrackpore. 239 p.

Jones, S. and K.K.Sarojini, 1952. History of transplantation and introduction of fishes in India. *J.Bombay Nat. Hist. Soc.*, 50(3):594-609.

Joshi, K.D. 1999. Prospects of fisheries development in Kumaon Hills. *Fishing Chimes*, 18 (10):70-74.

Joshi, K.D. 2009. Brood stock maturity and artificial breeding of rainbow trout *Oncorhynchus mykiss* (Walbaum). *Indian Journal of Fish.* 56(3):219-222.

Joshi, K.D. 2010. Rainbow trout farming in India: Present status and future prospects. In Coldwater Fisheries Management (Eds. P.C. Mahanta and Debajit Sarma). Directorate of Coldwater Fisheries Research, Bhimtal, Nainital. pp.43-48.

Joshi, K.D., K.K.Vass and H.S.Raina, 2005. Experiments on rearing of rainbow trout, *Oncorhynchus mykiss* (Walbaum) in Central Himalaya. *Indian Journal of Fish.* 52 (3):331-337.

Sunder, S.; H.S. Raina; K.K.Vass; U.Bali and R.K.Langer. 1986. An approach to the successful trout farming in Kashmir. *Zoologica Orientalis*, 3(1-2): 32-40.

Sehgal, K.L. 1999. Coldwater fish and fisheries in the Indian Himalayas: Rivers and

Fish and Fisheries at Higher Altitudes -Asia. FAO Fisheries Technical Paper 385: 41-63. Rome, FAO.

Vass, K.K., H.S..Raina and V.K.Bali. 1981. Observation on the rearing of brown trout *(Salmo trutta fario)* fry to fingerlings at Laribal trout farm in Kashmir. Kashmir University Research Journal 1:24-32.

Coastal Brackishwater Aquaculture for Livelihood Development

V. S. Chandrasekaran, B. Shanthi and A. G.Ponniah
Central Institute of Brackish water Aquaculture (Indian Councll of AgricultUl'al Research)
75, Santhome High Road, R.A.Puram Chennai-600028

Introduction

Living aquatic resources playa fundamental role in sustaining the livelihoods of many of the rural poor in Asia, providing food security and opportunities for diverse and flexible forms of income generation. However, the traditional capture fishery has reached maximum production levels and is therefore will not be able to provide for the estimated additional 37 million tonnes of fish needed to satisfy a growing world population by 2030. Currently 48 million tonnes of fish are destined to human consumption per year. It is estimated that in 20 years, the world's population will increase by two billion, and fish production will have to double in order to maintain current consumption levels.

Aquaculture is the highest ranking food sector with an annual growth rate of 8.8 per cent for the past 25 years. Livestock, for example, grew a mere 2.8 per cent during the same period. Currently, 45 per cent of total fish allocated to human consumption comes from fish farms. Not only does aquaculture provide foods rich in proteins, fatty acids, vitamins and minerals, it also significantly aids in combating hunger and malnutrition. Moreover, the sector is known to contribute to a nation's economic development by increasing income and generating employment. In Asia the sector provides employment for 12 million persons.

Aquaculture, though has more than 2500 years of history, its rapid growth has been experienced only since the last century. In India, although aquaculture has been practiced for centuries (as in China) the developments took place after attaining independence of the country, particularly in freshwater areas. In the brackish and coastal water regions, the transition from traditional to more scientific farming practices progressed in the past three decades to a level of considerable sustainability and revenue generation.

Coastal Brackishwater Aquaculture in India

Shrimp Farming

But for the traditional aquafarming in the extensive systems in West Bengal, Kerala, Kamataka and Goa, the shrimp farming has been the main stay of brackishwater aquaculture, contributing to the economic developments in the coastal belt of the country. The total shrimp farmed, predominantly the tiger shrimp (*Penaeus monodon*), through brackishwater aquaculture during 2006-07 was 1, 44,347 tonnes, from 1,49,632 ha area, accounting to a productivity level" of 0.96 t/ha/yr. Dependence on the farming of single species, viz., the tiger shrimp (*P. monodon)* in brackishwater aquaculture sector has been reduced by the introduction of the western white shrimp *Litopenaeus vannamei* all over the world, replacing to an extent of about 90 percent of the tiger shrimp produced through aqua farming. However, in India after a thorough analysis of pros and cons at various levels and after making the risk assessment on its introduction, the western white shrimp *L. vannamei* has been permitted for culture. During 2010-11, while the tiger shrimp production was 1, 22,822 tonnes from 1, 16,782 ha, the *L. vannamei* production was 20,000 tonnes from 3000 ha of farm area. During 2011-12, a production of 1, 16,000 tonnes of tiger shrimp from 2.16 lakh ha of area and 80,700 tonnes of *L. vannamei* from 7,837 ha of farm area were recorded. The shrimp farming in the coastal belts of our country supports the livelihood of about 1, 50,000 farmers (mostly small farmers having < 2ha of farm area, each) in the country and has a significant share of foreign exchange earnings through export.

Mud crab farming

Mud crab farming is an important alternative source of income for aqua¬farmers in India. On an average 1,500 tonnes of live mud crabs are being exported from India that fetches an earning of Rs. 26 crores per year. This includes the crabs captured from the wild as well as the ones cultured/fattened. The expanding export market for mud crab as an alternative for shrimp has led to intensified collection of wild seed for grow-out and fattening and has threatened the wild stocks. To ensure the sustainability of crab farming and reduce the fishing pressure on wild stocks, CIBA has developed the hatchery technology for the production of seeds of mud crabs, and also the nursery rearing technologies. The mud-crab hatchery technology developed at CIBA has also been transfelTed through training to a private entrepreneur who has established.a commercial scale mud crab hatchery, the first of its kind in the country, in Tamil Nadu.

Mud crab farming can be done as (i) the long term grow-out culture or (ii) the short term fattening method. Fattening of mud crab is done either to (i) gain weight in moulted larger species *(Scylla serrata)* in 3 to 4 weeks or to (ii) attain full development of ovary in adults of smaller species *(Scylla olivacea)* in 3 to 4 weeks. The mud crabs can be cultured in three types of culture systems in brackishwater areas, viz., 1. fenced earthen ponds, 2. Pens in open backwaters, 3. cages. The technology of mud crab fattening in pens and cages are a sort of small scale farming enterprise suitable for coastal fisher folk as an additional means of income generation. It is also quite suitable for adoption by women. CIBA has been engaged cUlTently in transfer of mud crab culture (fattening) technology to the coastal women as Self Help Groups for their economic upliftment.

Asian seabass farming

Asian sea bass *(Lates calcarifer)* known as 'Bhetki' in many parts of India is an important food fish. Though it forms negligible in perch fishery in commercial catches, it is highly suitable for farming. Sea bass is a euryhaline species capable of withstanding wide salinity fluctuations. It is a fast growing fish and suitable for culture both in earthen ponds and in cage system. Amongst the cultivable fishes in India, seabass fetches higher price in domestic market varying between RS.90-250 per kg depending upon the size, the availability and season. It is extensively cultured, in South East Asian Countries like Thailand, Malaysia, Singapore and Australia.

In India, culture of seabass in a limited scale is carried out in the traditional farms in coastal areas. Compared to the carp culture in freshwater or shrimp culture in brackishwater ponds, seabass culture is still in its infant stage in India. The main reason for this is that the market for shrimp is global while the market for seabass is largely regional. However seabass is the only species, most commonly farmed amongst fin fishes in South East Asian countries because the seed can be produced in the hatchery economically throughout the year at reasonable price.

Under cage culture, since seabass can be intensively stocked and properly managed, the production will be high. Frequently culling and maintenance of uniform sized fishes in to the cages will ensure uniform growth and high production. Production of 6-8 kg/m^2 is possible in the cages, under normal maintenance and production as high as 20-25 kg/m^2 is obtained in intensive cage management in the culture of seabass.

CIBA has achieved a major breakthrough in the captive brood stock development, induced breeding and seed production of the Asian seabass *Lates calcarifer* in 1997' for the first time in the country. The technology for seabass seed production has been also standardized. The existing facility of the Institute for controlled breeding and seed production has been expanded by the addition of a hatchery under Indo-French collaborative project "Seabass breeding and culture ¬pilot unit" with one million fry production capacity. This additional facility is the first model finfish hatchery in the country incorporating all the required facilities with biosecurity and water recirculation system for quality seed production. It is possible now to produce the seabass seeds round the year.

CIBA has taken up field demonstrations and trial culture of seabass in farms in Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra and Gujarat in order to develop the culture technology packages for the different coastal agro-climatic conditions of our country. The low cost pellet feed formulated specifically for the seabass in CIBA has also been found to be efficient and is being used for field trial culture to confirm its performance. In addition to the seabass farming practice, the seed production and nursery rearing of the seeds for stocking in grow-out ponds are the allied sectors that can be practiced as separate enterprises.

Brackishwater Ornamental fish culture

Ornamental fishes from brackishwater ecosystem are not being exported from India commercially because of the limited resource and sporadic distribution. However, it can be foreseen, if the large scale commercial production of the brackishwater ornamental fishes *in par* with the freshwater ornamental fishes, there is a great scope for this sector in our country. CIBA has initiated the development of captive broodstock and breeding techniques for the brackishwater ornamental fishes spotted scat (Scatophagus argus) and monos (Monodactylus argenteus) under controlled conditions and larval rearing techniques.

The spotted scat is found distributed in India in most of the places along the east and west coasts of India and occur in abundance in some brackishwater estuarine systems. They are omnivorous. The juveniles appear round in shape with variable colours but basically a spotted brown to green. The fish reaches 30 cm in length. Breeding of this species has been rarely reported. The young ones of scat are exported to USA from Asia for aquarium purpose and the cost is Rs 50-75/- per piece in India.

Monos are disc shaped fish from the coastal areas of Australia and the Red Sea. They are often called as fingerfish. They belong to the family Monodactylidae. In India they are found distributed in Gulf of Mannar. They have been reported from estuaries, rivers, and lagoons covering fresh, brackish and sea waters. However, they are ideally suitable for brackishwater aquarium. They are omnivorous and found to f~ed on flake, pellets, etc. The colour pattern of the young fish often have a black line running across the gill cover connecting with the black of the anal fin and the dorsal fin is marked with yellow tinge. The sexes are separate in this fish but difficult to distinguish. Successful captive breeding has not yet been reported for this species. On commercial aquarium trade this fish has very good demand, costing 4 - 5 Singapore Dollar / piece and the local price in India is Rs 75-1 00/piece of 4 inches size.

Culturing these species has potential scope for brackishwater ornamental fish trade at small scale levels and as a livelihood support for the middle and lower class level people in the' coastal areas of the country.

Livelihood options for coastal women self help groups

Brackishwater aquaculture offers plenty of scope for diversification of livelihoods for women, especially in coastal areas. Women in coastal areas play an indispensable role in capture and culture fishery sectors by taking part in various activities such as culture of fish and crab, fattening of mud-crabs, processing of shrimp and fish, as workers in shrimp hatcheries, aqua feed production, processing and marketing of value-added fish products, transportation and domestic marketing of fish. The Self Help Groups (SHGs) established as part of the rural development have now taken up aquaculture as an important income generating activity. Women in coastal areas always look for familiar eco-enterprises for income generation. The adoption of scientific farming through technology dissemination also needs to be sustainable among the women beneficiaries. With adequate technical skill, knowledge, financial assistance from banks, NGOs and also social support from their family and neighborhoods, the coastal women have progressed well in the fishery related avocations in the recent past.

CIBA has developed a number of technologies which were amenable to be tailored to suit the needs of the fisher folk to serve as alternative /supplementary livelihood options. The three technologies (i) crab fattening, (ii) farm made aqua feed development and (iii) value added fish products development, were identified for transfer to the identified women self help groups (WSHGs) in Tiruvallur and Kancheepuram districts and tested as viable technologies under the CIBA-DBT project titled 'Diversification of Livelihoods among the Women Self Help Groups through Coastal Aquaculture Technologies'.

1. Crab fattening technology

The mud crab fattening technology was found to generate Rs. 4000/cycle approximately, with 10 cycles per year, the WSHG could make a net profit of Rs. 40,000 per year. Savings money of the WSHGs was reinvested in this enterprise by erecting additional crab pens. The subsequent profit was shared among the group members and savings were made in the bank. Based on the deposits made by the group members, additional loans were granted by the Indian bank and subsidy was also given to the groups from the Integrated Fund for Agricultural Development (IF AD), Tamil Nadu Government schemes.

2. Farm made aquafeed technology

The farm made aqua feeds generated on an average Rs. 1000 profit margin for 200 kg of feed produced per day. Assuming a 25 day working period per month, the WSHG involved in farm made aqua feeds could generate Rs. 25,000/ month. This particular technology had evinced the maximum interest among the adjacent communities and had a large spill over general interest in adjacent villages. The farm made aqua feed technology has the scope for expansion on a larger scale, as it would cater not only to small scale shrimp• farming, but also the freshwater fish culture and ornamental fish farming sectors.

3. Value added fish products

The value added fish products developed in the project include shrimp pickle (net profit of Rs. 300 perl2 bottles); fish pickle (Rs. 204 perl2 bottles); fish samosas (Rs. 138 per a batch of 55 samosas); fish cutlets (net profit ofRs. 402 per a batch of 60 pcs). This intervention itself is a scaled up version of the home made pickles that generated sufficient social acceptance. Further, the intervention had good scope for up-gradation of scale of production based on the interest shown by the marketing agencies.

Conclusion

Active partICIpation, infrastructure, support from the State Government Programmes, along with technical and financial support offered to the coastal poor for their livelihood, particularly through the mechanism of women self help groups have made the technology adoption a successful one and thereby creating economic, social, environmental and technical sustainability in the small scale rural aquaculture.

With the progress of technological advancement in the field of coastal brackish aquaculture, such as nursery rearing of Asian seabass and mud crabs, development of the new line of small scale aqua business sector involving farm produce, such as, the species specific aqua feeds and value added fishery food products at commercial small scale levels or as cottage industry, would greatly help in the economic and social upliftment of coastal populace.

Present status and strategies for the development of trout farming in India

N.N. Pandey and S. Ali
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Distt. Nainital (Uttarakhand)

Introduction

Rainbow trout is native to the Pacific drainages of North America, ranging from Alaska to Mexico. The fish may be the world's most widely transplanted fish species. By 2006, 65 countries were reporting rainbow trout production. Many have relatively insignificant output in comparison to the production from the larger systems that are located in the primary producing countries in Europe, North America, Chile, Japan and Australia. Global production of rainbow trout is greatly expanding from 1950s onwards after development of its pelleted feed. Rainbow trout is a highly priced with better growth rate and maximum cultivable traits amongst coldwater species. The introduction of exotic trout (brown and rainbow) in Indian subcontinent dates back to about centuries back which have well established in northwestern uplands of the country. It is bare fact that brown trout has a better fighting quality for the anglers compared to rainbow trout. However, rainbow trout especially the quick growing strains introduced about two decades back are perhaps better suited for commercial production. Of late, it is a healthy sign that attention is being paid to this lordly fish by the state departments of Jammu and Kashmir and Himachal Pradesh to initiate the commercial venture of trout husbandry for table delicacy besides establishing the fish for ranching in selected natural biotopes for recreational fishing. At present, the trout production from Indian farms is to the tune of about 500 tonn against 508,662 tonn world production.

Historical perspective of trout introduction in India

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.

Trout introduction in India

	Species/State	Year	Status
A	Brown trout		
1	J &K	1890-1910	Established
2	Himachal Pradesh	1911-13	Established
3	Uttarakhand	1911-13	Established
4	North-East	1966	Not Established
5	Tamil Nadu	1863-73	Not Established
6	Kerala	1909	Not Established
B	Rainbow trout		
1	J &K	1904, 1986	Established
2	Himachal Pradesh	1919, 1992	Established
3	Uttarakhand	1976	Established
4	Tamil Nadu	1909,1920,1968	Established
5	Kerala	1941	Established
C	Eastern brook trout *(Salvelinus fontanalis)*		
1	J &K	1969	Not Established
D	Shastra trout *(Salmo gairdneri shastra)*		
1	Kerala	1941	Not Established
E	Loch-Leven trout *(Salmo levensis)*		
1	Tamil Nadu	1868-1900	Not Established
F	Splake trout (Hybrid of lake trout & brook trout)		
1	J &K	1959-70	Not Established
G	Golden Rainbow trout *(Salmo gairdneri aguabonita)*		
1	Tamil Nadu	1968	Not Established
H	Kokanee Salmon *(Oncorhynchus nerka)*		
1	Tamil Nadu	1968	Not Established
I	Landloack atlantic Salmon *(Salmo salar)*		
1	J &K	1959-70	Not Established
J	Steal Head Trout *(Salmo gairdneri irideus)*		
1	Kerala	1938-1941	Not Established
2	J &K	1904	Not Established

Status of Trout Farming in India

The general concept of trout as a highly expensive fish to cultivate in the farms and as a luxury food beyond the reach of the common man still holds good amongst the fisheries planners. Research and development carried out in India by State and Central organizations during the past three decades have shown appreciable achievements in trout farming practices. Adoption of the techniques that are currently in vague with suitable modifications to suit the prevailing conditions in trout farming of the country has led to achieving very high survival rates in the hatcheries and nurseries as well as the increased production of trout. Development of the some artificial diets based on locally available ingredients resulted in efficient food conversion and enhanced growth. The research in this area has clearly shown that trout farming can be done in this country by achieving high production at moderate cost of feeds. Presently the bulk of trout production is contributed by the Jammu & Kashmir and Himachal Pradesh, while the other hill states like Uttarakhand, Sikkim and Arunachal Pradesh are lagging behind in the trout production. In order to popularize trout production in other hill states, the Directorate of Coldwater Fisheries Research, (DCFR), Bhimtal has made concerted efforts towards the development of location specific trout farming practices. However, there is ample scope for further enhancement of trout production in these states through participatory approach. The present trout production of the country is around 500 tons against an annual demand of around 800 tons, which may increase during the coming decade. Being a low volume high value commodity, the trout has good potential for domestic consumptions as well as foreign export. Presently the rainbow trout has been established in Indian water and is now introduced successfully as a cultivable species having many positive traits such as:

- Trout farming provided excellent opportunity for utilizing the abundant resources of coldwater having the temperature range of 0-25°C in different hill states.
- Small scale trout farming provides a great opportunity for livelihood and nutritional security to the hill community.
- Despite of its low production trout fetch a very good market price, thus, trout farming has been one of the highly profitable coldwater aquaculture practice.
- Trout has higher export potential having high demand in international market.

Status of Trout infrastructure in India

Sl. No	State	infrastructure			Culture status
		Nos. of Govt. farms	hatcheries	Feed mills	
1	J &K	40	14	2	Govt. & private sector
2	Himachal Pradesh	5	5	1	Govt. & private sector
3	Uttarakhand	4	3	1	Govt. & private sector
4	Sikkim	5	5	nil	Govt. & private sector
5	Ar. Pradesh	3	2	nil	Govt. & private sector
6	Tamil Nadu	1	1	nil	Govt. farm only
7	Kerala	2	2	nil	Farms (Corporate)

Status in J & K

During the colonial rule, efforts were made to transport live eggs through shipment from the United Kingdom to the Kasmir Valley, but could not succeed due to long duration of shipment. In 1899, the Maharaja of J & K received a consignment of 1000 eyed ova of brown trout as a gift from Sir Albert Talbot, but could not succeed. In 1900, another consignment of eyed eggs of the same fish was procured from Howeitonin, Scotland, through Mr. J.S. MacDonnell. This consignment of ova arrived in excellent condition and hatched successfully to 1800 fry in a spring near Srinagar city. Out of this 1000 fry were transplanted to Panzagam (Harwan) about 24 km. from Srinagar and the rest 800 fry was reared in premises of a private carpet factory owner (Mr. Michel) in Bagh-i-Dilwar Khan in the heart of city near Khankahi Moula and Dachigam. During 1902-04 several consignment of eyed eggs, received from England were transplanted in Harwan. Later on, Mr. F.J.Michelle established a regular hatchery at Harwan with a capacity of 1,00,000 eggs during 1904-06. It was Harwan from where eyed eggs were transplanted to almost all suitable sites in Kashmir, Gilgit, Abbotabad, Chitral, Kangra, Kulu, Shimla, Nainital and Shillong. Eggs brought from England in 1904 also contained S.gairdeneri irideus, which did not succeed, leading to a setback to promotion of this species, Mr . Michelle achieved success in hatching rain bow trout eggs brought from Blagdon, England, at Harwan in the year

1912. Simultaneously, other species like Salmo salar were also tried but in vain. In the post independence period, the eastern brook trout and splake trout from Canada and Salmo salar from North America have been transplanted in various hatcheries in Kashmir. Out of these species, Splake trout was a total failure while the others two achieved only limited success.

Trout fish farming project was set off in 1984 at Kokernag through the European Economic Community assistance, which serve as mother unit for seed production of rainbow trout and brown trout.

Trout hatcheries in J & K

S. no.	hatchery	district	Unit	Ova capacity
1	Kokernag	Anantnag	3	35 lakh
2	Mammer	Ganderbal	2	12
3	Laribal	Srinagar	2	12
4	Kharhouz	Harwan	1	10
5	Chancer	Kulgam	1	10
6	Panzath	Anantnag	1	10
7	Bheja	Doda	1	10
8	Khag	Budgam	1	10
*9	Margunda	Ganderwal	1	10
*10	Marhama	Kupwara	1	10
*11	Chala asle khana	Bandipura	1	10
*12	Phalni	Rajouri	1	10
*13	Ariwal	Resai	1	10
14	Allayal pura	Sophian	1	10

*Under construction

Presently the trout farms are located at Kokernag, Achawal, Tricker, Pahalgam, Verinag, Panzath, Kulsore, Dandapora, Nambal, Jogigund, Tangmarg, Kalantra, Bela, Kanggroosa, Shokbala, Beerwah, Khag, Basantwoode, Bheja, Mammer, Murgund, Kaltari, tangdhar, Kalarose, kulgam, Chawalgam, Tchancer, Gatha, Mugal maidan, Bani, Khachan, Drass, Diskit, Sindhughat, Aripal, Rajpora, Phalni, Laribal, Harwan, Aliyal pora, Zainpora. There are about 307 raceways with the capacity of 212 tonn.

Location of trout beats in J & K

S. No.	district	Stream
1	Srinagar	Dachigam
2	Budgam	Dood ganga, Sukhnag, Shaliganga
3	Anantnag	Lidder, Bringhi, Nowbugh, ahlan, kokernag, Verinag
4	Baramulla	Hamal, Uri, Sukhnag
5	Ganderbal	Sindh, wanghat
6	Bendipura	Erin, madhumati, gurez
7	Pulbama	Naristan, Lam
8	Kupwara	Mawar, Dringyari, Kalaroos,, Moori, hardakhani, Doodi Nallah

Trout culture in Himachal Pradesh

The British tried to introduce trout during 1909 in Kullu and Kangra valley. In 1924, brown trout were stocked in Kareri Dal lake. During mid eighties, a project was formulated by HP govt. for mass scale rainbow trout culture. The Norwegian Govt. came forward to assist the state and a MOU was signed in 1988. The Norwegian Govt. provided 8 million NOK (Rs. 3 crore) mainly for infrastructure, training and equipments. A modern trout farm was established at Patlikulh with the capacity of 10 MT annually.

Trout farm	Year of est.	Raceways	Hatchery	Capacity fish in tonn	Capacity eyed ova in lakh
Patlikulh	1909	14	2	10	2
Barot	1959	6	4	5	1.3
Sangla	1965	14	1	5	5
Holi	2000	6	1	2	2
Dhamwari	2005	11	1	5	1
Hamini	Under construction				

The state has promoted about 75 trout farmers through various schemes.

Trout Farming in Sikkim

Sikkim, the small but beautiful kingdom is situated in the Eastern Himalaya. Sikkim is termed as the Switzerland of the East, a heavenly paradise on earth. It covers an area of 2818 square miles 7325 square kilometers. Geographically it is 28 degree 07' 48" degree and 27 degree 04' 46" North latitude, and 88 degree 00' 58' and 88 degree 55' 25" East longitude. State Fisheries Department of Govt. of Sikkim is associated with Directorate of Coldwater Fisheries Research, Bhimtal under the project entitled "Sustainable Utilization of Mountain Fishery Resources: A Partnership Mode. The Directorate has taken all possible initiatives to promote trout culture in the state considering the suitable climatic condition and abundance of water. As desired to the state, programme on brood stock management and seed production have taken on the priority basis since last four years. Brood stocks of the trout were maintained at State trout farm Uttarey and Yuksom with technical guidance of the Directorate.

Presently, three trout breeding units are functional for production of sufficient trout seed in order to stock in various Govt. farms and supply to the private farmers in the vicinity. This programme has given a boost in adopting technology in private sector as there are 199 farmers in the state (52 in East district, 72 in West district and 42 in North and 33 in South district) at present compared to 2008-09 when there was only one private farmer in the state.

Trout in Tamil Nadu

In 1863, Dr. Francis Day imported eyed ova of Rainbow trout but the eggs were received in very bad condition from New Zealand. In 1866, the second attempt was made which was followed by repeated efforts till 1906 to establish this fish in Nilgiri stream. It was Mr. Wilson who successfully developed the trout fishery in this region. He surveyed the entire area and finally selected Avalanche stream. He constructed trout hatchery in 1909-10 at Avalanche This hatchery continued to produce eggs by using brooders from Mukurti stream. The Fisheries department TN took over the management of hatchery in 1958. In February 1968 fresh consignment of 15000 eyed ova of golden rainbow trout, 15000 of ordinary rainbow trout, 10000 of tiger trout, 10000 of brown trout and 10000 of Konkanee Salmon were imported from Nikko Laboratory Japan for stocking in Avalanche hatchery. In 1969, another batch of O. nerka was imported from Canada. Off this new release only golden strain of rainbow trout survived well and established itself as a dominant strain. Again in 1974, 10000 eyed ova of albino were received from Hikko city, Japan. Another 10000 eyed ova of rainbow trout were brought from Himachal Pradesh during 1999.

The main objective of trout culture in western ghat is to meet the requirement of sport and recreational fishery. Commercial trout culture are not very bright either for consumers or for farmers.

Trout in Kerala

Munnar is one of the popular hill in south India. Effort for the development of trout culture in the Munnar hilly range commenced in the year 1909 with introduction of eyed ova of brown trout from UK. A trout farm was established in 1941 Eravicolam followed by another at Rajamallai. A trout hatchery is situated exactly in the Rajamallai under the control of TATA Tea company within the wildlife Sanctuary area. The capacity of this hatchery is 48000 eyed ova for rearing.The performance of this hatchery is better than the Avalanche hatchery.

North Bengal

Eyed ova of brown trout were introduced directly in the stream around the Dargiling during 1966. These eggs were brought from Kashmir. This effort miserably failed due to inadequate supervision.

Meghalaya

Eyed ova of brown trout brought from Kashmir and stocked in streams of Dargiling during 1966. This effort miserably failed due to inadequate supervision.

Nagaland

In spite of potential, progress is very poor for trout farming in Nagaland.There is only one private farm with a mini hatchery at Dzulakia in Kohima district. Some natural stock of trout was also reported in the Laang river in Tuensang district.

Manipur

Hilly region of Senapati and Ukhrul district is suitable for trout having rheophilic clear cool water streams. There is no report about trout implementation in this area.

Arunachal Pradesh

In the year 1967, first trout hatchery was established in Sela along the stream of Nuranangin Tawang district. The first attempt for transplanting eyed ova of brown trout was made during 1969, but failed. Another hatchery was established at Shergaon with the capacity of 1 lakh eyed ova. Soma private farmers are also doing trout culture in cemented as well as in earthen raceways.

Strategies and consideration required for further development

Trout culture is an intensive type of farming requires more input resources compared to other species for survival and growth. The feasibility of achieving required production naturally depends on a number of factors including seed, feed, health management and environmental consideration. Potential success in trout production requires better governance and significant improvement in the management practices. Therefore, it is necessary to have strategic plan to address technical, social and environmental constraints including:

- Availability of high quality seed at an affordable price.
- Good quality low cost feed.
- Control of disease and health management practices.
- Suitable culture system for efficient use of water resources.
- Development of market channel.

In order to achieve the goal of enhancing trout production, it is quite necessary to focus on improving existing technologies or developing new ones for increased and sustained production. Seed availability is the main bottleneck in the trout production. The transportation of seed is only possible at eyed ova stage therefore, a feasible technology is required to develop for the transportation of live trout seed at fry or fingerling stage. This is important because most of the fish farmer do not have facility for the incubation of trout eggs. Trout feed is also a second most important constraint in increasing the productivity and profitability of trout farming. At present the cost of trout production is high mainly due to high cost of feed. It is a major factor limiting the development of trout farming among the small and marginal farmers. Therefore, the development of low cost feed based on locally available ingredients would be helpful to reduce the cost of feed without reducing their efficacy. Disease plays a key role in sustaining aquaculture. Most of the disease in trout culture belongs to parasite, fungal and bacterial. The main strategy for the health management of trout is required to reduce the level of risk and accelerate the trout farming. Currently the cemented raceways are the dominant culture system for the trout cultivation. It may provide limited opportunity for expansion as it involves high investment cost. Strategy is necessary to develop the other production system such as cages, earthen raceways and tanks at various level of intensity as practices in many other countries, which would help in achieving national goal. Current trout production and demand suggests that there is high market demand for trout. Research is required to study the market demand and supply with projection for the future and how farmer should target consumer group for the future success of trout industry. Therefore, technologies to produce trout at competitive price adding value and regulation to maintain product quality and sanitary standards acceptable to world market are inevitable. Currently the trout farmers have fragmented production units. Strategy is required to promote for collective production and marketing in pocket areas/cluster to ensure that input transportation and delivery of harvested fish to market at a cheaper price.

References

FAO, 2003. Mountain Fisheries in Developing Countries. *Ed.* Petr, T. Food and Agriculture Organization, Rome.

Jhingran, V.G. and Sehgal K.L., 1978. Coldwater fisheries of India. *Inland Fish. Soc. India.*

Singh, B.N. 2002. Status of coldwater fisheries development in India. *In*: Highland fisheries & aquatic resource management (ed. Vass, K.K and Raina, H.S.) NRCCWF.

Sehgal K.L. 1999. Coldwater fish and fisheries in the Indian Himalayas: rivers and streams. *In*: Fish and fisheries at higher altitudes: Asia. FAO Fisheries technical paper no. 385 (Ed. Petr, T.) FAO, Rome.

Salim Sultan, 2012. Trout in India, publisher: national Fisheries Development Board, Hyderabad, p. 149.

Livelihood Security through Aquaculture in Assam

D. Sarma[1] K. Bhagawati[2] and M.S. Akhtar[1]
[1]Directorate of Coldwater Fisheries Research (ICAR), Bhimtal
[2]Central institute of Fisheries Education (ICAR), Mumbai

Introduction

Assam is the most water resourceful State in the North East part of the country. Fisheries sector is considered as an important economic activity in the socio-economic context in the State of Assam. Assam covers about 30 per cent of the North Eastern Region of India and has a total geographical area of 78,438 km² bordered by seven states viz. Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and West Bengal and two countries viz. Bangladesh and Bhutan. The vast water resources of the state are contributed by the Brahmaputra and Barak river systems. The state has a water spread area of 2, 05,000 ha. of river fisheries, 1,00,815 ha Beels/Ox-bow Lakes Fisheries, 5,017 ha of forest fisheries, 39,240 ha Derelict Water Bodies/ Swamp , 1,713 ha Reservoir Fisheries, 39,583 ha of ponds and tanks. With its vast water resources suitable for fisheries and aquaculture, the state fish production estimated by Directorate of Fisheries, Assam has reached the level of 232 million kg in 2010-11 compared to 219 million kg in 2009-10 with an overall growth rate of 6.4% in fish production with an assumption that 95% of population of the state is fish eaters. Besides culture fisheries contribute 85% of the total fish production of the state. These water bodies are a habitat for various species of freshwater fishes of commercial importance. Assam being basically a carp eating state, the inland carps and exotic carps, *Catla catla, Labeo rohita, Cirrihinus mrigala, Hypophthalmicthys molitrix, Ctenopharyngodon idella* and *Cyprinus carpio* var. *communis* account for the bulk of production, being as much as 85 percent of the total. Several other major and minor carps such as *Labeo gonius, L. bata* besides *Cirrihinus cirrhosa, Puntius sophore* and *Puntius japonicus* have also received attention. Large non-airbreathing catfishes such as *Wallago attu, Mystus seenghala, M. aor, Pangasius pangasius* are in increasing demand in the state, smaller varieties of both air-breathing *(Clarias batrachus, Heteropneutess fossilis)* and non-airbreathing fish *(Ompok bimaculatus, O. pabda)* are also considered a delicacy by the people of Assam. Murrels *(Channa marulius, Channa punctatus)* are also potential species for culture. Freshwater prawns *(Macrobrachium rosenbergii)* are receiving attention with regard to the establishment of hatchery and grow-out systems. There are about 220 hatcheries in private sector and 7 hatcheries under the Department which developed 4263 numbers of fish seed. However there has been an increasing demand of fish consumption corresponding to fish production and it needs some positive interventions through involvement of state fish farmers for sustainable development of this sector and to meet the ever increasing demand for fish to generate livelihood security of the rural population. The major fish farming activities in Assam are-

Integrated fish farming

Integrated fish farming offers a great scope for generating rural employment in Assam. Integrated livestock-fish, poultry-fish, and rice-fish farming and crop rotation in fish pond can be undertaken by the fish farmers to maximize their farm output in an unit culture area in order to augment fish production with less input derived from activities of agriculture and animal husbandry with plants and animal residues forming the major component of feeds and fertilizers in carp polyculture. Activities like mushroom cultivation piggery, silviculture, apiculture, etc. apart from providing for diversification of farming systems, also provide huge quantities of organic material that may become resources in the aquaculture system. The scope of integration in a fish farm is considerably wide. Ducks and geese may be raised on the pond, pond dykes may be used for fruit plants and mulberry cultivation or for raising pigs, cattle, and dyke slopes for fodder production. Thus the integrated fish farming system holds great promise and potential for augmenting production, betterment or rural economy and generation of employment. In Assam this has a special significance, as it can play an important role in improving the socio-economic status of a sizeable section of weaker rural community, especially the tribal population of Assam

Ornamental fish farming

Assam has the repository of 265 species of indigenous ornamental fishes. The mighty Brahmaputra and the Barak valley including the floodplain wetlands offer a rich biodiversity of aquatic resources including the ornamental fishes. The ornamental fishes of NE India including Assam are of greater demand in the international markets such as Singapore, USA, EU, and Japan. As the demand of ornamental fisheries has great export potential in the international market, ornamental fish breeding and culture is increasingly catching attention of fish farmer entrepreneurs in the state. However, in Assam, presently the production is mainly from wild collection and very little a culture operation has been undertaken. In order to take advantage of the availability of a large number of varieties, a strong supply chain needs to be established starting from fish collectors, agents, dealers and exporters. Further, suitable breeding facilities for exotic and indigenous ornamental fish may be created in areas having favorable climatic conditions. Agencies like Marine Products Export Development Authority (MPEDA), National Bank for Agriculture and Rural Development (NABARD), Northeastern Development Financial Institutions (NEDFI) are taking interest for promoting the development of culture of ornamental fishes. These institutes provides subsidy for the fish farmers who are coming forward to undertake breeding and culture of ornamental fishes on a commercial scale provided that they possess required technical knowledge in the particular field.

Culture of small indigenous fish species

Small indigenous fish species culture is an upcoming farming enterprise practiced by the farmers of Bengal, Assam and Orissa. The price of the small indegenious fish species (SIFFS) such as Mola *(Amblypharyngodon mola)*, *Puthi (Puntius* spp.*)* is of high demand in Assam and are valued at Rs 100-150/kg. The livelihoods of fishers are very dependent on the availability of SIFFS in Assam, as the price of SIFFS is very high. Moreover they are nutrient-dense fish. *Mola*, for example, can be considered a vitamin capsule, being rich in vitamin A and calcium. SIFFS are also found to be to be suitable for polyculture along with carps, and with minimal or no effect on commercial carp production. Given that SIFFS are self-recruiting, fish farmers are not required to invest money every year for fish seed. Even maintaining a small pond with a water depth of 1 m during the dry season is adequate in terms of providing refuge for SIFFS. The farmers are also practicing carp *mola* polyculture, carp-*mola*-prawn polyculture as they are now a rich man's food. *Mola* and *puthi*, are self-recruiting, there is also no need for hatcheries. *Mola* seeds are available in any natural water body. Species such as *bata (Labeo bata)* and *reba (Cirrhinus reba)* can be reared in composite fish culture (CFC), along with prawns. Assuming a survival rate of 80 per cent, this could result in a production that could meet the protein and micronutrient demands of the fish eating population of Assam. Incorporation of medium carps (namely *bata* and *reba*) in such systems, using a double cropping pattern, may offer higher returns, with reduced risk factors. Bringing them under need-based culture systems could enhance food security and employment, especially for rural people, including women, and lead to their socioeconomic upliftment. Therefore an appropriate policy framework and extension work is the need of the hour to increase awareness among marginal farmers about the advantages of culture of SIFFS.

Beel fisheries

Beels are major fishery resources contributing to about 25 % of the fish production in Assam. Together the beels constitute over 80% of Assam's lentic waters Wetlands are under serious treat due to anthropogenic pressures and indiscriminate industrial and development activities. The bio-diversity of wetlands is facing serious threats from the factors, like pollution, siltation, invasion of exotic species, eutrophication, encroachments and overexploitation of their resources. Unplanned drainage, land reclamation and political factors linked with detrimental land use, are posing challenges to the very existence of many of our precious wetlands, which need immediate responses of communities, civil societies, NGOs and government authorities. Beel fisheries in Assam are an untapped resource. The State has around 1392 nos. of beels encompassing an area of about 1.08 lakh hectares with the maximum number being in Nagaon district (289), followed by Cachar (263), North Lakhimpur (153), and Jorhat (131). The State having such a vast resource of derelict water bodies offers a great potential for fish farming through culture base capture fisheries approach with community participation in order to reclaim the derelict water bodies for enhancement of fish production and to provide employment to the rural unemployed youth with a strategy to convert them into scientific fisheries and enhancing their livelihood security.

Community tank development

The community tanks have the potential for increasing fish production through community participatory fish culture. These tanks are generally not used for fish production due to inadequate financial and technical resources. With government intervention and public support, some of them can be used for fish culture. Recognizing the potential of increasing fish production through the development of community tanks, the State Department of Fisheries has secured World Bank assistance for generation of funds for the sustainable use of the open water resource so that the fisher folks associated with it could be benefited.

Women Empowerment through fisheries

The empowerment of women could be the principal strategy to upgrade their status. The most effective ways of empowering rural women and enabling them to move out of poverty will depend on local economic, cultural and political conditions. The empowerment status of rural women can be significantly improved by increasing their involvement in income generating activities including aquaculture. Due to rapid development of small-scale aquaculture in rural areas of Assam, the women are now breaking through the traditional norms and coming forward to participate in the development activities outside their homesteads. Under Women Empowerment Programme women beneficiaries are imparted with required training and provided with inputs for rearing of fish seed to produce fingerlings in the backyard ponds as part time employment to provide additional income to their families. The number of beneficiaries was 1028 in 2010-11.

Employment Generation Scheme through SHG

Self Help Groups are the registered society mainly includes the unemployed educated youths. These societies take up many agriculture and allied activities in order to engage themselves and utilize the available resources for generation of income among them. SHG can be linked to the financial organizations like NABARD; other agriculture financing banks for availing better credit facilities. Under the fisheries extension programme training and extension services were offered to the SHG groups for undertaking scientific fish culture practices.

FFDA

One of the most important and effective national programme for the promotion of rural aquaculture development was the Fish Farmers Development Agencies (FFDAs), which was started in 1973-74 and is still going strong. During its 25 years of operational life, the programme has established 414 FFDAs and trained 537,956 fish farmers. The programme has achieved an average production of 2,183 kg/ha/yr. The FFDAs is a centrally sponsored scheme under Govt. of India that provide a package of technical, financial and extension support services to fish farmers. The agency arranges suitable area on long-term lease, identifies beneficiaries, and provides incentives in the form of subsidies/grants for pond construction/rehabilitation and input supplies and with financial assistance in the form of subsidies and bank loans. In Assam the water area developed under Aquaculture through FFDA was 144 Hectare in 2010-11. The FFDA provides a package of technical, financial and extension support to fish farmers. The agency arranges suitable water area on lease on long term basis to identified beneficiaries, provides incentives for construction of ponds and tanks, and also inputs for first year of fish culture operation.

Fisheries Extension and Training

At the national level, the Fisheries Division of the Ministry of Agriculture is the planning and policy making body for fisheries development. The training programmes in fisheries are mainly dealt with by the Fish Farmers' Development Agency in Assam. They also provide packages of assistance for popularizing aquaculture technologies. The research institutes and SAUs have also been taking training and extension work as part of their curriculum. The Department of Rural Development promotes fisheries through the Integrated Rural Development Programme. In the states, departments of fisheries have been established at the district level to take care of the fisheries development including training and extension. The aim and objectives of the training programmes is to impart training to the fish farmers on scientific fish farming and publication of training manual to popularize scientific fish farming among fish farmers. In Assam the assistance and training to unemployed youth as *Matsya Mitra* was provided to 109 and 90 numbers respectively under the scheme of Fishery Extension and Training undertaken by the Govt. of Assam.

Conclusion

As Assam is the most water resourceful State in the North East part of the country, the fisheries sector plays a pivotal role in its socio-economic development and livelihood security. With the vast water resources, the state fish production estimated by Directorate of Fisheries, Assam has reached the level of 232 million kg in 2010-11. However, the fisheries potential of its water resources is still underutilized. Hence, aquaculture reforms should address issues in the area of enhancing fish production in an eco-friendly and sustainable manner so as to ensure poor fishermen's livelihood security from capture and culture fisheries. The poorly explored native ornamental fish resources have tremendous potential in the development of Indian ornamental fish trade which will create new avenues for employment generation. The state and central governments should intervene in bringing improved scientific technologies to the farmers and other stakeholders for holistic development of the sector as a whole.

Reference

AAU (Assam Agricultural University) (1997). Package of Practices for Fish Farming in Assam. Assam Agricultural University, Jorhat, Assam, India.

Baruah UK, Bhagowati AK, Talukdar RK, Saharia PK (2000). Beel Fisheries of Assam: Community based Co-management Imperative. Naga, ICLARM Q.,23(2): 36-41.

Das, S.K., and U.C. Goswami. 2002. Current status of culture fisheries in the Nagaon and Morigaon districts of Assam. Applied Fisheries and Aquaculture. Vol .II (2):33-36.

Goswami, M and Sathiadhas, R (2000). Fish Farming Through Community Participation in Assam. Naga, The ICLARM Quarterly (Vol. 23, No. 3) pp.29-32

Mandal SC, Singh P, Borthakur BC, Mahanta K, Pande HK (1981). Report on ICAR Research Review Committee on National Agricultural Research Project. NARP Document No. 39. ICAR, New Delhi, pp. 167

SHBA (2009). Statistical Hand Book Assam, 2009. Department of Economics & Statistics, Govt. of Assam, India.

Sugunan VV, Sinha M (2001). Sustainable capture and culture-based fisheries in freshwaters of India. In: Pandian, T. J. (Ed.). Sustainable Indian Fisheries, National Academy of Agricultural Sciences, New Delhi, pp. 43-70.

ABSTRACTS

RA-1

Ecology and Fish diversity of Ladakh waters - A cold arid region of Jammu and Kashmir State

F. A. Bhat[1], A. R. Yousuf[2], M. H. Balkhi[1] and M. D. Mahdi[2].

[1]Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), Srinagar - 100 006.

[2]Centre of Research for Development (CORD), University of Kashmir, Srinagar - 190 006.

Ladakh is a dry land of rugged mountains and open plains having scanty vegetation and sparse population. Water resources are meager, only scattered "oasis" of small water holes with thin and small stands of trees are seen. The main rivers of ladakh are Indus, Zanskar, Nubra and Suru while as the important high altitude lakes are Pangong Tso, Tso Moriri, Tso Khar etc. The river systems showed the typical lotic type of water quality. The pH of these waters was on the alkaline side of neutrality (mean = 8.43) and the mean value of other parameters was, conductivity (215 µS), Total hardness (254 mg/l), Total alkalinity (171 mg/l) and high dissolved oxygen concentration (9 mg/l), Ammonical – N (41µg), Nitrate – N (211µg) and Total Phosphate Phosphorus (127 µg). Compared to river sites, lake sites showed higher values of pH (mean = 8.83), conductivity (1496µS), Total hardness (1343mg/l), Total alkalinity (1276), DO2 (7.0 mg/l), Ammonical – N (50 µg), Nitrate – N (260 µg) and Total Phosphate Phosphorus (472 µg). The usual progression of cations in the river sites was found as $Ca^{++}>Mg^{++}>Na^{+}>K^{+}$ while as in lake sites the trend was reverse and was as $Mg^{++}>Ca^{++}>Na^{+}> K^{+}$. The reason for this is that these lakes are land locked and over the years the cations and other salts have accumulated in these lakes, besides magnesium salt being more soluble is found in higher concentration than the other salts. No extensive work has been done on the fisheries of Ladakh except for few reports i,e. Hutchinson (1932), Hora (1936) and Mukerjee (1936). During present study a total of eleven species of fishes were recorded among which Snow trouts formed more than 60% of fishes collected. The fishes belonged to three orders; Cypriniformes, Siluriformes and Salmoniformes and four families Cyprinidae, Balitoridae, Salmonidae and Sisoridae. Altitude was found one of the main reasons for the distribution of fishes in the Ladakh. The fishes were: *Schizothorax plagiostomus, Schizothorax labiatus, Schizothorax progastrus, Schizothorax longipins, Ptychobarbus conirostris, Diptychus maculates, Triplophysa stolizakae, and Triplophysa kashmirensis. Glyptosternon reticulatum, Salmo trutta fario and Schizopygopsis stoliczkae. The S. labiatus, S. progastrus, D. maculates and S. longipins* were found restricted in the lower reaches of the Indus River whereas the *S. t. fario* was found only from the Bazgo stream, one of the crystal clear streams of the Ladakh. *S. plagiostomus, P. conirostris, T. stolizakae,* and *T. kashmirensis,* were found throughout the Indus river system. However, S. stoliczkae and T. stolizakae were restricted in some of the streams of high altitude land locked Lakes such as Tso Moriri and Tso Khar.

Keywords: Ladakh, River Indus, Pangong Tso, Tso Moriri, Land locked, *Schizothorax* spp.

E-mail: fabhat_fb@yahoo.com

RA-2

Mountain Fisheries and upland aquaculture development-An overview

M.L. Bhowmik
Barrackpore, Kolkata – 700120

The vast geographical area and an array of topographical features of our country has diverse natural resources which offer tremendous opportunities for livelihood support to the people. The Sub Himalayan region of India has unique area covered with parallel mountains of different altitudes. This area is endowed with rich aquatic resources in the form of large rivers, tributaries, hill streams, lakes and reservoirs. The entire upland water resources harbours 258 fish species belonging to 21 families and 76 genera. Among these some are known for sports, few for their ornamental value and the rest as food fishes including the highly priced exotic ones. Hill streams harbours a rich population of mashers and schizothoracids well know for sport fisheries started showing decline in size groups and the numbers landed during the last more than two decades back. In the contest of depleting fish biodiversity aquaculture is the opportunity to restore fish spices richness and conserve the ecosystem for further loss. The ICAR created the national research centre on coldwater fisheries with clear cut mandate of assessment of hill fishery resources in Indian upland region for formulating ecological management plans to achieve sustainable fish production. The NRC was elevated to the directorate of coldwater fisheries research (DCFR) with emphasis on various research projects aiming at aquaculture development in the mountain region along with comprehensive development of the mountain fisheries. Aquaculture has come to be recognized as the only solution for sustainable fisheries the world over. Most of the commercially important fish species – whether in the sea, brackish water or fresh water are being increasingly brought within the fold of aquaculture to of obtain high level of production per unit area. Through the intervention of the NRC on cold water fisheries / DCFR it has been possible to develop standard packages of practices for rainbow trout, mahseer farming and development of carp culture with common carp alone and common carp based carp polyculture. The techniques so refined are transferred to the farmers through front line demonstration. Now, the farmers are adopting the culture techniques getting additional income from fish culture .if this trend is continued the day is not far away when the farmers will derive their livelihood from fish culture alone and achieve sustainable food security.

Key words: Sub Himalayan region, upland water, masher, Schizothoracids

Email: mlbhowmik08@gmail.com

RA-3

Coldwater fisheries its status, conservation and management

Anita and Prem Kumar
College of Fisheries, GB.P.U.A&T, Pantnagar, U.S. Nagar
(Uttarakhand)

Coldwater fishes are the fishes that lives in high altitude of Himalayan regions and can sustain their life in cold temperature of 14-18 degree centigrade and flowing water current. They are excellent from the economic and sport fishery point of view, but many other species are fished for subsistence. Cold water fisheries offer a great opportunity for self employment and income generation among poor people living along rivers, lakes and other natural waters. Lakes in Kashmir valley {J&K} situated at an altitude of 1537 to 1587m. Gobindsagar& Pong reservoir {altitude 560& 436 m} and the Kumaun lakes {altitude 1220 to 1937 m} in the Uttarakhand are cold water fishing body in Himalayan region. Presently [2010-11 provisionally] production of cold water fish inland sector is 3.8 thousand tonnes with growth rate of 9.46% and the number of seeds production is 100.44 million

fry with growth rate of 191.38%. Cold water fisheries facing problems of dynamite fishing, bleaching powder/ poisoning & electric fishing which leads to extinction of these fishes from that place. The water bodies of Himalayan region are going eutrophication & biological degradation like in Kumaun region the growing demands of local resident to meet the challenge of high tourism & other development programmes have increased pressure on Nainital lake leads to decline in catch of mahseer from the lake. The conservation of cold water fishes includes rehabilitation, restoring & ranching of fish seeds in the lakes, streams, rivers as well as ban on fishing during spawning season will leads to sustainability of cold water fisheries.Five principal elements or tasks in the recovery programe have been to be identified as Habitat management, Habitat development and maintenance, Native fish stock, Non native and sport fishing and Research data management and monitoring. These elements will facilitate in developing a management framework for the conservation and equitable use of fishery resources and manage fisheries in balance with the ecosystem for present and future generations, monitor and assess the status and trends of fisheries resources and provide high quality, diverse, accessible fishing opportunities. The main goal in a conservation programme is to conserve the genetic diversity. The fish genetic resources can be conserved by protecting an ecosystem which is broad-based, on-specific, cost effective and relatively simplistic in approach. It may aim in general or at specific species like endangered or threatened ones. This can be achieved through many mechanisms including *in situ* and *ex situ* methods.

Keywords: Cold water, eutrophication, biological degradation, mahseer, habitat

RA-4

Ecology and fishery resources from upstream of Pagladia River, Assam and its present status

Hitesh Das and Amalesh Dutta
Department of Zoology, Gauhati University, Guwahati-781014

Pagladia is an important tributary on the north bank of the Brahmaputra valley.Chowki(26°48′31.402″N latitude, 91°25′35.34″E longitude) is the source point of this tributary where two streams 'Pagla' and 'Dia' that originate from Bhutan Hills of Himalayan range unite together and flows in the form of Pagladiariver towards the Brahmaputra through

Bagsa and Nalbari districts of Assam. A study was under taken to investigate the abundance and diversity of fish fauna along with physico-chemical parameters of water of this tributary. During the period of study it was observed that a total of 14 fish species belonging to 12 genera, 3 families and 2 orders have been recorded.Out of these 14 species, 10 belong to family Cyprinidae, followed by Cobitidae (3), and Bagridae (1). Species abundance was measured maximum during winter and minimum during monsoon. Species diversity was found maximum during pre-monsoon and minimum during monsoon. During 2009 physico-chemical parameters ranged as water depth (0.92-1.8 m), velocity (0.70-1.38 m/s), temperature (11.4-18.3 °C), transparency (0.10-0.235 m), DO (9.5-12.6 mg/l), FCO_2 (0-2.2 mg/l), pH (6.79-6.95), total alkalinity (32.23-55.65 mg/l), total hardness (58-86 mg/l) and total chloride (6-21 mg/l). During 2010 physico-chemical parameters ranged as water depth (1.11-2.10 m), velocity (0.65-1.20 m/s), temperature (10.7-18.6 0C), transparency (0.09-0.41 m), DO (9.6-12.3 mg/l), FCO2 (1.1-1.8 mg/l), pH (6.72-6.94), total alkalinity (29.23-52.44 mg/l), total hardness (52-84 mg/l) and total chloride (3-14 mg/l).

Keywords: Ecology, fishery, upstream, Pagladia, Assam

E mail: hiteshdas11@gmail.com

RA-5

Nutrient dynamics and fishery potential of Asan wetland in Garhwal region

D.S. Malik and Nidhi Joshi
Deptt.of Zoology and Environmental sciences, Gurukul Kangri University
Haridwar (Uttarakhand)

Asian wetland, a notified conservation reserve situated on the confluence of Asanriver and Yamuna hydel canal near village Dhalipur in district Dehradun of Garhwal Himalayan region. The wetland is a famous ecotourism centre for its rich biodiversity especially endemic fish species and avian species as migratory birds. The natural and anthropogenic factors have been significantly contributed to ecological degradation and trophic status of wetland. The present study reveal that the input of nutrient load is increasing as nitrate(0.39 to 4.25 mg/l), potassium(1.40 to 2.60 mg/l), chloride (20.0 to 23.5 mg/l), sodium (25.0 to 35.5 mg /l) and phosphate(2.50 to 5.25 mg/l) in different zones of wetland. The present load of nutrient level also affected the physico-chemical and biological characteristics of wetland. The aquatic macrophytic infestation gradually increasing toward open water surface area of reservoir due to high input of nutrient load and degree of sedimentation. The present fish inventory data represented about 32 fish species belong to 10 families. Cyprinidae family showed maximum abundance with total of 58% among all the fish families. The fish species *Tor tor, Tor putitora, Schizothorax richardsonii, Labeo sp.* may be enhanced the fishery potential of Asian wetland based on sustainable conservation programme and replenishment of fish germplasm is urgently required in wetland. The sport fishery along with bird watching activities plays a vital contribution to enhance the socio-economic condition of local inhabitants of catchment basin under ecotourism programme promoted by Govt. of Uttarakhand.

Keywords: wetland, nutrient load, sedimentation, fish germplasm

Email: malikdsgkv@gmail.com

RA-6

Potential application of plant based growth promoters in aquaculture with special reference to papain

Grishma Tewari and R. N. Ram
Department of Fishery Biology, College of Fisheries, G. B. Pant University of Agriculture & Technology, Pantnagar-263145, Uttarakhand, India

The expansion of global aquaculture is increasing the demand for aquaculture feed which is the prime input in fish culture practices. For augmenting aquaculture production various anabolic products, hormones and their analogues, antibiotics, and synthetic growth promoters are also used. Even though they give positive effects, they cannot be recommended due to their residual and other side effects. The alternative herbal and plant based products in the aquacultural operations have the characteristics of growth promoting ability and tonic to improve immune system, as appetite stimulators, induce maturation, and have antimicrobial capability and antistress characteristics that will be of immense use in the aquaculture operations without any environmental and hazardous problems. *Carica papaya* (papaya), *Quillajasaponins* (soap bark tree), *Ocimum sanctum* (Tulsi), *With ania somnifera* (Ashwagandha), *Ferula asafoetida* (Hing), *Mucuna pruriens* (Velvet bean), *Myristica fragrans* (Jaiphal), *Ficus bengalensis* (Bargad), *Asparagus adscendens* (SafedMusli), *Ochrocarpus longifolius* (Nagkesar) are some plants have potential applications in aquaculture subsequently results into better growth performance. A study was carried out to assess the effect of papain enzyme derived from papaya plant on gonadal maturity of male and female *Cyprinus carpio*. The fishes were fed with conventional diet mixed with three different sources

of papain (i.e. papain powder, unripe fruit and green leaves of papaya) for a period of 150 days. The better results regarding gonadosomatic index (GSI) and maturity of oocytes and spermatocytes were obtained in feeding groups supplemented with papain in comparison to control. In another experiment, *Cyprinus carpio* fed a diet digested with papain yielded significantly better growth in terms of weight and length gains, than their counterparts fed without digestion. The water quality parameters were regularly recorded during whole experimentation period and no adverse effect was reported subsequently resulted into normal behavioural response and physiological performance of fish.

Keywords: growth promoter, papain, common carp, aquaculture

E-mail: grishmatewari11@gmail.com

RA-7

Catch statistics and quality assessment of low value fishes from Baigul and Dhaura reservoirs of Uttarakhand

Ritu Agrawal, Smita Chauhan, Malobica Das Trakroo and A. K. Upadhyaya
College of Fisheries, G. B. Pant Univ. of Agri. and Tech., Pantnagar

Reservoirs constitute the single largest inland fishery resource, both in terms of resource size and productive potential. The fish yield from reservoirs of Uttarakhand is about 3000 tons/year. The catch statistics details of harvest from these reservoirs suggest that about 21% of produce comprise of commercially important fish species which include Indian major carp, Chinese carp and cat fishes while the rest 79% of the harvest is received from moderate to low quality, uneconomical fishes. The present investigation was carried out during 2005-2009 to study the quality parameters of mince from fresh water fishes of reservoirs from Uttarakhand region. The fresh fishes namely, *Nandus nandus, Channa marulius and Puntius sarana* were collected from Baigul and Dhaura reservoirs in iced condition and the fillets were rendered for mincing. All the samples were frozen at -40°C and were cold stored at -20°C for six months. All the samples were assessed fortnightly for proximate *Puntius sarana* possess high nutritional quality for protein supplementation. Mince rendered composition, physical parameters, microbiological parameters and sensory evaluation. The results concluded that the small, economically inferior quality fishes such as *Nandus nandus, Channa marulius* and form these fishes are of high quality and indicate sustenance of biochemical, physical and sensory parameters upto four months. If properly cold stored, the high quality of mince even can last for more than six months and can be utilized for the development of mince based value added products. The development of value added products from economically cheaper fishes would not only incur the less cost in production but can also substantially help in attending nutritional upliftment of poor rural folk beside being having high potential for income generation and manpower development.

Keywords: reservoirs, uneconomical fishes, mince, value added products, income generation

E-mail: ritu_fish@rediffmail.com

RA-8

Ecological imbalance and dangerous impact on fish faunal diversity of Ganga river system: A Review

Shobhna , H.S. Singh, Anshu Chaudhary, Manu Varma, Haren Ram Chiary, Neetu Singh, Garima Kansal
Molecular Taxonomy Laboratory, Department of Zoology
Chaudhary Charan Singh University, Meerut

Riverine fisheries are an indicator of the health of the river itself. Reviving fisheries by restoring rivers and their flows will help not only the poorer riverine fisherman, it will help a number of other communities and livelihoods dependant on rivers. The inherent resilience of riverine ecosystems will ensure that socio-ecological impacts of restoration work will be evident in a short to moderate time span and will benefit millions of fisher folks and ecosystems. Fisheries in Ganga are on a steep decline due to hydrological changes and various other changes associated with large scale water diversion through barrages and canals. Impact of these changes on the fish faunal diversity of Ganga river system and associated canals has been discussed.

Keywords: Riverine, livelihoods, ecosystems, .hydrological changes

RA-9

The threats of climate change affecting lakes and their fisheries in Kumaon region of Uttarakhand State

N.N. Pandey, R.S. Patiyal and Prem Kumar*
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

Climate change is affecting Coldwater resources and their fisheries through its impact on water quality and overall productivity. An attempt was made to observe the significant changes in lakes and rivers of the Kumaon region during the year 2012 in comparison to previous years due to the higher temperature and scanty rainfall pattern. In Bhimtal lake (Latt. 29 ⁰ 30'N, Long. 79 ⁰ 36'E) situated at an altitude of 1370 amsl with water spread area of approximately 85 ha. This lake provides water for drinking purpose and also the healthy brooders of Golden Mahseer for artificial propagation. Marked water shortage during the summer was observed in the lake during the year 2012. There was only 20 % water spread area of the full capacity of the lake. High water temperature (upto 28⁰C during the month of June), infestation of algae due to the shallow depth and high temperature, high density of rotifers and cladoceran with the dominance of Brachionus spp. and Daphnia spp, appearance of rooted Vallisnaria and disappearance of submerged Ceratophylum, occurrence of Argulus, a fish parasite and little earlier onset of maturity in the Mahseer brooder was observed due to draught like condition in the lake. Availability of the Mahseer brooder for artificial propagation was very rare, while this lake was a good source of Mahseer brooder in previous years. Almost similar condition was observed in Nainital lake (Long. 29 ⁰ 23 'N, lat. 79 ⁰ 30 'E,) situated at an altitude of 1938 amsl with 24.2⁰C water temperature during the month of June, high density of Gambusia spp. in the shallow shore area and high density of Daphnia spp. in the littoral zone. Tourist season (summer) was badly affected due to the limited boating facility in small water of lakes.

Keywords: Bhimtal lake, Golden Mahseer, artificial propagation, algae, Nainital lake

***E-mail:** nityanfish@yahoo.co.in

RA-10

Temporal variation and draught like condition in rivers and streams of hills

R.S. Haldar, N.N. Pandey, S. Ali and R.S. Patiyal*
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

The river system of Uttarakhand state has a total length of 2,686 km. An attempt was made to observe the significant changes in these water resources due to the higher temperature and scanty rainfall pattern. The Kosi river, situated in the lower areas of the Kumaon region with a total area of 386 thousand hectares was estimated from the data of satellite images that the total length of the main river with trunk streams from its origin was 279.9 Km during 1997 and 249.4 Km in 2004. On the basis of the satellite data, there was shrinkage of about 30.5 km during the period (1997-2004) with down ward shifting of main stream about 100m from its originating point. Water temperature was in higher side in comparison to previous years. During the summer season in the year 2012, this river was observed with availability of fish in only the lower retches, adult mahseer population only in the Ramnagar region having the deep pool like places, 2 weeks earlier onset of maturity and natural spawning in Golden mahseer, *Labeo dyocheilus and in L. dero.* The minima and maxima of total plankton density were observed in August and May respectively with average plankton population as 102-365 units/l, which was in higher side than the previous year. Marked difference was observed in the dissolved oxygen content. Draught like condition with significant changes was observed in the River Ravi and Satluj in Himachal Pradesh and in Gola and Ladhia streams in Uttarakhand.

Keywords: scanty rainfall pattern, satellite images, adult mahseer, plankton density, dissolved oxygen

***E-mail:** nityanfish@yahoo.co.in

RA-11

Investigation of fish fauna along the stretch of the river Ravi falling within the Chamba district of Himachal Pradesh

S. Ali, N.N. Pandey and P. Kumar
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

A detailed survey was made on the occurrence of important fish species along the stretch of the river Ravi falling within the Chamba district of Himachal. The temperature range was found conducive for breeding of the coldwater species. Due to the sub-temperate climate of the area, the primary productivity in the river is confined only in the form of periphyton attached on boulders of the river and the plankton community is less. Water flow passing through the river at any instant is one of the most important conditioners of river ecology. It affects directly the physiology of the fish acting as a trigger for migration and breeding activities and indirectly affects the habitat structure required for the survival of both resident and migratory species. The most dominant species in the area is Indian snow trout *(Schizothorax richardsonii)* which has significant population in the river but due to various factors including existing hydroelectric projects shows fragmented distribution. In order to enhance the population of snow trout, there should be a programme based on "the species approach" for the mitigation and enhancement of wild stock in the area. The species approach concentrates on one or more species judged to be of particular economic or social value. Ranching of snow trout fingerlings in the stream on regular basis need to be taken up for maintaining the wild population.

Keywords: river Ravi, primary productivity, periphyton, migration and snow trout.

E-mail: nityanfish@yahoo.co.in

RA-12

Biodiversity of plankton population in Bhimtal Lake of Kumaun Himalayas (Uttarakhand) during winter season

Gulam Ali[1], Prem Kumar[2], D.S. Rawat[1], Raghvendra Singh[3]
[1]Department of Zoology, BFIT, Dehradun,Uttarakhand
[2]Directorate of Coldwater Fisheries Research, Bhimtal (Nainital),Uttarakhand
[3]College of Fisheries, G.B.P.U.A.& T. Pantnagar, Uttarakhand

The research paper represents a brief analysis of plankton community occurring in a semi temperate lake located at Bhimtal, Nainital, Uttarakhand during winter season. The analysis of phytoplankton samples,collected from the lake during winter months revealed the occurrence of 15 species of phytoplankton, out of 15 species of phytoplankton recorded 4 species belongs to the Chlorophyceae, 7 species belongs to the Bacillariophyceae, 3 species from Cynophyceae and one from pyrrophyceae. Data on collected zooplankton samples revealed the occurrence of 8 species of zooplankton belonging to the 3 species from Rotifera, 2 species from Cladocera, 2 species from Copepoda, and one from protozoa. The overall result reflected that the phytoplankton diversity was found in poor side, while the population of zooplankton was dominated during the winter months.

Keywords: plankton community, semi temperate lake

RA-13

Managing endangered species: suggestion for prioritizing management strategies for conservation of *Tor putitora*

R.S. Patiyal, A. Barat, P. Kumar, N.N. Panday and S. Chandra
Directorate of Coldwater Fisheries Research (ICAR)
Bhimtal-263136, Nainital, Uttarakhand, India

Over the last few decades the habitat of mashseer fishery resources has been targated for the development activities and anthropogenic causes. A combination of factor including loss of breeding area, rearing habitat, over exploitation and low recovery rates of fishes, result in poor record of sustainability of *Tor putitora*. One of the greatest challenge is to find a ways to deel with sustainable level of endangered speciese. Poor general recording of endangered species mahseer landings and paucity of mahseer landing data at the speciese level also undermine development of effective mahseer management strategies. This papers review the problem that must be faced everywhere if mahseer not managed sustainably and lay out a comprehensive set of prioritized management strategies to facilitate the sustainable management of mahseer fisheriese. It is needed to incorporate different management strategies relavant to local socio- economic agendas. The management recommendation deel with method to improve the regulation of fisheries, ways to improve conservation ethics and encourage active participation of locals in management, as well as means by which specific management strategies may be implanted. In this endeavor, now time has come to domesticate the fishery resources together establishing of fish parks, fish reserves and conservation efforts of natural resources would facilited faster action on conservation and breeding. Under this perspective, we have conceived a multiferous programme / concept to establish a Agro-climatic zones wise establishment of "Live Fish Gene Banks" and "Self sustained mahseer conservation model linking ecotourism" as a tool for interlinking *in- situ* and *ex- situ* conservation.

Key Words: Fish conservation, *Tor putitora, in situ* and *ex situ* conservation.

RA-14

Seasonal variations in biotic parameters of river Kosi and its impact on fish biodiversity

R.S.Haldar[1], *N.N.Pandey*[1], *H.C.S. Bisht*[2]
[1]Directorate of Coldwater Fisheries Research (ICAR)
Bhimtal-263136, Nainital, Uttarakhand, India
[2]Department of Zoology, D. S. B. Campus, Kumaun University
Nainital-263 002, Uttarakhand, India

The present investigation deals with the study of biotic community of Kosi river, in Kumaon region of Uttarakhand state. The investigation was undertaken for one year, monthly collection were made and analyzed seasonally. Average plankton population was observed in the range of 49-305 units/l with minima and maxima during August and May, respectively at all the stations. Bacillariophyceae dominated at all the stations followed by Chlorophyceae and Cyanophyceae with occurrence of *Navicula, Cymbella, Amphora, Synedra* and *Fragillaria* throughout the year. The density of zooplankton ranged between nil in July to34 units/l in February with maximum population at station-VI. The density of epiphytic community and benthos was in the range of 86333-110916 units/cm^2 and 51-74 units/m2 respectively with abundance at station-III. The fish fauna is comprised of Mahseers, Snow trouts, Minor carps, Sucker heads, Loaches, Cat fishes and Baam. Total 26 fish species belongings to 6 families were recorded with majority of mahseer and Snow trout. Study reflects a correlation between fish species distribution and biotic community.

Key words: Kosi river, Kumaon region, plankton, epiphytic community, benthos, mahseer

RA-15

Occurance, fishery, breeding and status of the mahseer in Ladhiya and Kali river of Kumoan, Uttrakhand

R.S. Patiyal
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

This paper reports observation on distribution, fishery, breeding and conservation status of a endangered Tor species based on monthly sample fishing conducted in the selected sites of Ladhiya and Kali river of Uttrakhand. The fish had a wider distribution in the river –Ladhia and kali. Its fishery was mostly restricted to pre monsoon (June-July) and post monsoon months (October November) and a different type of fishing methods were employed for its capture. During the sampling, 7 species *Schizothorax richardsoni, Tor Putitora, Garra gotyla, Barilius bendelesis, Tor chilinoides, Nemacheilus botia* and. *Tor tor* were recorded. The sample size observed belonged to measuring 3.0 cm to 55.0 cm. Survival of this fishes being threatened on account of vulnerability to over exploitation, extraction of sand and boulders and habitat destruction in the form of reclamation marginal areas. Following the CAMP workshop criteria for determining the threatened status of the fish, it has been categorized as a Endangered speciese. The need to formulate suitable conservation strategy for this speciese as well as to explore its potential role as a food and game fish is discussed.

Key Words: Fish conservation, *Tor putitora,* Over exploitation, Game fish

RA-16

Ecological State of Diatom Communities in Some Lesser Himalayan Foothill Streams

P. Nautiyal, A. S. Mishra and U. Singh
Aquatic Biodiversity Unit, Department of Zoology, HNB Garhwal Central University
Srinagar, Uttarakhand, India

The ecological state of diatom communities were examined in the prevailing landuse along the course of some lesser himalayan foothill streams, the Gaula and Kosi in Kumaun region, while the Khoh and Nayar in the Garhwal region. The landuse categories observed in these rivers are; forest (F) alone or in combination with agriculture and/or human habitation of different magnitudes. The saprobic state is mostly beta-mesosaprobous. The trophic status is eutraphentic in all seasons except the Gaula which is mesotraphentic in postmonsoon. Its lower half turns eutraphentic in winter when flows become lean. Hyper eutrophentic conditions appear in the Gaula during postmonsoon at Kathgodam city, while in the Nayar and Khoh during postmonsoon in locations influenced by human settlements. The severity is reflected in other indices (HSI) as saprotroph and polysaprob conditions occur in postmonsoon near Kotdwar city along lower part of the Khoh. Denys index shows that life forms are purely benthic and habitat 'also commonly dry subaerial' compared with tachyplanktonic, epontic origin and 'also commonly moist subaerial' at other locations in this zone. Organic pollution is non-existent; degradation low to medium and anthropogenic eutrophication is low.

Keywords: diatom, foothill streams

RA-17

Distributional Patterns of the Fish fauna in the western Himalaya rivers of India

P. Nautiyal, A. S. Mishra & U. Singh
Aquatic Biodiversity Unit, Department of Zoology, HNB Garhwal Central University
Srinagar, Uttarakhand, India

The investigation on the distributional patterns of the Himalayan fish fauna in the glacier and spring fed rivers of Uttarakhand revealed thirty four common fish species, of which 10 species were common to glacier and spring fed rivers/streams, while 7 were restricted in the glacier fed rivers/streams and 17 are restricted to spring fed rivers/streams. These fish species showed various range of distribution among these rivers. *Schizothorax* spp. and *Barilius bendelisis* indicated a wide range of distribution from higher (2500 m asl) to low elevation (500 m asl), while *Schistura rupecola* and *S. montanus* were restricted to springfed streams and were found even at 1600-1800 m elevation. *Labeo* spp. were restricted only at low (<500 m) elevation. *Puntius* spp. were observed only in the mid elevation range <1000m especially in Doon valley region. The exotic common carp (*Cyprinius carpio*) was observed only in the Tehri reservoir on the Bhagirathi river. Its presence is attributed accidental introduction from adjoining fish farms during submergence for formation of reservoir, while the wide range of snow trouts is attributed to wide range of water temperature and velocity form high to low elevation.

Keywords: Spring fed rivers, Tehri reservoir, Bhagirathi river, snow trout

AQ-1

Effect of dietary prebiotic on growth and survival of Tor *khudree* (Sykes, 1839) fry

Gunjan Karnatak, V.K. Tiwari, Kiran Dube and Kundan Kumar
Central Institute of Fisheries Education
Mumbai, 400 061

This investigation was undertaken to evaluate the potential effects of prebiotic Fructooligosaccharide (FOS) on growth and survival of *Tor khudree* (Deccan mahseer) fry. Four experimental formulations containing different doses of prebiotic and a control diet without the prebiotic was formulated. Formulated dietary treatments were T1 (0.5% FOS), T2 (1 %FOS), T3 (1.5% FOS), T4 (2% FOS), and control (0% FOS). A total of 450 advanced fry of 3.26g each were randomly assigned to these five dietary treatment groups. Each treatment was fed to 3 replicates of 30 fry per replicate for a period of 90 days. Growth performance of fishes was significantly higher ($p<0.05\%$) in diets containing FOS. Mean final weight, specific growth rate (SGR), feed conversion ratio (FCR), feeding efficiency ratio (FER) ,average daily growth (ADG) and percentage weight gain(PWG) were significantly higher in T2 , T3 and T4 groups. Although there was insignificant difference in survival percentage amongst the treatments, survival rate was better in FOS fed fishes. Results of Experiment show that growth performance and survival of fishes was better in dietary supplemented group. Overall results of this study indicated that Fructooligosaccharide is capable of enhancing growth performance and survival of the fish. Supplementation at the rate of 1.5- 2% can be used for better growth and health management.

Keywords: *Tor khudree,* Prebiotic, Fructooligosaccharide, growth, immunity, Gut microbiota

E-mail: gunjan.aq252@cife.edu.in

AQ-2

Influence of feeding regimes on the ultrastructure of digestive tract of Indian major carp, *Catla catla*

Ingochouba Meetei Lukram[1], S. N. Mohanty[2] and Rina Chakrabarti[1]*
[1]Aqua Research Lab, Department of Zoology, University of Delhi, Delhi 110 007, India
[2]CIFA, Kausalyaganga, Bhubaneswar, Orissa 2465430, India

Indian major carp *Catla catla* larvae were cultured under six different feeding regimes of zooplankton (LF), artificial food (AF), mixed food (MF), zooplankton for initial 12 days then shifted to artificial food (LF-AF-13), zooplankton for initial 17 days then shifted to artificial food (LF-AF-18) and zooplankton for initial 12 days then shifted to mixed food (LF-MF-13). Ultrastructure study showed that height of microvilli was significantly ($P< 0.05$) higher in fish fed with artificial diet compared to others. It was higher in proximal segment compared to middle and distal segments regardless of feeding regime. Among these three segments, the number of mitochondria was maximum in the proximal segment of fish cultured in LF-MF-13 and middle and distal segments of fish cultured in AF compared to others. Total number of mitochondria and lipid droplet were maximum in the artificial diet fed fish. MF and LF-MF-13 were conspicuous by the absence of lipid droplet in the proximal and middle segments. Significantly ($P< 0.05$) higher number of goblet cell was observed in LF-MF-13 and this was followed by AF. Pinocytotic channels were found in the distal segment of the fish cultured in LF and LF-MF-13. This study shows that the ultrastructure of the digestive tract of *Catla* is influenced by the food.

Keywords: Microvilli,lipid droplet, Pinocytotic channels

***E-mail:** aquaresearchlab@yahoo.co.in

AQ-3

Effect of temperature on the food consumption rate and digestive enzyme profile of *Clarias batrachus*

JaiGopal Sharma[1], Tauqueer Ahmad[2], Samar Pal Singh[1], Bronson Kumar Khangembam[2] and Rina Chakrabarti[2]*

[1]Department of Biotechnology, Delhi Technological University, Dwarka, New Delhi, India

[2]Aqua Research Lab, Department of Zoology, University of Delhi, Delhi 110007, India.

The effect of temperature on the food consumption rate and the digestive enzyme activities of *Clarias batrachus* were evaluated in the present study. Fish were exposed to different temperatures: 10, 15, 20, 25, 30 and 35°C following an acclimatization temperature of 25°C for 21 days. Fish were fed with practical diet @ 5% of body weight during the study period. Highest food consumption of fish was recorded at 25°C and the food consumption rate gradually decreased with decreasing water temperature. In the present study, 46.67, 8.20-23.58 and 1.02-6.15% reduced food consumptions were recorded in fish exposed at 10, 15 and 20°C temperatures, respectively compared to the fish maintained at acclimatization temperature. The consumption rate was not affected in fish exposed at 30 and 35°C. Total protease, trypsin and chymotrypsin activities were significantly (P<0.05) higher in fish exposed at 25°C compared to others. Protease activity was more sensitive towards the decrease of temperatures compared to the increase of temperature from the acclimatization temperature. Lipase activity was significantly (P<0.05) higher in fish exposed at 30°C compared to others. Minimum enzyme activities were recorded at 10°C. Reduced food consumption and less digestive enzyme activity showed the stressful condition of fish exposed to low temperature. Proper care should be taken during the winter months in the pond culture.

Keywords: *Clarias batrachus*, protease, trypsin, chymotrypsin activities

E-mail: aquaresearchlab@yahoo.co.in

AQ-4

A first report on rearing of Mahseer in cages in Indryani river of western Maharashtra

Gopal Krishna[1], S.N. Ogale[2], NK Chadha[1], V.K. Tiwari[1], Rupam Sharma[1], Mahesh Mahajan[2], Sonali Bhatade, Atul Bahlekar, Pranita Chavan, RohitNagalgao and W.S. Lakra[1]

[1]CentralInstitute of Fisheries Education, PanchMarg, Off Yari Road, Mumbai – 61

[2]Friends of Nature Association, Talegaon, Pune

Mahseer, an endangered fish was taken up for culture and rehabilitationin Indryani River in Western Maharashtra. A total of 8 cages measuring 3x3x3 meters were floated in the river and the seed was stocked in the cages after rearing in cement nursery. The fry were stocked in cages at the rate of 500 fry per cage and reared for a period of eight months. The fingerlings were fed initially on ground nut oil cake and rice bran (1:1) and after one month, with ABIS formulated pelleted floating feed procured from Chhattisgarh with Crude protein – 32%, crude fat – 4%, crude fiber – 5%, moisture – 10% and pellet size – 2mm at the rate of 5% BW twice daily. The water quality and other parameters in the nursery and river stretch were monitored and recorded. Growth and mortality of the fishes were also recorded. After rearing for 240 days in cages, a total of more than 6000 advanced fingerlings have been released in the river Indryani in two instalments. This is the first attempt on cage culture in river in India under the project 'Genetic conservation and live gene banking of Mahseer in Indryani river' funded by NFDB, Government of India.

Keywords: Mahseer, rehabilitation, Indryani river, cage culture

AQ-5

Effect of incorporation of coconut oil cake in the diet of tiger shrimp, *Penaeus monodon* on growth, digestibility, amino acid and fatty acid profiles

J. Syama Dayal, V. Rajaram and K. Ambasankar*
Central Institute of Brackishwater Aquaculture, (ICAR)
75, Santhome High Road, RA Puram, Chennai -600 028, India

The effect of incorporation of coconut oil cake in the diets of tiger shrimp, Penaeusmonodonwas studied by including at 0, 2.5, 5.0, 7.5 and 10% levels. The results of a 45 day growth cum digestibility study indicated that the weight gain was significantly ($P < 0.05$) reduced at 7.5% of inclusion level (185.3 ± 5.03) compare to 2.5% inclusion level (201.8± 4.06). No significant differences were observed in FCR and survival percentage. The apparent protein digestibility was significantly reduced at 10.0% inclusion level compared to 2.5% inclusion level (72.3 ± 1.2; 86.75 ± 1.06%, respectively). The lysine and leucine digestibility (87.3 and 88.69%) were high at 2.5% level of inclusion compared to 10% (81.69 and 80.97% respectively). The essential free amino acids like arginine and methionine are 46.11 ± 2.98; 4.62 ± 0.95 and 34.25 ± 3.3; 3.85 ± 0.91 µmol/g tissue in shrimp muscle fed with 2.5 and 10% copra cake, respectively. The concentration of ω-3 PUFA, eicosapentanoic acid (EPA) and docosahexanoic acids (DHA) were 9.93 ± 0.24; 9.25 ± 0.48 per cent at 5% inclusion and these levels decreased to 7.82 ± 0.50; 8.07 ± 0.35 at 10% inclusion. Based on the results copra cake can be incorporated in shrimp feed in the maximum level of 5%.

Keywords: Shrimp, Plant protein sources, amino acid digestibility, free amino acid profiles, fatty acid profiles

E-mail: syamdayal@ciba.res.in

AQ-6

Dietary vitamin E supplementation restores the physiological changes in nitrite exposed *Labeo rohita*

Ciji and N.P. Sahu
Central Institute of Fisheries Education
Off Yari Road, Versova, Andheri (W), Mumbai-400061, India

An experiment was conducted to study the effect of sub-lethal concentrations of nitrite exposure on *Labeo rohita* juveniles fed elevated levels of vitamin E (VE). Fishes fed with normal and elevated levels of vitamin E for 60 days were exposed to sub-lethal concentration of nitrite (2.0 mg/l) for another 45 days with the same feeding regime. There were six treatment groups, *viz.*, VE_0-N, VE_0+N, VE_{100}-N,VE_{100}+N,VE_{150}+N and VE_{300}+N. Except the groups VE0-N and VE100-N, all other groups were exposed to nitrite. Effects of nitrite exposure on *L. rohita* juveniles were evaluated in terms of growth performance, alterations in metabolic, biochemical, ion regulatory and haematological profile of the fish. The lowest and highest specific growth rate was observed in VE_0+N and VE_{100}-N group, respectively. The Reno-somatic index and methaemoglobin reductase activity found to be significantly increased by nitrite exposure and the unexposed (VE_0-N & VE_{100}-N) groups recorded the lowest values. The lowest RBC, Hb and Hct values were observed in VE_0+N and were significantly increased by dietary supplementation of additional amounts of VE. A significant difference in the concentration of serum sodium, potassium and chloride was observed among the different treatment groups. However, calcium concentration and serum osmolarity was not significantly affected ($p>0.05$) by nitrite exposure. Nitrite exposure caused a marked increase ($p<0.05$) in the concentration of nitrite in the gill, liver and muscle compared to the unexposed groups. Accumulation of nitrite was found to be higher in gill compared to muscle and liver. In both liver and muscle dietary supplementation with

additional amounts of vitamin E found to reduce the nitrite accumulation. It was noticed that nitrite exposure has adversely affected growth, metabolic activity and ionic balance of *L. rohita* juveniles and dietary supplementation with additional amounts of VE found to overcome the adverse effect of nitrite exposure. Detoxification of nitrite by methaemoglobin reductase system found to be enhanced by dietary supplementation of additional amounts of vitamin E.

Keywords: *Labeo rohita*, sub-lethal, nitrite, Reno-somatic index, methaemoglobin reductase

E-mail: cijialex83@gmail.com

AQ-7

Alterations in sex steroids and thyroid hormones of *Labeo rohita* juveniles on short term exposure to sublethal dose of nitrite: Effects of dietary vitamin E and L-tryptophan

Ciji and N.P. Sahu
Central Institute of Fisheries Education
Off Yari Road, Versova, Andheri (W), Mumbai-400061, India

An experiment was conducted to study the effect of sub-lethal concentration of nitrite exposure on sex steroids (testosterone and estradiol), cortisol and thyroid hormones (T_3 and T_4) of *Labeo rohita* juveniles. Fishes previously fed with normal or elevated levels of vitamin E (VE) and tryptophan for 60 days, were exposed to sub-lethal concentration of nitrite for another 45 days with the same feeding regime. There were nine treatment groups, *viz.*, VE_0TRP_0-N, VE_0TRP_0+N,$VE_{100}TRP_0$-N, $VE_{100}TRP_0$+N, $VE_{100}TRP_{0.75}$+N, $VE_{100}TRP_{1.5}$+N, VE_{150} TRP_0+N, $VE_{300}TRP_0$+N, $VE_{200}TRP_1$+N. Except the groups VE_0TRP_0-N and $VE_{100}TRP_0$-N, all other groups were exposed to nitrite. At the end of 45 days of nitrite exposure, serum samples were assayed for sex steroids, cortisol and thyroid hormones. The serum T_3 and T_4 levels decreased to the extent of 84.5% and 94.06%, respectively upon nitrite exposure. The highest levels of both T_3 and T_4 were observed in $VE_{100}TRP_0$-N and lowest in VE_0TRP_0+N group. Dietary supplementation with additional amounts of VE and tryptophan appears to reduce the decline of the production of T_4. $VE_{300}TRP_0$+N group recorded similar levels of serum T_4 as that of $VE_{100}TRP_0$-N. The serum testosterone and estradiol decreased 97.31 and 92.86%, respectively upon nitrite exposure. Supplementation with additional amounts of VE found to reverse the nitrite induced inhibition of testosterone and estradiol production. Serum cortisol increased upon nitrite exposure and unexposed (VE_{100}-N) group showed lower levels, which were comparable to groups fed with elevated levels of vitamin E (VE_{150}+N and VE_{300}+N). The overall results of the present study revealed that the environmental nitrites have a negative impact on steroidogenesis, which can be overcome by dietary supplementation of elevated amounts of VE (minimum of 150 mg VE/Kg diet) and to a lesser extent by tryptophan (only at the level of 1.5% of the diet).

E-mail: cijialex83@gmail.com

Keywords: Nitrite, Labeo rohita, serum cortisol, steroidogenesis

AQ-8

Effect of non-detoxified defatted Jatropha kernel meal on growth and nutrient utilization in *Labeo rohita* fingerlings

Angel G., P. Sardar, N.P. Sahu, V. Phulia,N. Shamna, S. Gupta and K.K. Jain
Central Institute of Fisheries Education, ICAR, Mumbai- 400 061.

An 30 days feeding trial was conducted to evaluate the effect of non-detoxified defatted *Jatropha curcas* kernel meal (DJKM) on growth and nutrient utilization in *Labeo rohita* fingerlings. Fishes (average body weight 7.12±0.05 g) were randomly distributed in four treatment groups with each in triplicate containing 10 fishes in each experimental tub of 150 L capacity. Four isonitrogenous (35% crude protein) and isoenergetic (418 kcal 100 g-1 digestible energy) experimental diets such as control (C, 0% DJKM), T1 (5% DJKM), T2 (10% DJKM) and T3 (20% DJKM) were prepared and fed to the fishes of respective treatmentsat satiation level. Fish fed DJKM containing diets showed inferior performance in comparison to fish of control group might be due to presence of some deleterious factors in DJKM. It can be concluded that without undertaking suitable detoxification measure DJKM cannot be incorporated the carp diet.

Keywords: *Jatropha, Labeo rohita,* growth, nutrient utilization

E-mail: vikas.phulia@gmail.com

AQ-9

Captive breeding and embryonic development of butter catfish *(Ompok bimaculatus)*, a threatened fish of Indian sub-continent in northern India

Sudhir Raizada, K. K. Lal, U. K. Sarkar, P. K. Varshney,Vikash Sahu, Kailash C. Yadav and J. K. Jena*
National Bureau of Fish Genetic Resources
Canal Ring Road, Telibagh, P.O. Dilkusha, Lucknow – 226 010, India

The butter catfish, *Ompok bimaculatus* (Bloch 1794) is a threatened teleost of Indian sub-continent and commonly found in India, Pakistan, Bangladesh, Myanmar, Sri Lanka and Afghanistan. In India, it is widely distributed in the plains and submontane regions and is considered a delicacy in many parts of India particularly north-eastern hill states. The fish breeds in rivers and do not spawn under captive conditions. Hence, there is need for the development of *ex-situ* seed production protocol so that the species can be cultured as table fish as well used for conservation needs. Ten induced breeding trials were conducted at NBFGR, Lucknow in controlled conditions using sGnRH analogue and dopamine antagonist as inducing agent. The fish spawned naturally with 50% success and the most economical dose estimated was 0.7 ml kg^{-1} body weight for female and 0.5 ml kg^{-1} for male. The latency period for spawning was observed 7-8 hours at temperature 27+0.5 °C and fertilization and hatching rates were found in the range of 75-90% and 80-90% respectively in flow-through system. The egg hatched out in 21+1 hour at temperature 27+0.5 0C and yolk sac was completely absorbed in 48 hours. A larval survival of 70% was observed up to 5 days, whereas, it to 10.4% at 10 days rearing, reason being, poor food acceptability and cannibalism reduced. The fish responded well when injected with hormonal formulation within 36 hours of procurement from the pond but thereafter did not respond probably due to stress factor. These trials may be useful in standardizing the ex-situ breeding protocol for *O. bimaculatus.*

Keywords: *Ompok bimaculatus,* butter catfish, captive breeding, embryonic development

E-mail: sudhirraijada2hotmail.com

AQ-10

Skewed sex ratio in golden mahseer *Tor putitora* of upland waters: endangerment and reproductive management

A. K. Singh
National Bureau of Fish Genetic Resources
Canal Ring Road, P.O. Dilkusha, Lucknow-226002 (Uttar Pradesh)

Golden mahseer, *Tor putitora* is one of the important species of upland water serving recreational, subsistence fishery as well as aquaculture in upland waters. The fish is largely confined to lotic habitat (river and streams) and its abundance is declining fast over the years.

Data collected on natural breeding and mature brood fishes collected from streams and lakes revealed that golden mahseer could spawn in July, August, September and October. However, we observed skewed sex ratio at most of the locations we studied and found the presence of very few females (24.4%) showing male predominant populations. Breeding response and sex related studies in mahseer from the field showed that golden mahseer could breed most months of a year when water temperature ranged between 18.5 and 23°C. Females were found to release 550 to 19795 ova at single response. In this study, we compared the size of ova, larvae and fecundity (released ova/body weight of female) of golden mahseer from riverine environment to lacustrine environments and recorded variations in some of their morphomeristic characters. Experimental studies were conducted on the amenability of sex ratio of the fish. The results suggested that the declining population of mahseer could be due to presence of low females in nature.

Keywords: Golden mahseer, spawn, lacustrine, morphomeristic, sex ratio

Email: aksingh56@rediffmail.com

AQ-11

Breeding biology of fresh water prawns of Kumaun Himalaya, Uttarakhand

H.C.S.Bisht, Meena, Mamta, S.S. Kunjwal and Somya
Department of Zoology, D. S. B. Campus
Kumaun University Nainital-263002

The gonadosomatic index (GSI) and hepatosomatic index (HSI) and the availability of sexual matured prawns of both the sexes and also that berried females, the breeding pattern of *Macrobrachium hendersodayanum, Macrobrachium assamensispeninsularis and Macrobrachium lamarreilamarrei* from the Kumaun hills and tarai region of Uttarakhand was determined. Whereas, the *M. assamensispeninsularis* breed mainly from April to August, *M. hendersodayanum* is accomplished during February to May and *M. lamarreilamarrei* breed during May to Jul y. The breeding cycle is govern by some environmental factors like temperature, pH, water depth, turbidity, dissolved oxygen and carbon di-oxide etc.

Keywords: gonadosomatic index, matured prawn, breeding cycle

E-Mail: hcsbishtji@yahoo.com.

AQ-12

Evaluation of formulated microparticulate diets for larval rearing of golden mahseer *(Tor putitora)*

M. S. Akhtar, N.N. Pandey, Debajit Sarma and Santosh Kumar*
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

Live food organisms have been considered as the most suitable feed for successful rearing of fish in their early larval stages, but there are many problems inherent to it. Nutritionally complete, formulated diets are seen as attractive and valuable alternatives to live food. In this context, we evaluated microparticulate diets for successful rearing golden mahseer larvae. Twelve hundred golden mahseer larvae were randomly distributed in four treatment groups (100 larvae/tank) following a completely randomized design (CRD). The four treatment groups were: T-art– fed with *Artemia* nauplii; T-liv– fed with macerated goat liver; T-mpd0– fed with micro diet without exogenous digestive enzyme mix supplementation; T-mpd1– fed with micro diet with exogenous digestive enzyme mix level 1 supplementation and T-mpd2– fed with micro diet with exogenous digestive enzyme mix level 2 supplementation. There was significant ($p<0.05$) effect of different dietary regimes on the weight gain % of golden mahseer larvae among different groups. The highest weight gain % was observed in the T-art group fed with *Artemia* nauplii as reference diet followed by T-mpd1 group which was fed with micro diet with exogenous digestive enzyme level 1 supplementation. Growth % in T-mpd1 group was almost 80.4 % that of reference diet. The lowest weight gain % was evidenced in the group T-liv fed with macerated goat liver. The growth levels in T-mpd0 and T-mpd2 were similar but significantly lower than T-mpd1. There was no significant ($p>0.05$) effect of different dietary regimes on survival of golden mahseer larvae. However, the highest survival was seen in T-art followed by T-mpd1 and T-mpd2. The highest SGR % was observed in the T-art group fed with *Artemia nauplii* followed by T-mpd1 group which was fed with micro diet with exogenous digestive enzyme level 1 supplementation. The lowest SGR % was seen in the group T-liv fed with macerated goat liver. The SGR % in T-mpd0 and T-mpd2 were similar but significantly lower than T-mpd1. The overall results of the present trial demonstrate that the growth and survival of golden mahseer larvae is highest when fed with live feed i. e *Artemia* nauplii. However, the micro diet supplemented with exogenous dietary digestive enzyme mix (2.0 g/Kg diet) gives nearly comparable growth with similar survival. Hence, the micro diet supplemented with exogenous dietary digestive enzyme mix (2.0 g/Kg diet) is recommended for the exclusive feeding of golden mahseer larvae after 15 days of hatching.

Keywords: microparticulate diet, mahseer, T-liv, artemianauplii

***E-mail:** mdshahbazakhtar@gmail.com

AQ-13

In situ seed rearing of golden mahseer *(Tor putitora)* in floating cages at Bhimtal Lake

M. S. Akhtar, N.N. Pandey, Debajit Sarma, S. K. Mallik and R.S. Haldar*
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

Fishery enhancement in open water bodies like lakes and reservoirs etc are of important concern to increase fish productivity in these water bodies. However, protocols of stocking density for *in situ* seed rearing upto advanced fingerling stage for stocking in coldwater lakes and reservoirs are not in place. To optimize the *in situ* rearing

density of golden mahseerupto advanced fingerling stage for stock enhancement, fry of golden mahseer has been stocked in four stocking densities viz. 60 nos/m³, 70 nos/m³, 80 nos/m³ and 90 nos/m³. Periodic monitoring of growth and water quality parameters like temperature, alkalinity, free CO2, pH, TDS, phosphate, nitrate, ammonia, sulphate, dissolved oxygen; nitrite, pH, and alkalinity were done.The values of these water quality parameters during the rearing period were as : Temperature – 6.8 to 21.2 °C, pH – 8.0 to 8.8, DO- 5.2 to 8.4 mg/L, Free CO2 – 0 to 10 mg/L, Total Dissolved Solids – 95.0 to 97.2 mg/L, Nitrate – 2.6 to 5.0 mg/L, Ammonia – 0 to 0.07 mg/L, Phosphate – 0.07 to 1.0 mg/L, Total hardness – 86 to 120 mg/L, Sulphate – 12 to 16.6 mg/L and Total alkalinity – 84 to 94 mg/L. Periodic monitoring of growth has been done. At the end of the completion of the experiment, the weight of yearlings of mahseer were 10.1 ± 0.31, 9.84±0.42, 9.68±0.27 and 9.81±0.33 gram in all the density groups viz. 60nos/m³, 70nos/m³, 80nos/m³ and 90nos/m³ respectively. The growth performance showed that there is no significant ($p>0.05$) difference in weight gain% in all the stocking density groups which warrants further experimentation to standardize the optimum stocking density of golden mahseer. The survival percentages were 95.7, 96.1, 95.3 and 95.5 in all the density groups viz. 60nos/m³, 70nos/m³, 80nos/m³ and 90nos/m³ respectively.

Keywords: fingerling, *in situ*, alkalinity, golden mahseer

***E-mail:** mdshahbazakhtar@gmail.com

AQ-14

First report on induced breeding, mass seed production and conservation of snow trout *(Schizothorax niger)* in Kashmir Himalaya

A.M. Najar*, F.A. Bhat, M.H. Samoon and M.H. Balkhi
Faculty of Fisheries, Rangil, Ganderbal, SKUAST-K, 190 006.

This is the first report of induced breeding of any snow trout from Kashmir waters through use of any hormone preparation. Induced breeding was carried out successfully in *Schizothorax niger* with the application of synthetic hormone preparation – Ovatide. The male and female brooders were injected with calculated doses of ovatide at the rate 0.5 ml/kg body weight of female brooders and 0.3 ml /kg body weight of male brooders. The brooders responded well to the hormone preparation and spawned within the breeding pool. A good fertilization rate of 90% was achieved through artificial fertilization experiments of dry method (Greenburg 1960). Hatchability rate was around 65%. The juveniles were initially fed with skimmed milk powder and emulsified egg yolk of hen in the ratio of 1:1, supplemented later with live zooplankton comprising of *Daphnia, Keratela, Moina* etc. The fry were subsequently fed with formulated feed (having crude protein around 40%) at the rate of 10% body weight.

Keywords: Induced breeding, seed production, conservation, ovatide, Schizothorax niger

***E-mail:** dramnajar@gmail.co.in

AQ-15

Prospect of Koi carp breeding *(Cyprinus carpio)* and culture at mid-altitudinal Himalayan region

R.S. Patiyal, Vijay Singh and N.N. Pandey
Directorate of Coldwater Fisheries Research, Bhimtal -263136

Mid-altidunial Himalayan region is characterized by undulating landscape, low temperature and poor infrastructure. It has good water resources in the form of rivers, drainage, lakes, streams etc. which is inhabited by more than 200 fish species. In spite of all this the fish production in this area is very poor mainly because of the slow growth and long maturity period. In the present study we explore the possibility of ornamental fish culture as an alternative method for economic benefit to the people. The growth and the breeding of koi carp was experimented in DCFR's farm for this purpose. The koi carp of average length 155mm and average weight 125gm were procured from local ornamental fish market in the month of November and were reared in polythene lining tanks for five months. Within a rearing period of five months the fishes attained the average length of 200 mm and average weight of 160gm and attained maturity. Matured healthy koi carp brooders (160-250 g), at the ratio of 2:1 were selected for breeding experiments they were acclimatized in the plastic trough1mx1mx0.5 for 3 hour. The water temperature varying between 10°C to 14° C Dissolved oxygen and pH observed during the study were 6.8 ml/l and the pH is fluctuated from 7.2 to 7.4. Mature female brooder were injected by OvaprimSynchromate B, GnRh regulator at caudal-peduncle at the dose of 0.6 mL/kg body weight and 0.3ml/kg body to the male fish and released to the plastic trough. Continuous aeration and showering of water was maintained. Spawning period was observed after 10 hrs after the administration of the ovaprim injection at ambient temperature (12°C-13°C) and water temperature 9°C-10°C.The fertilized eggs with diameter ranging between 0.9mm and 1.10 mm. the ing the adhesive eggs. Spawning period was observed 10 hrs after the administration of the ovaprim injection at ambient temperature (12°C -13°C) and water temperature 9°C- 10°C.The fertilized eggs were found adhesive and transparent with diameter ranging between 0.9 mm and 1.10 mm by quantitative estimate since the eggs has been sporadically scattered and seen all through the trough. The hatching of eggs took place after 120 hrs. The fry were reared successfully for one month with a survival rate of 30%. The same stocks were ready for breeding again in the month of July of the same rearing year this give a indication of multiple breeding occurred at the mid-altitudinal Himalayan region. The fry rearing was also standardized. The success of koi carp breeding and rearing will open a new avenue for income generation for the farmer which has a better price.

Keywords: koi carp, Ovaprim, multiple breeding

E-mail: rsp01@sife.co

AQ-16

Impact of increasing temperature and draught like condition on Coldwater aquaculture practice

N.N. Pandey, Prem Kumar, R.S. Haldar and Santosh Kumar
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

Trout requires cool clean and continuous flowing water in enough quantity. The draught condition and changing climate decreasing the trout production potential and the trout cultivation line is gradually shifting towards the higher elevation. At Experimental Fish farm, Champawat (Uttarakhand) sufficient quantity of stream water was available, but marked water shortage was noticed at the farm during 2008-10. Presently, average annual water availability to the farm was estimated 3.75 lps, while the availability during lean period remains <1 lps. The inadequate water supply directly limits the production cycle of the trout and often causes fungal and bacterial infection to the fish stock, which leads to diseases and mass mortality.The breeding season is directly correlated to the water temperature. At trout farm, Uttaray (Sikkim) temperature remains in higher side and trout perform the breeding during last week of Nov. In Himachal, trout performs breeding earlier than the J&K due the slightly higher thermal regime. In Uttarakhand, there is a difference of 1-3.2 ^{0}C at Champawat and State trout farm Bairangna (Chamoli). Similarly, trout performs the breeding in the first week of January at Champawat, while during the 3rd week at Bairangna. Generally, male rainbow trout attain maturity after 2nd year and female after completion of 3rd year. For the first time, rainbow trout brooders of the age of 2+ years, weighing 200-250g were found

fully matured for the breeding at State trout farm, Bairangna and DCFR farm, Champawat might be due to the comparatively higher temperature, which was 2-3.5 OC in higher side than the previous year. On the other hands, in case of *L. dyocheilus*, two weeks earlier maturity in captivity was observed than the previous year, might be due to the high temperature, which was 2-3.0 OC in higher side. These incidences indicate towards the impact of increasing temperature on breeding season and onset of gonadal maturity in Coldwater fishes. The unspawned trout stock is required less temperature for the complete absorption of the eggs of last breeding cycle. During 2010, It was observed that there was not complete egg absorption in unspawned females of the breeding activities even upto last of the Dec. months of 2011(Temp-6-24°C). However, new eggs were partially developed and both types of eggs were released by the female at the time of spawning. These eggs were not viable. This situation was also observed during the year 2012(Temp-6-26°C).

Keywords: trout production, thermal regime, gonadal maturity, unspawned trout stock.

E-mail: nityanfish@yahoo.co.in

AQ-17

Impact of poultry birds integration on water quality characteristics of fish ponds in coldwater conditions

U.P.Singh[1], N.N.Pandey[2], H.C.S Bisht[1]
[1]Department of Zoology, Kumaon University, Nainital-263001, Uttarakhand
[2]Directorate of Coldwater Fisheries Research, Bhimtal-263136, Nainital, Uttarakhand

An attempt has been made to assess the impact of poultry integration on water quality of the fish ponds of different farmers of the Champawat district of Uttarakhand state. Experiment was conducted for different three fish stocking densities (2.5, 3.0, 4.0 fish/m^3) and two integration level of the poultry birds (10 and 20 chicks/100m^2) in double replication. Chemical properties of pond soil directly influenced the water quality of the pond. A decreasing trend in soil pH, increased organic carbon, nitrogen and phosphorus was found in integrated ponds. .All parameters of physico chemical properties of the water in integrated ponds were found in permit tablelimits indicates the feasibility of higher stocking of fish and higher level of poultry bird's integration in coldwater conditions without any adverse effect on water quality. This might be due to the cool, clean and well oxygenated water of the hilly region.

Keywords: poultry integration, water quality, stocking densities, Coldwater conditions, hilly region.

E-mail: upendrapsingh@yahoo.com

AQ-18

Nutritional requirement and grow out feed for Rainbow trout

N.N.Pandey, S.K.Srivastava, S.K. Gupta, M.S Akhtar and Santosh Kumar
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

Feeds were formulated with different levels of protein and lipid using fish meal, roasted soybean flour, GOC, wheat flour, Starch, fish oil, brewer's yeast powder, linseed oil cake, dried milk and Vit.& min. mixture. These diets were tested in field condition for the fry, fingerlings and yearlings of the rainbow trout. Data on growth performance

and nutritional value revealed that 50% protein and 14 % lipid for starter feed, 45% protein and 16 % lipid for fingerlings feed and 35% protein and 14 % lipid for growout feed is required for proper growth. Solvent extracted soybean meal (SESM) contain 48% protein and has best amino acid profile and is highly palatable, digestible to trout (Digestion coefficient 80%). It also contain Arginine (3.91% of dry basis), an important amino acid for the trout. 40% fish meal can be replaced by SESM without impairing feed intake, growth and FCR. Protein utilization of the trout diet may be improved by adding papain in the diet of the trout. Turmeric powder as anti-biotic, asafetida as appetizer for improving feed intake and Ashwagandha *(Withania somnifera)* as anti-stress may be incorporated in the trout diet in little proportion for better feed performance. Production of unwanted ammonia in trout rearing water may be reduced by reducing protein content in the diet. DCFR trout growout feed is environmentally friendly, cost effective, nutritious diet for trout with 35% protein and good FCR- 1.26.

Keywords: rainbow trout, protein, fish meal, fry, fingerlings, growout feed

E-mail: nityanfish@yahoo.co.in

AQ-19

Seed production of snow-trout *(Schizothorax richardsonii)* by stripping method

[1]R.S. Chalal, U.P. Singh, [2]N.N. Pandey and [2]Prem Kumar
[1]G. B. Pant University of Agriculture and Technology, Pantnagar – 263 145, (Udham Singh Nagar), India
[2]Directorate of Coldwater Fisheries Reaserch, Bhimtal

Study on breeding operation of snow-trout, *(Schizothorax richardsonii)*, by dry stripping method was conducted during the period of July - November 2008. Healthy brooders of the age of 2-3 years were collected from river stream having the average body weight of 175 ± 5 gm& 62 ± 5 gm for female & male, respectively and successfully bred from 30th August to 3rd November at water temperature of 12.4 -18.5^{0}C . Males were always ripe during the entire study while females were matured during 15th September to 5th October in normal condition. The general breeding season (15 September - 5 October) was extended by early maturity of female with slight dose of P.G.E. @ 1-2 mg/kg body weight and late maturity of females in poly house covered tank by raising 2ºC temperatures during the breeding season. The G.S.I. was observed 1.2 - 14.3 with fecundity in the range of 10520 - 24124 eggs/ kg body weight. In the present study, fertilization rate 40 - 70%, hatching rate 67- 81%, incubation period 255 - 270 hours and survival rate 55% were observed at most suitable breeding temperature of 14 - 18^{0}C. The water quality of hatchery, nursery and brood stock pond was monitored with optimum range of temperature 8.0 - 19.3^{0}C, pH 7.8 - 8.7, DO 7.0 - 9.4 mg/l, free CO2 1.4 - 2.0 mg/l and total alkalinity 20-24 mg/l with water flow rate of 0.5 - 1.0 l/m in hatchery, 2-3 l/m in nursery and 10-30 l/m for brood stock tanks.

Keywords: stripping, P.G.E, G.S.I., fecundity, survival rate.

E-mail: rameshchala@gmail.com

AQ-20

Recovery of carp's fingerlings from different types of ponds in mid hills conditions of Kumaon region in Uttarakhand

N.N. Pandey and Prem Kumar
Directorate of Coldwater Fisheries Research
Bhimtal, Uttarakhand (India)

Rearing trials were conducted in two types of nursery ponds viz. cemented tank and poly tank having size of 40m^2 with an average depth of 0.75 m with two different stocking densities of fry (1.0 million/ hectare and 2.0 million/ hectare) in triple replication in Lower belt of Central Kumaon Himalayas at an altitude of 1550 msl. Experiment was conducted for Silver carp, Grass carp and Common carp (6 months) fry rearing up to advanced fingerling stage during 2008-09. All ponds were limed @ 1.2 kg/40 m^2 and manured with 7 days old soaked diluted mixture of raw cow dung, mustard oil cake and lime (7:1;1) @ 4.5 kg/40 m^2 on monthly basis. Over liming resulted in eye protrusion and increase in favourable water pH and ultimately fungal infection. Manuring with soaked mixture resulted in optimum water pH and production of dense population of natural food, plankton (1.5-2.2ml/50 lit. pond water). After field trial, it was found that 1 million stocking density is optimum for better survival, growth and recovery of fingerlings from rearing ponds in coldwater conditions. Poly tanks are more suitable for rearing of carp fingerlings with better survival and growth due to the advantage of higher temperature and abundance of plankton.

Keywords: Poly tank, raw cow dung, stocking density, fingerlings.

E-mail: nityanfish@yahoo.co.in

AQ-21

Comparative study of polyculture of exotic carp in polytanks and earthen ponds of the mid altitudinal area of Uttarakhand

N.N. Pandey, Prem Kumar and Santosh Kumar
Directorate of Coldwater Fisheries Research, Field Centre
Champawat, Uttarakhand (India)

An on farm study was conducted for the growth evaluation of the exotic carp in polytanks and earthen ponds in farmer's fields at Doonagiri area of the district Almora of Uttarakhand State. Three earthen ponds and nine polytanks of different 3 types (lined with polyfilm, sand bed in bottom, sand layer in slops and bottom) were selected for the study. Fish seed (Fry) of three exotic carps; Silver carp *(Hypophthalmichthys molitrix)*, Grass carp *(Ctenopharyngodon idella)* and Common carp *(Cyprinus carpio)* was stocked in 3 fish/m3 density with 30:40:30 species ratio, respectively during the month of June, 2011. The growth of these carp in 12 months was found 40% better in polytanks with highest growth and production in polytanks with bottom sand bed. This is due to the advantage of comparatively higher water temperature in the polytanks. Low temperature and the sharp diurnal fluctuation inside the earthen were experienced as major factor of the slow growth of carps in cold climate of the hills. The availability of the natural fish food organisms, plankton and periphyton is better in the polytanks due to the higher temperature. The qualitative and quantitative analysis of plankton community in polytanks was carried out and 11 phytoplankton and 5 species of zooplankton were recorded. The total plankton volume varied from 1.6-3.2 ml/50 lit. in different experimental ponds. Maximum diversity of the plankton was observed in polytanks with comparatively higher population.

Keywords: exotic carp, polytanks, plankton, stocking density

E-mail: nityanfish@yahoo.co.in

AQ-22

Use of Papain and Ashwagandha *(Withania somnifera)* in Aqua-feed for better growth performance of Common carp *(Cyprinus carpio)*

Jimmy Mize[1], Avdhesh Kumar[1] and N. N. Pandey[2]
[1]G. B. Pant university of agriculture and technology, pantnagar – 263 145, (Udham Singh Nagar), India
[2]Directorate of Coldwater Fisheries Reaserch,Bhimtal, Uttarakhand

The study reveals that Papain being a plant based digestive enzyme has paramount importance to enhance the growth performance in a natural way and the addition of medicinal herbs like Ashwagandha can give result that are superior to the results obtained using enzymes alone. Better feed preparation procedure has to be developed for use of plant products like soybean which contains anti-nutritional factors which if inactivated without deteriorating the protein quality will have even better results. On the Basis of experimental results it can be concluded that feed supplemented with 2% Papain + 2% Ashwagandha resulted in better growth rate, better FCR values, better PER value and high Apparent Protein Digestibility as compared to results obtained from control as well as from treatment containing only @ 2% Papain enzyme. All the physico- chemical parameters of water were in the optimum range for fish culture practices which proved Papain and Ashwagandha to be an eco-friendly growth promoting agent. The study can further be extended for endemic *Schizothorax* sp. and other cold water species.

Keywords: Papain, Ashwagandha, FCR, endemic

E-mail: nityanfish@yahoo.co.in

AQ-23

Plankton biomass in integrated Poultry-Cum- Fish culture ponds of Kumaon hills

U.P. Singh[1], H.C.S Bisht[1] and N.N. Pandey[2]
[1]Department of Zoology, Kumaon University, Nainital-263001, Uttarakhand
[2]Directorate of Coldwater Fisheries Research, Bhimtal-263136, Nainital, Uttarakhand

Study was conducted in ponds having polyculture of exotic carps with or without integration of poultry in Champawat district of Uttarakhand. A total 14 genera of phytoplankton were recorded in integrated ponds including 6 genera of chlorophyceae, 3 genera of bacillariophyceae, 3 genera of cynophyceae, 1 genera of euglenophyceae and one genera of dinophyceae. In non- integrated ponds, a total of 17 genera of phytoplankton were recorded including 7 genera of chlorophyceae, 4 genera of bacillariophyceae, 3 genera of cynophyceae, 2 genera of euglenophyceae and one genera of dinophyceae), maximum numbers was observed for green algae (51.5-54% in non integrated and 50.5-60.8% in integrated ponds)) followed by diatoms (17.0-20.5% in non integrated and 20.7-31.5% in integrated ponds). Total zooplankton density varied from 106-289 nos./L., 139-432 nos./L and 132-442 nos./ L in ponds of without integration, integration with 10 chicks and integration with 20 chicks, respectively. Highest density was observed in the month of November. A total of 7 species of zooplankton were observed with abundance of rotifers in non integrated ponds, while only 6 species were seen in the integrated ponds. Rotifers were more dominant (54- 61.5% in non integrated ponds and 46.5-51.55% in integrated ponds) in total composition of zooplankton population of control pond.

Keywords: phytoplankton, integration, zooplankton

E-mail: upendrapsingh@yahoo.com

AQ-24

Effect of probiotic and protease supplement diet on growth in fingerlings of *Labeo rohita* (Hamilton)

Akansha Bisht
College of Fisheries, G.B.P.U.A&T Pantnagar
(Uttarakhand)

A feeding trial of 90 days was conducted to examine the effect of probiotics and proteolytic supplement diet on weight gain and growth performance of *Labeo rohita* fingerlings. Intestinal bacteria were isolated from healthy fingerlings and *Bacillus subtilis* was selected as probiotic bacteria. Three isocaloric and isonitrogenous diets (D1, D2 and D3) were prepared containing 30±.6% crude protein, 4.8±2% crude fat and 11.6±0.2%. Experimental diets D2 and D3 were supplemented with probiotics at the rate of 4×10^8 cells per 100 gram of feed and Diet D3 was also supplemented with Papain at the rate of 10g/Kg along with same level of probiotics as in diet D2. Feeding was done at the rate of 5% twice a day. Rearing of fingerlings on diet D3 resulted in better growth of *Labeo rohita* fingerlings compared to those with the experimental diet D2 followed by control diet D1. Comparison of growth performance was done on basis of specific growth rate, condition factor, length weight relationship and RNA: DNA Ratio.

Keywords: probiotics, *Labeo rohita*, Bacillus subtilis RNA: DNA Ratio

E-mail: mushkaan_bisht@yahoo.com

AQ-25

Effect of formulated Feed on growth and development of fresh water prawn *Macrobrachium assamensis peninsularis* (Tiwari)

Mamta Joshi, H.C.S Bisht
Department of Zoology, Kumaon University
Nainital-263001, Uttarakhand

The present paper deals with the effect of forrmulated diet (D0, D1, D2, D3) on the fresh water prawn *Macrobrachium assamensis peninsularis* (Tiwari). The feeding was inducted twice a day. The stocked animal were fed with control diet (D0) and three experimental diet D1-D3 having same level of dietery protein with different ingredients composition. The omnivorous prawn shows the best performance to the diet D3. The test group of prawn fed with diet D3 having soybean meal and fishmeal as protein source showed best growth. This may be due to better profile of amino acids and efficient use of dietary protein. The incorporation of soybean meal with fishmeal improves the amino acid profile as well as lower the feed cost. In the present investigation it has been reflected that soybean meal and fishmeal combination is a better protein supplement ingredient in the diet of coldwater prawn. It has been also experience that the required dietary protein level of this species is in the range of 40 - 50 %.

Keywords: formulated diet, fresh water prawn, omnivorous, fishmeal

E-mail: amitisha2006@yahoo.com

AQ-26

Polyculture of Exotic carps in mid hills conditions with relative importance of stocking density and species combination

K.S. Mehta[1], H.C.S Bisht[1] and V.K. Singh[2]
[1]Department of Zoology, Kumaon University, Nainital, Uttarakhand(India
[2]Krishi Vigyan Kendra, Lohaghat. District- Champawat, Uttarakhand (India).

An attempt has been made to evaluate the production performance of different 3 exotic carp species (silver carp, grass carp and common carp) under polyculture system of carps in different 3 combinations (silver carp, grass carp and common carp 40:30:30, 30:40:30 and 30:30:40) and with 2 density (3 and 5 Fish/m^3). In control, the density was 10 Fish/ m3with combination of 25:25:50 of silver carp, grass carp and common carp, respectively. In present study, 3 combinations of exotic fish species in two stocking densities were tested in on farm trial. Results were compared with the control having the stocking rate and species combination in accordance of existing practice i.e 25:25:50 for silver carp, grass carp and common carp, respectively in the density of 10fish/m^3. Over all better growth of all tested 3 exotic fish species was observed in the low stocking density i.e. 3 fish/m^3.The net production was 12.6% higher with stocking density of 3fish/m3. The best combination of species i.e 30:40:30 was 45.6% better over the control in terms of growth and production. In cold water conditions of mid hills, the growth of exotic carps in 10 months was recorded in the range of 200-310g with stocking density of 3fish/m^3. The maximum growth was recorded for grass carp followed by common carp and silver carp.

Keywords: exotic carp, stocking density, common carp, silver carp

E-mail: kishore_mehta26@yahoo.com

AQ-27

Successful induced breeding of indigenous minor carp, *Labeo dyocheilus* in captivity under coldwater conditions by using synthetic hormone ovaprim (GnRH- domperidone)

Monika Gupta[1], N.N.Pandey[2], V.K.Tiwari[1] and Raghvendra Singh[1]*
[1]Central Institute of Fisheries Education, Yari road, Versova, Andheri West-400016, Mumbai
[2]Directorate of Coldwater Fisheries Research (ICAR), Bhimtal-263 136, Nainital, Uttarakhand, India

In the Kumaon Himalayan region, *L. dyocheilus* locally called Kali, one of the most economically important cold water fish has been categorized as threatened and vulnerable. Induced breeding was conducted by using different doses of the synthetic hormone ovaprim (GnRH-domperidone) through intra muscular rout. Male and female brooders at a ratio of 2:1were injected once and left to spawn in FRP tank. Eggs were incubated in trays placing in trough having flowing water. It was observed that all females released viable eggs after 14-16 hrs of the hormone injection. The statistical analysis showed significant ($P \leq 0.05$) effect of hormone doses on spawning rates, fecundity and hatching rate. The present experiment suggests that Hormone dose of 0.6 ml kg^{-1} body weight for females and 0.3 ml kg^{-1} body weight for males was found optimum for spawning with 84-98% fertilization and high rate of hatching (65-80%) and can be considered optimal for seed production of the *L. dyocheilus* held in captivity and can therefore be also be utilized for stock augmentation in wild.

Keywords: *L. dyocheilus*, Ovaprim, captivity

***E mail:** monika_gupta22@yahoo.com

AQ-28

Successful induced spawning of indigenous carp, *Labeo dero* in captivity under Coldwater conditions

N.N. Pandey, R.S. Haldar, S. Ali and Monika Gupta
Directorate of Coldwater Fisheries Research (ICAR)
Bhimtal-263 136, Nainital, Uttarakhand, India

Labeo dero is a commercially important cold water fish which needs immediate attention due to its reduced abundances in Kumaon Himalayan region. The fish was bred successfully in captive condition by using different doses of the synthetic hormone ovaprim (GnRH-domperidone). Male and female brooders at a ratio of 2:1were injected once and left to spawn in FRP tank. The present experiment suggests that Hormone dose of 0.6 ml kg-1 body weight for females and 0.3 ml kg-1body weight for males was found optimum for spawning. Eggs were incubated in trays placing in trough having flowing water. Fertilization percentage of eggs ranged from 80 to 85. Incubation period varied between 14-19h and the percentage of hatching was 75-80. Yolk-sac absorption in larvae was complete in 4+ days after hatching. The spawn was stocked in FRP tanks and on an average, 80% survival was recorded after 15 days of rearing when they attained an average length of 2.5 cm and weight of 0.18 g. Successful seed production of this species can be considered for restore its population in wild and species diversification in cold water aquaculture.

Keywords: *Labeo dero*, ovaprim, species diversification

E-mail: nityanfish@yahoo.co.in

AQ-29

Monoculture of grass carp in the Pithoragarh district

R.S. Chalal
Department of Fisheries
Vikas Bhawan, Pithoragarh, Uttarakhand

An on farm testing was carried out in the cemented tanks of the 6 farmers having the average size of 100m^2. The healthy fingerlings of grass carp of the size 2.5-3 inch were stocked at the density of 3fish/m^3. The same sized seed of the 3 exotic carps (silver carp, grass carp, common carp) were stocked in the 6 control ponds having almost same size. The species ratio was 30:40:30, respectively. In a 12 months rearing period, 1.5 kg/m^3 grass carp was harvested from the monoculture practice, while it was only 1.2 kg/m^3 in the polyculture practice. Better production was achieved due to the terrestrial grass feeding and conducive water temperature (18-28^{0}C) in monoculture ponds. The study reveals that the grass carp is the best candidate species for the mid altitudinal area of hill for the aquaculture purpose.

Keywords: on farm, fingerlings, monoculture

E-mail: rameshchalal@gmail.com

AQ-30

Polytanks are Better Option for Integrated Fish culture in Mid Hills

Prem Kumar[1], N.N. Pandey[1], P.K. Agrawal[2] and P.C. Mahanta[1]
[1]Directorate of Coldwater Fisheries Research, Bhimtal-263 136
[2]Vivekanand Parvatiya Krishi Anusandhan Sansthan, Almora

The study area; Champawat district of Uttarakhand suffers from the paradoxical situation of being classed as both 'high potential' and a 'water scarcity'. The area is seen as dry in summer months because the unimodal rainfall pattern limits water availability in tributaries & rivulets. The region faces marked water shortage during the summer. This is a paradox based on the description of the physical environment of the area. Nonetheless, there is no comprehensive package of water management options that can be taken up immediately. Therefore, there was a need to undertake multidisciplinary research which will involve water conservation using suitable culture model. On farm trial was conducted in Polytank in triple replication at farmers fields of Champawat district of Kumaon region of Uttarakhand, located at 80° 10' E longitude, 29° 60' N Latitude and an altitude of 1750 m. above the mean sea level. The soil of this site is moderately fertile having pH ranging 6.5-7.5. The experiment was conducted during under polyculture system with three exotic carps. A combination of three exotic species such as Silver carp, Grass Carp and Common Carp were stocked at a rate of 2-3 fingerlings/m^3 and were fed with artificial feed (a combination of rice polish/wheat polish and mustard oil cake) at the rate of @ 2-3% of body weight.

In this study, water temperature was observed 2-6 °C higher than that of the cemented/ conventional earthen ponds since poly lining conserved the heat energy gain by the water from the sun light by acting as an insulator between water and earth. In upland region where temperate climate is prevailing, the conserved heat energy favors in performing normal physiological activities of the fishes. As mention earlier, the conserved temperature helps in regulating the fish physiological activities resulting in more growth of fish compare to conventional tanks. Moreover, because of this property of Polytank to conserved heat of the water in it, increase the rearing period of fish thereby giving longer growing period to the culture fishes to 9 months compare to 7 months period in cemented or conventional earthen ponds. This method obtained a significant increase in fish yield ranging 0.3 kg - 0.7 kg/ m3 of water in comparison to previous record of 0.12-0.36 kg fish /m^2 area in cemented and earthen ponds. The main reason for higher production of fish yield in Polytank was because of its heat conserving nature which was not happen in cemented/ conventional earthen ponds.

Key word: Polytank, integrated fish farming

E-mail: prem_nrc@rediffmail.com

AQ-31

Studies on the effect of dietary zinc on growth, survival and physiological response of *Tor putitora* fry

Kaustubh Bhagawati[2], Debajit Sarma[1], M.S. Akhtar[1], N.K. Chadha[2], P. B.Sawant[2] and P. Das[1]
[1]Directorate of Coldwater Fisheries Research, ICAR, Bhimtal-263136
[2]Central Institute of Fisheries Education, ICAR, Mumbai- 400061

The golden mahseer is the king of game fish which population has been declining in recent times due to various natural and anthropogenic factors. Therefore, the population needs to be enhanced through *ex situ* conservation. The breeding technology of golden mahseer has been standardized and documented. However the successful seed rearing is still a challenging task in relation to supplemental nutrition for the better growth and survival. Keeping

this in mind, the proposed work on 'studies on the effect of dietary zinc on growth, survival and physiological response of *Tor putitora* fry' was carried out to evaluate the efficacy of dietary zinc for maximizing the growth and survival of *T. putitora* during early developmental period. It is found from the experiment that different levels of proteins with incorporation of dietary zinc have had positive impact on the growth and survival during early stages of development of *Tor putitora*. The study embodied in up-scaling the protocol of artificial propagation of this species through maximizing the growth and survival.

Keywords: golden mahseer, anthropogenic, artificial propagation

E-mail: kaustabh.bhagawati@gmail.com

BH-1

Effect of environmental temperature on some immune related gene expressions in the Indian major carp, catla *(Catla catla)*

Mrinal Samanta[1], Madhubanti Basu[1], Samar Pal Singh[2], Rina Chakraborty[2] and Pallipuram Jayasankar[1]
[1]Fish Health Management Division, Central Institute of Freshwater Aquaculture (CIFA)
Kausalyaganga, Bhubaneswar, Odisha-751002
[2]Department of Zoology, University of Delhi, Delhi- 110007

The health status of fish is uniquely influenced by their immediate surroundings and water temperature is considered as an important factor that plays a significant role in their immunity against diseases. Fish primarily depends upon innate immunity, and under thermal stress, the innate immune system is likely to be down-regulated enabling various opportunistic pathogens to cause diseases. However, no studies yet describe the effect of thermal stress in immune related gene expression in any freshwater fish species. We studied this in catla *(Catla catla)*, a freshwater fish species of prime commercial importance. Catla fry (0.676 ± 0.026 g) were acclimatized at 25°C for 21 days and after that they were exposed to 10, 15, 20, 25, 30 and 35°C for 12 h and 7 days. Various organs and tissues were collected, and real-time quantitative PCR (q-RT-PCR) was applied to analyze lysozyme G, TLR2, TLR5, NOD1 and NOD2 gene expression at designated temperature for their effects of immediate and chronic thermal stress respectively. The data of qRT-PCR revealed significant ($p < 0.05$) up-regulation of TLR2, NOD1 and NOD2 genes in majority of the tissues, whereas lysozyme G and TLR5 showed tissue specific modulation during cold and heat shock. This is the first study to show the effect of temperature in modulating the innate immune genes expression in fish, and is likely to be important in evolving strategies to prevent diseases during heat and cold stress.

Key words: Thermal stress, immune genes, catla

E- mail: msamanta1969@yahoo.com

BH-2

Studies on the status of lipids, lipid peroxides and antioxidants with dietary supplementation of water-soluble chitosan during aging in young and adult rats

T.K. Thankappan, B. Ganesan and A.A. Zainudheen
Central Institute of Fisheries Technology
Matsyapuri P.O., Cochin - 682 029, Kerala, India

Aging is a post-maturational process with progressive decrease in physiological capacity and the reduced ability to respond to stress leading to increased susceptibility and vulnerability to diseases. Advancement of age increases the risks related to various pathological conditions associated with cholesterol. In the present study the beneficial properties of dietary supplementation of water- soluble chitosan at 2% and 4% level in young and adult rats is envisaged.In aged animals total cholesterol, triglycerides, phospholipids, free fatty acids and lipid peroxidation were considerably high whereas antioxidants, superoxide dismutase, catalase, glutathione peroxidase and glutathione were low in the liver tissue. Dietary supplementation of water soluble chitosan reverted these age-associated differences to the status comparable to young rats. The results of this study conclude that dietary supplementation of water- soluble chitosan can improve liver function during aging and minimize the age- related disorders.

Key words: Aging, lipids, lipid peroxidation, anti-oxidants. water-soluble chitosan

E-mail: tkthankappan@rediffmail.com

BH-3

Biochemical and sensory evaluation of Rainbow Trout *(Oncorhynchus mykiss Walbaum)* in chilled and frozen storage conditions

George Ninan, A.A. Zynudheen, K.V. Lalitha, C.N. Ravishankar and T.K. Srinivasa Gopal
Central Institute of Fisheries Technology (ICAR), Kochi -682 029, Kerala, India

This paper discusses the results of biochemical and sensory evaluation of chill and frozen stored rainbow trout (*Oncorhynchus mykiss* Walbaum). In this study the peroxide value showed fluctuations during the chilled storage, but the values were very low to cause rancidity or off flavour at any point of time during the study. Thiobarbituric acid values for whole ungutted trout samples remained low but increased steadily and reached a value of 14.1 µg MA/g on 9th day of chilled storage. Significant increase in TVBN values ($p < 0.05$) was observed from the 9th day and reached 31.25 mg N 100g^{-1} by the 14th day of chilled storage. During frozen storage at -20 0 C, peroxide values were relatively low and stable till 8 months after which there was significant increase reaching 6.89meq O_2 / Kg of oil. Free fatty acids showed the same pattern in frozen storage.Significant increase in pH was observed by the 10th month of frozen storage which corresponded to the spoilage of samples.Sensory evaluation indicated that the fish samples were spoiled after 14th day in chilled storage and the frozen samples were fit for consumption upto 10 months after which they were considered to be spoilt.

Keywords: Rainbow trout, chilled storage, frozen storage, Peroxide value, Total volatile nitrogen bases, sensory evaluation

BH-4

Hygienic handling and value addition options for rainbow trout (*Oncorhynchus mykiss* Walbaum)

George Ninan, A.A. Zynudheen, P.K. Vijayan, C.N. Ravishankar and T.K. Srinivasa Gopal
Central Institute of Fisheries Technology (ICAR), Kochi -682 029, Kerala, India

This study deals with the hygienic handling and processing of rainbow trout for better utilisation and value realisation. The methods for the preparation and process yield of various value added products viz., smoked trout, smoked & canned trout steaks, coated fillets are discussed in detail. Whole farmed rainbow trout stored in ice in chilled conditions can retain its saleable quality upto 14 days. The fish remained in excellent condition upto six days and can retain high quality upto nine days. Vacuum packed smoked trout had a shelf life of 4 weeks in chilled conditions compared to air packed samples which retained the quality upto one week. Coated trout fillets retained good sensory qualities for twelve months in frozen storage at -20^0 C. Smoked and canned trout steaks had good texture and flavour. This product had a salt content of 2.61% and the pH of the meat was 6.02.

Keywords: Rainbow trout, handling, process yield, value added products, chilled trout, smoked trout, canned trout steaks, coated trout fillets

BH-5

Quality evaluation of rainbow trout (*Oncorhynchus mykiss* (Walbaum, 1792) in chilled storage

George Ninan, K.V. Lalitha, T.V. Sankar, A.A. Zynudheen,C.N. Ravishankar and T.K. Srinivasa Gopal
Central Institute of Fisheries Technology (ICAR), Kochi -682 029, Kerala, India

The shelf life and quality of farmed rainbow trout from India (*O .mykiss*) stored in ice and kept at chilled conditions ($0-2^0$ C) was evaluated based on chemical (Thiobarbituric acid (TBA), Total Volatile Base Nitrogen (TVBN), Peroxide Value (PV) , Free Fatty Acid (FFA), & pH) microbiological (Total viable aerobic bacterial count (TVC) Enterobacteriaceae& Coliform count) and sensory methods. Oxidative rancidity indices viz., PV and TBA were found to be poor indicators of quality. A two log reduction ($P< 0.05$) was noticed in the Enterobacteriaceae count the end of storage on day 15 while there was an increase in TVC over the same period (10^7cfu g^{-1}). The faecal coliforms and *E. coli* population in trout decreased during ice storage The TVB-N content ranged from 14.53 to 31.32 mg TVB -N/100 g flesh for whole trout samples, during the 15 day period of storage in ice. Significant reduction in NPN value was observed by the end of chill storage period, indicating the loss of flavour as well as commencement of spoilage of the samples. There was a sharp decline in protein extractability by the end of chill storage. The study shows that whole ungutted rainbow trout stored in chilled conditions can retain its saleable quality upto 14 days. The fish will be in excellent condition upto six days and can retain high quality upto nine days. Detailed sensory evaluation is the effective and practical method to assess the freshness of chill stored whole ungutted rainbow trout.

Key words: Shelf life, Quality, Rainbow trout, chilled storage, sensory evaluation

BH-6

Molecular Characterisation of Toll like Receptor-3(TLR-3) in snow trout *Schizothorax richardsonii*

Kiran Belwal, Anand Kumar B.S, Dimpal Thakuria and Amit Pande
Directorate of Coldwater Fisheries Research
Bhimtal (Nainital) 263136, Uttarakhand

Toll-Like Receptors (TLRs) are evolutionarily conserved, type-I transmembrane receptors. They are responsible for initiating and directing immune responses to pathogens including viruses, bacteria, fungi and protozoans. They also control activation of adaptive immune response. Seventeen distinct TLRs have been identified in teleosts, of which, a few are direct structural orthologs of mammalian TLRs and some are characterized as fish specific TLRs. In fish, as the adaptive immune system is poorly developed, identification and molecular characterization of innate immune receptors like TLRs will unravel their role in inherent resistance to diseases in snow trout *Schizothorax richardsonii*. Thus, characterization of TLRs and its agonists in snow trout will reveal how it has evolved unique ways to counter the pressures posed by pathogenic microbes. To begin with, an attempt was made to characterize TLR 3 of snow trout, as in mammals it is known to recognise ds RNA, a molecular pattern, that is produced by most viruses at some stage of their replication. TLR3 recognizes dsRNA, induces the production of type I interferons. Total RNA from kidney tissue of the fish was extracted and used for the preparation of cDNA using oligo-dT primer. This cDNA was used for the amplification of a 500bp fragment within the TLR 3 mRNA, cloned in to pTZ57R/T vector and sequenced. Analysis of the nucleotide sequence of the amplicon revealed 95% identity with the TLR 3 of common carp.

Key words: Receptors, pathogens, snow trout, nucleotide sequence

BH-7

Molecular cloning and characterization of important antimicrobial peptide genes of golden mahseer *(Tor putitora)*

Preeti Chaturvedi, Dimpal Thakuria and Amit Pande
Central Institute of Fisheries Technology (ICAR)
Kochi -682 029, Kerala, India

Aquaculture industries worldwide have a significant problem of fish losses. One of the reasons is attributed to infectious diseases that are caused by several pathogens. Fish have restricted antibody repertoire, affinity maturation, memory and slow proliferation of lymphocytes due to their poikilothermic nature and evolutionary status. The adaptive immune response is therefore quite slow and less developed as compared with innate immune response which is fast and temperature independent. Innate immune system in fish is therefore of vital importance in combating diseases. Antimicrobial peptides (AMPs), an important component of innate immune system, are effector molecules and and have quick response time. They have the ability to function without either high specificity or memory and have been identified in all living organisms like insects, plants animals and humans. They have broad spectrum antimicrobial activity therefore active against bacteria, viruses, fungi, yeast and protozoa. Increased use of antibiotics against infectious pathogens has lead to the development of antibiotic resistance in pathogens. Controlling multiple drug resistant pathogens is a big challenge in medicine therefore the use of antibiotics is restricted in the control of fish pathogens. It is known that the antibiotic resistant pathogens limit profitability from aquaculture worldwide. AMPs can lead to an antiviral state in fish and can be used for controlling fish pathogens, as they have no such limitations like antibiotic resistance. In response to viral

infections, AMPs cause up-regulation of pro-inflamatory cytokines, interferon, interferon regulatory factor (IRF3) and other molecules. Thus, application of AMPs as antiviral agent in aquaculture can be a promising way to combat the viral diseases of fish.

Key words: infectious diseases, antibody repertoire, innate immune response, interferon regulatory factor

BH-8

Isolation and characterization of possible antifreeze protein gene (AFP) in *Schizothorax richardsonii* (Fam: Cyprinidae)

Chirag Goel, Prabhati K Sahoo and Ashoktaru Barat
Molecular Genetics Laboratory, Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

In order to survive under extremely cold environments, many organisms produce antifreeze proteins (AFPs) and altering different enzyme activities in glycolytic pathways. AFPs inhibit the growth of ice crystals in body fluids and protect from freezing damage in several fish species inhabiting in Arctic and Antarctic areas during adverse winter conditions. It was expected the same phenomenon occurring in some Indian freshwater fishes of the Himalaya. Some indigenous trout species like *Schizothorax richardsonii* prefers a wide thermal regime of snowmelt waters of the Himalayas and slopes of Western Ghats at a high altitude of above 1500msl. This snow trout is an important trans-Himalayan coldwater fish species which inhabits different thermal regimes (5°C to 22°C). Hence, some AFP specific primers were designed from the sequences of winter flounder, eel pout, rainbow smelt and Atlantic herring obtained from public domain NCBI. The primers were then tested on cDNA synthesized from total RNA of different tissues (liver, heart, fin, spleen, brain) of *S. richardsonii.* Preliminary PCR amplification with three sets of primers in liver cDNA revealed some possibilities of presence of AFP or AFP like genes in *S richardsonii.* The confirmation of the same is in progress using cloning and sequencing.

Keywords: *Schizothorax richardsonii*, Antifreeze protein, cDNA

Email: abarat58@hotmail.com

BH-9

Polymorphic microsatellite loci for population studies of the sucker head, *Garra gotyla* (Family: Cyprindae, Pisces)

R. Matura, S. Chandra and A. Barat
Directorate of Coldwater Fisheries Research
Bhimtal-263 136, Nainital, Uttarakhand

Garra gotyla, commonly known as sucker head fish belongs to family Cyprinidae. It has a wide range of geographical distribution i.e. all along the Himalayas, Chota-Nagpur plateau, the Vindhya-Satpura mountains of the Indian peninsula; Pakistan, Bangladesh and upper Burma. The wide distribution implies the wide environmental adaptation of the species, but there is a very limited study on physiology, genetics, breeding and other aspect of the species. In the present paper attempts were made to develop microsatellite markers and study the genetic structure of geographically isolated populations of *Garra gotyla* using microsatellite markers. Microsatellite-enriched libraries for *Garra gotyla* was constructed from fin tissue. Around one thousand clones were isolated which were known to

contain cloned DNA. Primary screening was done using Colony Hybridization. Eighty-two clones containing repeat motifs were identified. Further secondary screening of these clones was carried out using PCR amplification of the screened clone with M13F/R primer and repeat specific probe which was used as in colony hybridization. Fifty-five clones which were giving positive signal were isolated and sequenced in order to develop a series of new PCR-based molecular markers to be used in genetic studies. Fifty-two clones containing microsatellites sequences were submitted to NCBI (Acc. No. HQ288484-HQ288526 and JF268657-JF268665). Thirty-two of these clones were selected to design primer pairs for the PCR amplification of microsatellite alleles. 28 primers were validated in two population of Garra. Twenty SSR loci were selected which were polymorphic to analyze the genetic diversity in 90 individuals of *Garra gotyla* collected from three different riverine sources viz. Alaknanda River (Srinagar Garhwal), Kosi River (Ramnagar) and Gola river (Ranibagh) Uttarakhand. A total of 105 alleles were detected with average of 4.95 alleles per locus. Ramnagar Population (Kosi River) had the highest mean number of alleles with 5.15. These markers showed high level of variability with mean observed heterozygosity ranged from 0.07 to 0.78. The hierarchical analysis of molecular variance (AMOVA) within 3 population revealed a highly significant subdivision between population in the total sample (Fst= 0.46688; P, 0.05). It was further revealed that out of total variation, 53.31% was contributed due to variation within population and 46.69% due to variation among population. The pair wise Fst comparison of population samples showed significant genetic difference between all the populations. These polymorphic microsatellites represent the first set of genetic markers available for *Garra gotyla.* The high variability of these markers within species confirm the value for evolutionary and conservation genetics studies in *Garra.*

Keywords: *Garra gotyla,* Isolation, Microsatellite, PCR, Conservation genetics.

BH-10

Multivariate morphometric analysis of populations of *Tor putitora* (Hamilton, 1882) along the trans-Himalayan region of India using truss network analysis.

Rohit kumar, Jyoti Sati, P.K. Sahoo, R.S. Patiyal and A. Barat
Directorate of Coldwater Fisheries Research
Bhimtal-263 136, Nainital, Uttarakhand

Golden mahseer, *Tor putitora* (Hamilton, 1882) belongs to family Cyprinidae. Geographical isolation of mahseer along wide Trans-Himalayan region of India may result in the development of different morphological features because of the interactive effects of environment. The identification of stock structure of this fish is relevant to stock assessment and harvest management. Hence this study was made to identify different stocks of golden mahseer along the trans-Himalayan region of India. Lots of genetic and morphometric methods are available for studding stock structure however environmentally induced phenotypic variation may have advantages in the stock identification because sometimes at intra-specific level the phenotypic variation is not directly under genetic control but subjected to environmental modification. Different types of body measurements have been traditionally used to characterize stocks but these methods also had been criticized because of inherent biases and weaknesses. In present study, a new system of morphometric measurements called Truss Network System has been used for stock identification of five different populations of *T. putitora* collected from Anji (AJM), Basoli (BJM), Badon (BHM), Ramnagar (RUM) and Bhalukpong (BAM) from different states of India. Study indicates that the shape of head and tail region is mainly responsible for phenotypic difference between populations. Findings generated by both discriminate function analysis (DFA) and multivariate analysis of variance (MANOVA) suggested 3 phenotypically distinct stocks varying in the degree of differentiation. Also this study revealed that Basoli (BJM) and Bhalukpong (BAM) are morphometrically most diverge populations from others.

Keywords: Golden Mahseer, phenotypic variation, morphometrically

BH-11

Mitochondrial Cytochrome b gene Polymorphisms in three populations of Golden Mahseer *(Tor putitora)* (Family: Cyprinidae)

Jyoti Sati, Rohit Kumar, S. Ali and A. Barat*
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

The golden mahseer, *Tor putitora* (Family: Cyprinidae) is the commercially important for both food and sport fish in cold water of the Himalayan region. Despite its great economical importance it is treated as one of the endangered fish in many water bodies of Uttarakhand region. The conservation and management of the fish is an urgent need using molecular breeding plan. But there is lack of population structure analysis by which population size and genetic status can be estimated. Hence, in the present study we have sequenced a fragment of the cytochrome b mitochondrial gene of three population of *T. putitora* to investigate the nucleotide variation in different population i.e. river Jiaboroli (Bhalukpong, Arunachal Pradesh), river Kosi (Ramnagar, Uttarakhand) and river Satluj (Bhakara, Himachal Pradesh). Gene sequences of the cytochrome b of three populations were analyzed and 3 polymorphic nucleotides were observed in the population of Arunachal Pradesh. The mutation involves 3 codon in position 276 CTA, 318 GGG and 465 CTA of the cytochrome b mitochondrial gene. All polymorphism represent conservative missense mutation, and do not alter cytochrome b protein structure and biological function. They might be employed as marker for the genetic characterization of different population.

Keywords: *Tor putitora*, Cytochrome b, Polymorphism, mitochondrial DNA, conservation.

***Email:** abarat58@hotmail.com

BH-12

Standardization of prerequisite parameters for flow cytometric estimation of Genome size

Chirag Goel, Vijay K Singh, Amit Pande and P K Sahoo*
Directorate of Coldwater Fisheries Research, Bhimtal -263136, Nainital, Uttarakhand

Genome size (c-value) is the measurement of the haploid DNA content per cell. It is the characteristic of the species and remains constant among different individuals of the same species. So, the determination of genome size can be used for the species identification and also for genetic mapping. There are about 258 coldwater fish species in India. Among them the development of molecular markers/ taxonomic keys are still in its infancy. With the aim of determination of genome sizes the present study was undertaken to optimize the requisite parameters for flow cytometric determination of genomic size. For this 20µl whole blood was taken from *B. bandelesis* and *T. chelynoides* by puncturing heart in heparinized syringe and was immediately added to Citrate-DMSO buffer. The cells were washed twice in PBS and RBC's were fixed in ethanol. RBC's were stained with a fluorescent dye propidium iodide. After staining, the cells were analyzed by excitation at 488nm wavelength in a Leica DM 2500 fluorescent microscope to study the size of nucleus and staining properties suitable for flow cytometry.

Key word: Genome size, flow cytometry, fluorescence dyes

***E.Mail:** psahooin@yahoo.co.in

BH-13

Utilisation of Deccan Mahseer, *Tor khudree* (Sykes) for development of convenience products

Bindu J[1], Ninan G[1], Dinesh K[2], Ravishankar C.N[1]&Gopal T.K.S[1].
[1]Central Institute of Fisheries Technology, Cochin -682029
[2]KUFOS, Panangad, Kerala

Tor khudree or Deccan Mahseer is unique to the peninsular region of India. The fish is highly priced for food and sport due to its large size, durability and taste. Deccan Mahseer is a source of livelihood and food security for the local fishermen and tribal population inhabiting the Chalakudy high ranges in Kerala. Limited quantities of fishes are caught and sold in nearby markets in the fresh and dried forms. This paper describes different types of convenience products that have been developed from Mahseer. They include ready to eat products like Mughalai UP curry and Punjabi curry in retortable pouches which can be stored for a period of one year at ambient temperature (28±2°C). Smoked skinless fillets had a shelf life of 2 months at 2-3 °C when packed in polyester polythene laminate pouches. Cutlets from the mincemeat of Mahseer have also been successfully prepared and stored for 12 months at -18°C. The meat of Mahseer is comparable to any other fresh water fishes like carps and can be effectively utilized for the development of different types of convenience products.

Keywords: Deccan Mahseer, Chalakudy, Smoked

BH-14

Serum electrolytes, anti-oxidative enzymes and haematological parameters of *Labeo rohita:* effects of nitrite exposure

A. Ciji and N.P. Sahu
Central Institute of Fisheries Education
Off Yari Road, Versova, Andheri (W), Mumbai-400061, India

An experiment was conducted to study the effects of short-term exposure of sub-lethal concentration of nitrite on electrolyte regulation, antioxidative enzymes and haematological parameters in *Labeo rohita* juveniles. The fishes were exposed to graded levels of nitrite (0–15 mg l-1) for different duration (0, 12, 24, 48 and 96 h). The 96-h LC50 value for *L. rohita* (avg. wt, 66.5 ± 0.5 g) was found to be 11.28 mg l-1. Activities of anti-oxidative enzymes (catalase and superoxide dismutase), acetylcholine esterase (AChE) and methaemoglobin reductase, serum electrolytes (sodium, potassium and chloride), haematological parameters and blood glucose level significantly varied in a dose-dependent manner. With increasing nitrite concentration and exposure period, a progressive reduction in the total erythrocyte count and haemoglobin were observed. With increase in nitrite concentration, a significant increase in activities was evidenced in catalase and superoxide dismutase in liver as well as gill, methaemoglobin reductase in blood, while a progressive decline in AChE activity in brain was recorded. The serum sodium and chloride content showed a progressive decline, while potassium showed an increasing trend upon increase in nitrite concentration. The serum K+ and Cl- after 96-h exposure demonstrated a linear relationship (Y = 0.221x + 2.542, R2 = 0.938, P≤0.01 and Y = -5.760x + 129.5, R2 = 0.952, P≤0.01, respectively) with nitrite concentrations. This study revealed that nitrite exposure causes alteration in all measured tissue enzymes, serum electrolytes and haematological parameters.

Keywords: nitrite, electrolyte regulation, anti-oxidative enzymes, haematological parameters, *Labeo rohita*

E-mail: cijialex83@gmail.com

BH-15

Evaluation of effect of different solvents on *in vitro* antibacterial potential of some medicinal plants

Neelesh Kapoor* and Veena Pande
Department of Biotechnology, Kumaun University
Nainital

The antibacterial activity of hot water, ethanol, methanol, acetone, chloroform and petroleum ether extracts of *Allium sativum*(L.) (bulb), *Tageteserecta* (L.) (flower), *Coriandrum sativum*(L.) (dried fruit), *Syzygium aromaticum* (L.) (bulb) and *Psidium guajava* (L.) (leaf) were studied against two gram positive *(Staphylococcus aureus, Bacillus subtilis)* and three gram negative bacteria *(Escherichia coli, Klebsiellapneumoniae, Salmonella typhi)* by disk diffusion method. The patterns of inhibition varied with the solvent used for extraction, the plant extract and the organisms tested. The ethanolic and chloroform extracts of all the plants were found to be active against all the investigated bacterial strains. The extracts were more active against gram negative bacteria as compared to gram positive bacteria. The highest antibacterial potential was observed for the ethanolic extracts of *Allium sativum* and *Psidium guajava. Tageteserecta* showed minimum inhibition potential among all tested plants. *Coriandrum sativum* exhibit antibacterial potential only with acetone.

Key words: antibacterial activity, medicinal plant, gram negative, gram positive

***E. mail:** kapoor_nk2005@rediffmail.com

BH-16

Molecular identification of *Aeromonas* species by the phylogenetic analysis of 16s rDNA and Restriction Fragment Length Polymorphism (RFLP) of gyrB gene

Poonam Kumari[1], Neetu Shahi[2], Sumanta Kumar Mallik[2]
[1]Sai Institute of Paramedical & Allied Sciences (H.N.B Garhwal University), Dehradun
[2]Diretorate of Coldwater Fisheries Research (Indian Counsil of Agricultural Research)
Bhimtal, Nainital (Uttarakhand)

Identification of *Aeromonas* species emergent pathogen for humans has long been controversial due to their phenotypic and genomic heterogeneities. In this study, two isolates of β haemolytic *Aeromonas* species were identified by PCR amplification and sequencing of partial 16srDNA gene, and by Restriction fragment length polymorphism (RFLP) pattern analysis of *gyr*B amplified fragment. PCR amplification of 16srDNA region using universal primer for conserved region has generated a 1.4 kb amplified product, which is sequenced. The sequence was analysed using BLAST and it is confirmed that the strain RTM 02 is *A. hydrophila* (100% match) and RTS 08 is *A. veronii* (99% match). The phylogenetic tree was also constructed by MEGA 4.0. In PCR RFLP of *gyr*B gene, out of seven restriction enzyme (RE) tested, Alu I and BamHI generated restriction pattern(2-3 bands), which was compared with the standards from ATCC 7965 and ATCC 35654. Amplification of gyrB gene using primers UP-1 & UP-2r has generated a single band of approximately 1.2 kb. This band was used for PCR RFLP.

Key words: *Aeromonas,* phenotypic, genomic, 16srDNA gene, gyrB amplified fragment

BH-17

Biochemical and Molecular Characterization of Bacteria Isolated from Diseased Eye of Rainbow Trout (*Oncorhynchus mykiss* Walbaum) and Golden mahseer (*Tor putitora* Hamilton)

ShailajaVerma[1], Neetu Shahi[2], Sumanta Kumar Mallik[2]*
[1]Sai Institute of Paramedical & Allied Sciences (H.N.B Garhwal University), Dehradun
[2]Diretorate of Coldwater Fisheries Research (Indian Counsil of Agricultural Research) Bhimtal, Nainital (Uttarakhand)

Rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792) and golden mahseer *Tor putitora* (Hamilton) are two economically important coldwater fishes in hilly regions of India. *T. putitora* is indigenous fish and *O. mykiss* was introduced in India during British period as game fish. These two fishes are also important from aquaculture point of view. However, under intensive cultured conditions with supplementary feeding the chances of occurrence of disease is high. In this study, the bacterial samples were collected from the opaque eye of rainbow trout (8 bacterial isolates), and from the eye of golden mahseer (11 isolates).The isolated bacteria were identified by biochemical and molecular methods. In biochemical test majority of bacteria were gram negative motile rods. Some of the bacteria were positive for β haemolysin on sheep blood agar plates. A 1.4kb fragment was amplified by primer based on conserved reason of 16S rDNA. The amplified segment was purified, sequenced and sequence similarity was matched with other bacteria by BLAST. The bacteria which showed β heamolytic is *Aeromonas* spp. (RTE 7, RTE 2 and RTE 5), *Brevi Bacillus* (MHE 5 & MHE 7), *Micrococcus* (MHE6), whereas others which is notβ hemolysic is *Pseudomonas* (MHE1 & MHE 2) and *Acidovorax* (MHE 3 & MHE 4). All strains of RTE series were resistant against ampicilline except RTE 6. RTE4, RTE8, MHE2 observed partial resistance against ciprofloxacin.

Key words: Rainbow trout, golden mahseer, isolates, β haemolytic

***E. mail:** shahineetu@rediffmail.com

BH-18

Population genetic study of five population of *Schizothorax richardsonii* using Cytochrome b gene sequences

Shahnawaz Ali[1], Ashoktaru Barat[1], Himani Pandey[1] and G. K. Sivaraman[2]
[1]Directorate of Coldwater Fisheries Research Bhimtal-263136, Nainital, Uttarakhand
[2]Veraval Research Centre of CIFT, Matsyabhavan, Bhidia Plot, Veraval, Gujrat

The snow trout *(Schizothorax richardsonii)* is an economically important fish in the Northern and Western Himalayan regions inhabit fast flowing snow fed streams and lakes. Due to their over exploitation this species were listed as endangered by the National Environmental Protection Agency and Endangered Species Scientific Commission. A comprehensive literature survey revealed that there is little information available on the wild population diversity of this species. In order to undertake a conservation program for this species in India, it is essential to evaluate its genetic diversity and population structure. Hence, the present study aims to infer the genetic diversity and phylogenetic relationships of different *Schizothorax richardsonii* population using mtDNA Cytochrome b gene sequences. 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 (1140 bp) was used to investigate genetic variation of five population of *Schizothorax richardsonii.* The statistical analysis of mtDNA sequences was performed with the software MEGA 4.0 DNA SP 5.1 and Arliquin 3.11. The overall nucleotide diversity (π) and haplotype diversity (h) was found to be low (π=0.00270, h=0.90514). Result obtained from present study showed that haplotype diversity and nucleotide diversity was high in Bairangana population (h=1.00000, π=0.00421) and low in Kosi population (h=0.00000, π=0.00000) . Results of AMOVA indicated that a majority of the genetic variation in Cyt b was contributed due to variation among population (52.69%). The total Fst value (FST= 0.57690; P<0.05) was found to be significant. The findings from the present study have important implication for aquaculture, management and conservation of *Schizothorax richardsonii*.

Keywords: *Schizothorax richardsonii*, mtDNA, Cytochrome b, nucleotide diversity, haplotype diversity.

***Email:** alicife@gmail.com

BH-19

Activities of amylase and lipase during ontogenic development of golden mahseer *(Tor putitora)* larvae

M. S. Akhtar*, Debajit Sarma and N.N. Pandey
Directorate of Coldwater Fisheries Research
Bhimtal-263136, Nainital, Uttarakhand

Analysis of digestive enzymes activities is an easy and reliable methodology that can be used as indicator of digestive processes and nutritional condition of fish larvae. Samples of mahseer larvae of different age groups viz. 0 day after hatching (0 DAH), 3 DAH, 7 DAH, 15 DAH, 21 DAH, 30 DAH and 45 DAH had been collected from DCFR mahseer hatchery, Bhimtal. Whole larvae (till age 21 DAH) and dissected larvae (30 and 45 DAH) were homogenized with 5 % chilled 0.25 M sucrose solution. The homogenized samples were centrifuged (6000xg for 10 min) and supernatants were collected and used for amylase and lipase assay. The minimum amylase activity in mahseer larvae was found on 0 DAH and 3 DAH. There was a sharp significant ($p<0.05$) increase in the activity of amylase upto 7 DAH and reached maximum. On 15 DAH, there was a slight decrease in the activity. From 15 DAH till 45 DAH, amylase activity increased linearly ($Y = 0.5053X + 7.475$, $R^2 = 0.9837$). While the lipase activity was minimum at 0 DAH. There was a significant ($p<0.05$) linear increase ($y = 12.15x - 4.95$, $R^2 = 0.98$) in its activity upto 7 DAH. The activity sharply decreased on 15 DAH followed by a significant ($p<0.05$) abrupt increase to a maximum on 21 DAH. Again, lipase activity sharply decreased to a minimum level on 30 DAH. Compared to 30 DAH, there was a slight increase in the activity of this enzyme on 45 DAH. Hence, the present study on ontogeny of amylase and protease of golden mahseer larvae will give an insight on the development of the larvae digestive functions with respect to carbohydrate and lipid utilization in order to obtain essential data for the formulation of a compound diet adapted to larvae of this species.

Keywords: mahseer larvae, amylase, lipase, protease

***E-mail:** mdshahbazakhtar@gmail.com

BH-20

Comparative analysis of the genetic structure of *Labeo gonius* from three reservoirs of Uttrakhand using RAPD profile

Grishma Tewari and I. J. Singh
Department of Fishery Biology, College of Fisheries, G. B. Pant University of Agriculture & Technology, Pantnagar-263145, Uttarakhand, India

Genetic profile of the fish, *Labeo gonius* population from three different sized reservoirs of Uttarakhand *viz.*, Dhaura, Baigul and Nanak Sagar was studied by applying random amplified polymorphic DNA (RAPD) markers. GenomicDNA was extracted from the fin tissue of each individual by standard SDS-phenol / chloroform method. Total eighty decamer primers from each series of OPA, OPB, OPC and OPY, (Operon Technologies, Alameda, USA) were used out of which, only 15 primers i.e. OPA- 01, OPA- 05, OPA- 13, OPA- 14, OPA- 15, OPC-07, OPC-08, OPC-11, OPC-15, OPC- 18, OPY-05, OPY-13, OPY-14, OPY-15 and OPY-20 were selected for the further study on the basis of repeatability, sharpness and intensity of the bands.PCR was carried out following the standard RAPD protocol with minor modifications. RAPD profile was computed by using the software POPGENE Version 1.31 and molecular weight of amplified bands were assessed by comparing with Gene Ruler™ 1 kb DNA ladder (Fermentas Life sciences).Total 11487 numbers of different randomly amplified DNA fragments from *L. gonius* were detected consistently out of which only 8344 scorable polymorphic bands were generated with fifteen RAPD primers in all three stocks of *L. gonius*. The size of the fragments ranged from 450 bp to 3000 bp and the number of fragments generated per primer varied from 03 to 10.Total 3829 fragments were amplified in Dhaura reservoir population, out of which 61.37% fragments (2350 nos.) were polymorphic while rest were monomorphic. In Baigul reservoir population 69.60 % bands (2665 nos.) were polymorphic and 1164 fragments were monomorphic and in Nanak sagar population, 86.94% fragments were polymorphic (3329 nos.) and rest 500 bands were monomorphic. These RAPD banding patterns revealed highest polymorphism in *L. gonius* stock of Nanak sagar reservoir followed by Baigul and Dhaura reservoirs. As polymorphism is positively correlated with the heterozygosity, these observations on polymorphism indicated that stock of *L. gonius* in Nanak sagar reservoir is likely to be most heterozygous out of three followed by stock of Baigul and Dhaura reservoirs. The work done and observations made under the present study will be discussed in detail.

Key words: population genetics, *Labeo gonius*, RAPD, genetic diversity

E-mail: grishmatewari11@gmail.com

BH-21

Microbiological Quality Assessment of Fresh and Frozen Mince of Rohu *(Labeo rohita)*

Smita Chauhan, Ritu Agrawal, Malobica Das Trakroo and Vipul Gupta
Department of Fish Processing Technology
College of Fisheries, G. B. Pant Univ. of Agri. And Tech., Pantnagar

Fishes like many other forms of life are of immense value to human and have been a staple item of the diet of many people since long. Fish is highly nutritious commodity with high protein rich dietary material. It supplies an ample quantity of vitamins and minerals with relatively low calorie content. Physical and chemical changes caused by enzymes and microorganisms begin to occur just after death of the fish. The spoilage of fish mince is due to the growth and multiplication of microorganisms in the muscle constituents. Microbiological quality

of fresh fish, fish mince and frozen fish can be judged by using several criteria especially total plate count. Total plate count for enumeration of bacterial population was done after 15th day and then repeated after an interval of 15 days of storage for checking the changes in microbial load and observing the shelf life of raw minced meat of Rohu frozen stored at -20°C.Total number of microorganisms was enumerated by serial dilution and pour plating methods. A maximum decrease in total bacterial count was recorded from 0 day to three months of frozen period *i.e.* 3.5×10^5cfu g^{-1} to 1×10^4 cfu g^{-1}in the minced meat of Rohu .This range of microbial counts in raw and frozen stored mince of Rohu was under the limits of normal standards that was set up by the ICMSF *i.e.* 10^6cfu g^{-1}. Based on the findings of the present study, mince meat of Rohu was acceptable for cooking and product development because it did not spoil throughout the whole storage period. Therefore, it was concluded that mince of *Labeo rohita* is safe for consumption for more than three months when stored in deep freezer at -20°C with slight change in its colour along with least microbial population.

Key words: microbial quality, pour plating, deep freezer, total plate count

Email: smitachauhansingh@yahoo.com

BH-22

Saprolegniasis in the farm raised Golden mahseer *(Tor putitora)* at mountainous region of Kumaun Himalayas, Uttarakhand

Sonika Sharma[1], N. N. Pandey[2], D.S. Rawat[1], Raghvendra Singh[2]
[1]Department of Zoology, BFIT, Dehradun, Uttarakhand
[2]Directorate of Coldwater Fisheries Research, Bhimtal (Nainital), Uttarakhand

The research paper represents an on-farm observation and laboratory analysis of fungal infected Golden mahseer, reared in cemented tanks at DCFR, Bhjmtal, District Nainital (Uttarakhand). 90% stock was found infected with *Saprolegnia parasitica* and *Saprolegnia diclina* with cotton like appearance, elongated zoosporangia and pear shaped primary sporangium. Temperature has a significant effect on the severity of infections. Most epizootics occur when temperature goes below the optimal range (5-14°C) for that species of fish. Physical injury due to the cemented surface of the pond and insufficient water exchange was the major cause of infection.

Key words: Golden Mahseer, Zoosporangia, Epizootics, Fungal Infection.

E-mail: nityanfish@yahoo.co.in

BH-23

Fatty acid, amino acid and mineral composition of rainbow trout *(Oncorhynchus mykiss)* of Indian Himalaya

D. Sarma[1], P. Dhar Das[1], P. Das[1], H. C. S. Bisht[2], M. S. Akhtar[1] and A. Ciji[1]
[1]Directorate of Coldwater Fisheries Research, Bhimtal-263136, Nainital, Uttarakhand, India.
[2]Department of Zoology, Kumaun University, Nainital, Uttarakhand, India

The present study was conducted to determine fatty acid profile, amino acid and mineral content of rainbow trout from Indian Himalayan region. It was found that the crude protein, crude fat and ash content were 19.44, 5.18 and 1.37% respectively. Protein had a well-balanced amino acid composition, with higher amounts of proline.

The highest amino acid score was observed for tryptophan followed by isoleucine. Total monounsaturated fatty acids were the highest followed by saturated fatty acids and polyunsaturated fatty acids. Oleic acid was dominant, followed by palmitic acid and linoleic acid. Among the n-3 PUFAs DHA was the most dominant followed by linolenic acid. The ratio of n-3/n-6 PUFA was 0.77. Among the minerals K was highest followed by Ca, Na, Fe, Zn, Se and Mn. From the present study, it can be concluded that rainbow trout has a rich amount of quality protein with well-balanced essential amino acids, PUFAs and minerals.

Key words: Rainbow trout; PUFA; amino acids; amino acid score; minerals; proximate composition.

BH-24

Nutritional quality in terms of amino acid and fatty acid of five coldwater fish species: implications to human health

Debajit Sarma[1], M.S. Akhtar[1], Puspita Das[1], Partha Das[1], Neetu Shahi[1], Sona Yengkokpam[2], Dipesh Debnath[2], A. Ciji[1], B. P. Mohanty[3] and P. C. Mahanta[1]

[1]Directorate of Coldwater Fisheries Research, Indian Council of Agricultural Research,
Bhimtal–263 136, Nainital, Uttarakhand, India.
[2]Central Inland Fisheries Research Institute, Regional Centre, HOUSEFED Complex,
Dispur, Guwahati–781 006, Assam, India.
[3]Central Inland Fisheries Research Institute, Barrackpore, West Bengal

Muscle samples of *Tor putitora, Neolissochilus hexagonolepis, Oncorhynchus mykiss, Schizothorax richardsonii* and *Cyprinus carpio* were analyzed for fatty acid and amino acid composition with a view to generate nutritional information of the five important coldwater fish species of Indian upland Himalayan region. In the present study, all the fish species recorded good amounts of n-3 fatty acids (8.69-21.48 %) and the n-3/n-6 ratio ranged from 0.7-4.98. The amino acid score calculated based on the World Health Organization (WHO) protein standard indicated good quality proteins in the species but with mostly marginally lower values for *C. carpio*. However, when the amino acid levels of the fish species were compared with the recommended amino acid levels, all the fish species were found to constitute a good source of essential amino acids. Limiting amino acids such as lysine, methionine and cysteine occurred at levels higher than or marginally lower than the recommended amino acid profile. It could be concluded that the five coldwater fish species from upland Himalayan region contained high quality lipids and proteins constituting a healthy addition to the human diet.

Keywords: Coldwater fish species; Amino acid; Fatty acid; Nutrition; Human health

BH-25

Nutritional Quality of Exotic Rainbow Trout *(Oncorhynchus mykiss)* and Indigenous Snow Trout *(Schizothorax richardsonii)* in Upland Himalayan Region

Puspita Das[1], Debajit Sarma[1], N. N. Pandey[1], H. C. S. Bisht[2] and Partha Das[1]

[1]Directorate of Coldwater Fisheries Research, Bhimtal-263136, Distt- Nainital, Uttrakhand, India
[2]Department of Zoology, D.S.B. Campus, Kumaun University, Nainital, Uttarakhand, India

The exotic rainbow trout *(Oncorhynchus mykiss)* and indigenous snow trout *(Schizothorax richardsonii)* are two important coldwater fish species having high consumer preference and market value. The study embodies to evaluate the nutritional quality of rainbow trout and snow trout in terms of proximate composition, macro and

micro minerals. In rainbow trout, significantly (P<0.01) higher protein (75.81±0.42) and moisture (77.14±0.09) were recorded during February-May whereas; crude fat (13.76±0.29) and dry matter (27.32 ± 0.21) were significantly higher in October-January. Ash level (6.21±0.10) was significantly (P<0.01) higher in the month of June-September. Similarly, in snow trout higher protein (72.45±0.65) and moisture (77.34±0.01) were found in winter period. Crude fat (20.59±0.03) and dry matter (29.87±0.01) content were significantly (P<0.01) higher in the month of June-September. Ash (10.68±0.06) level was highest (P<0.01) in winter. Results from the analysis revealed that sodium, potassium and calcium concentration of rainbow trout sampled from Patlikuhal trout farm were significantly (P<0.01) higher (216.66±3.055; 1538.67±8.504; 488.0±4) respectively in comparison to two other geographical locations. Snow trout of Nandprayag contained significantly higher (P<0.01) values of sodium (241±31.19) and potassium (1246.67±59.07) in comparison to other two geographical locations. The higher concentration of calcium (417± 12.013) was recorded from Champawat fish farm. Significantly (P<0.01) higher concentration of manganese (0.193±0.011; 0.345±0.013), zinc (1.789±0.012; 2.705±0.013) and selenium (1.66±0.029; 1.032±0.016) were noted from Champawat fish farm for both the trout. Higher amount of iron (0.892±0.011) was found in snow trout and rainbow trout (5.171±0.011) fish collected from Bairangana fish farm and Champawat fish farm. From the study it may be recommended that the rainbow trout and snow trout are having rich nutritional quality and play a vital role in human nutrition.

Key words: *Oncorhynchus mykiss, Schizothorax richardsonii,* minerals, proximate composition

BH-26

Non target effect of pesticide on upland fishery resources

A. U. Khan, Banu Saidullaha and S.P. Singh
College of Sciences, Indira Gandhi National open University
New Delhi, India

The use, misuse, and abuse of pesticide have caused significant fishery recourse losses in many areas of the Indian upland fishery. Pesticide-related losses have occurred from fish kill, habitat deterioration, and declining productivity. Pesticide residues in fish, at levels considered dangerous for human consumption. The environmental fate of chemicals used in agriculture can be expressed in terms of four basic process: Application, Attention, transport, and accumulation. Fish and other aquatic biota may be harmed by pesticide-contaminated water. Application of herbicides to bodies of water can cause fish kills when the dead plants rot and use up the water's oxygen, suffocating the fish. Some herbicides, such as copper sulfite, that are applied to water to kill plants are toxic to fish and other water animals at concentrations similar to those used to kill the plants. Repeated exposure to sublethal doses of some pesticides can cause physiological and behavioral changes in fish that reduce populations, such as abandonment of nests and broods, decreased immunity to disease, and increased failure to avoid predators.

Key words: Pesticide, Fish

Email: amankhanfish@gmail.com

BH-27

Influence of physico-chemical properties of the water on organoleptic quality of pond reared and wild Indian Major carp

Monika Gupta, A.K.Upadhayay and Raghvendra Singh*
College of Fisheries, G.B.Pant University of Ag. & Tech. Pantnagar-263145
U.S.Nagar, Uttarakhand

An attempt was made to distinguish the possible organoleptic differences between the pond reared and wildfish species of reservoirs and correlate these with thephysicochemical characteristics of water bodies. The texture was found to firmer in wild varieties of fishes than pond reared fish, with best in *Catla catla* followed by *Labeo rohita* and *Cirrhinus mrigala*. All the cultured fishes had lighter colour than wild fish species which were darker in appearance. Comparatively, higher dissolved oxygen and transparency levels with low temperature and alkalinity levels were found in reservoirs. Hydrobiologically, the efficient ecosystem of reservoir was responsible for stronger texture and dark colouration in wild fish species. The fishes from reservoir exhibit tendency to lead active and agile life, comparatively the fishes from ponds are docile. Reservoirs have the potential of enhanced quality fish production.

Keywords: organoleptic,physico-chemical, reservoirs, texture, Indian Major Carps

*** E-mail:** monika_gupta22@yahoo.com

BH-28

Medicinal and Aromatic Plants: An Eco-friendly approach in Fish Health Management

Raghvendra Singh[1], N.N. Pandey[2], Monika Gutpa[1] and Santosh Kumar[2]*
[1]Central Institute of Fisheries Education, Mumbai.
[2]Directorate of Coldwater Fisheries Research, Bhimtal Uttarakhand.

Aquaculture has been a growing activity for the last 20 years worldwide. This plays an important role in the production of safe food and economical growth. But simultaneously with increase in production some problems are also associated with it, of which, losses due to disease outbreak is a major and serious issue. Outbreak of diseases is a limiting factor in fish culture. Various microbes like virus, bacteria, fungi, and protozoa affect the fish health severely.Even though many synthetic drugs are available and are used to control the disease, but unfortunately they have certain drawbacks. Some pathogens have developed resistance to these chemicals and some are not readily biodegradable, carcinogenic and tend to persist in the environment. Hence, it becomes necessary to develop ecologically safe, effective and economically feasible method of disease management. In the same context the herbal bio-medicinal products may be proved as the correct answer as they have the characteristics of growth promoting ability and tonic to improve the immune system without any environmental and hazardous problems. Medicinal plants as the alternative agents are effective to treat the infectious diseases and mitigate many of side effects that are associated with synthetic antimicrobials. In addition, plant-derived phytomedicines provide a cheaper source for treatment and greater accuracy than chemotherapeutic agents in this field.Therefore, medicinal plants may be proved as potentially beneficial alternative in aquaculture for health management practices.

Key words: Fish diseases, Phytomedicines, Antimicrobials.

*** E-mail:** shakya.raghav@gmail.com

BH-29

Effectiveness of some herbal extracts against Saprolegniosis, a fungal infection in Golden mahseer *(Tor putitora)*

Raghvendra Singh[1]*, N.N.Pandey[2], Avdhesh Kumar[1] and Monika Gupta[3]
[1]College of Fisheries, G.B.Pant Univ. of Agri. & Tech. Pantnagar, Uttarakhand.
[2]Directorate of Coldwater Fisheries Research, BhimtalUttarakhand.
[3]Central Institute of Fisheries Education, Mumbai.

The investigation was aimed to isolate the pathogenic fungi from Golden Mahseer *Tor putitora*, a cold water fish and their environment to assess the efficacy of some medicinal plants extracts as antifungal agents *(in vitro)* against the isolated pathogenic fungi. Fungus was isolated using hemp seeds as bait and further grown over SDA medium to obtain bacteria free, pure fungal isolate. This pure culture was identified as *Saprolegnia Sp.* Sterilized aqueous extracts of leaves of Kalmegh *(Andrographis paniculata)*, Pine *(Pinus roxberghaii)*, Marigold *(Targetes erectus)*, Black Musturd *(Brassica nigra)* and Lemon grass *(Cymbopogon citratus)* at different concentrations (5%, 8%, 10% w/v) were tested against the mycelial mass of the *Saprolegnia sp.* for three different time periods (20 min., 40 min., and 60 min.) and colony diameter of *Saprolegnia* fungus was measured and compared with control. All the tested extracts showed good antifungal activities against the test pathogen. Extracts of *Cymbopogon citratus* and *Brassica nigra* were found most effective with MIC as 5% w/v concentration for 20 min. exposure time. Therefore, on the basis of these findings, a cheap, eco-friendly, and potent antifungal can be developed for poor fish farmers.

Key Words: *Tor putitora, Saprolegnia,* colony diameter, aqueous extracts, MIC (minimum inhibitory concentration)

*** E-mail:** shakya.raghav@gmail.com

BH-30

Phylogenetic relationship among the five species of *Mystus* distributed in North East India as inferred from cytochrome oxidase 1 gene sequence

A. Darshan, A. Barat, P.K. Sahoo, S. Ali, P. Kumar and P.C. Mahanta
Directorate of Coldwater Fisheries Research (ICAR)
Bhimtal 263136, Nainital, India.

Fishes of the genus *Mystus* Scopoli are small to medium-sized bagrid catfishes occurring in South and Southeast Asia. Mo in 1991, characterized the genus to have a thin needle-like first infra orbital, twisted and thickened metapterygoid loosely attached to the quadrate by means of ligament or a small extent of cartilage. Despite numerous previous studies base on morphological and molecular aspects, the true diversity of the group and the phylogenetic relationships among them remain poorly understood. Recently in 2005, Hardman confirmed the non-monophyly of *Mystus*. This study established the phylogenetic relationship of five species of *Mystus viz. M. rufescens* (Vinciguerra), *M. ngasep* Darshan *et al., M. cavasius* (Hamilton), *M. tengara* (Hamilton) *and M. bleekeri* (Day) for the first time using partial sequence of cytochrome oxidase 1 DNA barcodes. The first two species are collected from Chindwin-Irrawaddy drainage and the later three species from Ganga-Brahmaputra drainage of northeast India. The phylogenetic tree, constructed by maximum parsimony (MP), maximum likelihood (ML) and unweighted pair group average (UPMGA) methods revealed that *M. bleekeri, M. rufescens and M. ngasep* are closely related to each other which is also supported by the morphological similarities, while *M. cavasius* and *M. tengara* nested together in another group despite their difference in morphological character as observed on the length of adipose fin, fontanel structure and colouration. The result of this study indicates that cytochrome oxidase 1 sequencing or

barcoding is useful in identification of *Mystus* species and solving phylogenetic relationship. This study will help future worker to established an acceptable phylogenetic relationship among these poorly understand group.

Keywords: catfishes, *Mystus*, cytochrome oxidase, phylogenetic relationship

*E-mail: achom_darshan@yahoo.com

WC-1

Status and Potential of Watershed-Based Fisheries Development In Uttarakhand Himalayas

M. Muruganandam, V.N. Sharda, P.K. Mishra, G.P Juyal and R.K. Pande
Central Soil and Water Conservation Research and Training Institute
218-Kaulagarh Road, Dehra Dun-248 195.

Composite carp culture and paddy-fish culture practiced under Integrated Watershed Management (IWM) programs yielded 4.5 t ha^{-1} $year^{-1}$ and 0.6 t ha^{-1} $year^{-1}$, respectively in Garhwal Himalayas. An empirical projection on water harvesting potential based on published information indicated that about 52,662 ha-m of rainwater can be harvested even if 10% of the total catchment area and the reported rate of 1 ha-m water yield from every 10 ha of catchment in Dehradun (Uttarakhand) are considered, which would produce a total of 1,18,490, 59,245 and 23,698 t additional fish per annum at50%, 25% and 10% of the experimentally observed average fish production rate (4.5 t ha-m^{-1}), respectively. Considering the existing limited assured irrigation facility and land constraints, paddy-fish culture can be integrated in at least 5% (14,411 ha) of the total paddy fields (2,88,225 ha) present in Uttarakhand, which would produce about 4,300 t of additional fish at 50% (*i.e.,* 300 kg ha^{-1}) of the production achieved in experiments. Accounting all nominal fish production potential of 30,532-34,420 t including the present fish production range of 2,534-6,422 t $year^{-1}$ would not meet the empirically estimated demand of 41,127 t for 50% of the >7 years-old fish consumers based on average recommended consumption rate of 200 gm per individual per week and leave a deficit of 6707-10,595t annually. The present highest production level of 6422 t in Uttarakhand is over 6 times lower than the demand of 50% of fish consumers in the State.The existing or projected demand can be met by either increasing the area of production from 10% to 20% of harvested water or by increasing the production potential to 20% of the observed production. Fish demand of 50% consumers (41,127 t) may also be achieved if the ultimate potential of the State contemplated (44,000 t) in NABARD (undated) is realized mainly by harnessing running water area for trout production and low-lying area in plains for carp production in Uttarakhand. The projected total fish production of 1,18,490 t from 10% of the harvested water area at 50% production level of the observed potential would meet the demand of 90% of >7 years-old fish consuming population of the State leaving a surplus of 36,235 t for export to other regions. Further at national level, if a fraction of about only 20% of the projected water resources developed (4.8 M ha-m) as contemplated is used for fish culture, an additional yield of about 2.4 mt annually in the country is possible even at a modest rate of 0.5 t ha-m-1.Approaches and strategies to scale up hill fisheries and aquaculture require integration of fisheries into Integrated Watershed Management (IWM) programs since watershed management and fisheries development have good compatibility in terms of resource utilization and conservative production. Nonetheless, consideration for watershed-based fisheries development presently is very meager due to various constraints. Considering the potential of composite carp culture of both Indian Major Carps (IMC) and exotic carps in plains and foothills, exotic carps in mid-hills, trout in upper hills and conservation of local fish species in different elevations or agro-climates of Himalayan region that may bridge existing wide supply-demand gap and promote sustainability of fisheries production, an inclusive proposal for IWM programs covering fisheries and aquatic biology has been discussed in the paper.

Keywords: Composite carp culture, Integrated Watershed Management, conservation. Himalayan region

WC-2

Effects of Small Dams on Coldwater Stream Fish Communities

Jitendra Singh
College of fisheries, G.B. Pant University of Agriculture and Technology,
Pantnagar-263145

Dams provide many benefits to society, yet they have profound impacts on aquatic ecosystems. In addition to blocking fish migration, small surface-release dams on coldwater streams generally increase water temperature below the dam. Dams have been built on many streams across the India, vastly altering stream ecosystems. The presence of a dam and impoundment in the course of a free flowing river creates a discontinuity in the natural structure and function of a stream, leading to changes in physical, chemical, and biological conditions both upstream and downstream of the dam. The effects of dams vary depending on their size and ecological and environmental setting. Some of the dominant impacts include:

1) Reduction in sediment and woody material transport; 2) Change in water temperature and flow regime; and 3) Creation of a barrier to upstream and downstream movement of organisms and nutrients. Dams affect stream fish communities in many ways, but two of the primary mechanisms of direct impact are the alteration of stream habitats above and below dams and fragmentation of stream fish habitat and populations. It is commonly viewed that the combined effect of dams on stream fish communities is to reduce biodiversity and reduce productivity of valued fisheries. The problems for policy decisions where the benefits of dam removal or fish passage must be weighed against the cost of these management actions. Many watersheds contain multiple dams, but the lack of information makes it difficult to prioritize restoration activities. Fragmented populations experience reduced gene flow, resulting in lower effective population sizes and eventually deleterious effects of inbreeding. The impact of habitat alteration on fish populations and communities has received less attention, however. This is particularly true for small dams (e.g., <10 m in height) which have received less study than larger dams, despite the vastly greater number of small dams in India.

Keywords: dam, migration, habitat, biodiversity, inbreeding, stream

Email: jeets95@gmail.com

WC-3

PVC geomembrane for aquaculture in sub-montane Himalayan region

Sudhir Raizada
National Bureau of Fish Genetic Resources
Canal Ring Road, Teli Bagh, Dilkusha PO, Lucknow – 226 010, India

Water conservation is one of the most important issues in the 21st century. Aquaculture that requires large volume of water needs to be operated on rational basis so that water may be conserved to maximum possible extent. The requirement of water in aquaculture ponds, however, depends on several factors like size of the pond, seepage, evapo-transpiration and exchanges rates. The soils found in the sub-Himalayas ranges are of diverse nature and are in general moderate to highly permeable and poor in nutrient availability making it unsuitable for aquaculture. Such soils could be reclaimed for aqua farming if dug out ponds are lined with impervious geomembranes not only for the retention of water but also for effective nutrient management. Several types of geomembranes are now-a-days available globally like LDPE (Low-density polyethylene), HDPE (High-density polyethylene), PVC (Polyvinyl chloride), PP (Polyurea and Polypropylene) and Butyl. Each type of geomembrane material has

different characteristics which affect use and installation procedure, lifespan and performance. Amongst all the geomembranes, PVC liner is the best for mountain regions as it comprises of an amorphous material, highly elastic and is not subject to environmental stress of cracking particularly in colder climate. While there are multiple uses of geomembranes in industry and agriculture but rarely it is used for aquatic Farming owing to higher cost and no consideration is given to the value of water and cost effectiveness during long use. A good quality geomembrane like PVC and HDPE totally stops water percolation and thus minimize cost of water filling and nutrient wastes. PVC geomembranes are normally available in the thickness of 0.5-1.0 mm with a width of 3-5 meters that can be used for lining of small to large ponds. It can be sealed by soldering method as well as solution binding before and after installation. They are non-toxic and can be used with and without soil base depending on species preference. The performance of geomembranes have been tested with number of fresh, brackishwater and marine species and its suitability has been assessed at the sites of poor quality soils in many part of the world. In mountain regions, this membrane can be used for developing aquaculture ponds and race-way structures over the poor quality soils particularly for IMC, chinese carps, common carp and trout farming.

Keywords: Geomembranes, PVC liners, aquaculture, seepage control, nutrient management

E-mail:

WC-4

Study on water budgeting and water management for trout raceways at experimental fish farm, Champawat

N.N. Pandey, S.K. Srivastava, S.K. Gupta
Directorate of Coldwater Fisheries Research (ICAR)
Bhimtal-263136, Nainital, Uttarakhand, India

One of the most important prerequisite for the successful trout farming is availability of year round uninterrupted supply of clean water which should be free from pollutant and suspended matter with high dissolved oxygen. Study was conducted at experimental fish farm Champawat during the year 2009-10. The required quantity of water was calculated on the basis of the fish biomass. To hold one ton of fish nearly 3 liters/second of water flow is sufficient at an average temperature of 15^{0}C. This requirement gets further reduced at the lower temperatures. The water flow also varies with the life stages of trout. Some of the estimated water requirement for trout culture is 1.0 L / min/kg of trout without aeration or 0.3 l/min/kg of trout with aeration. With a target of one ton trout production having the size of 400-450g in two years, 3000 yearlings and 400 kg broodstock for the 1.5 lakh eyed ova, the total calculated water requirement of the farm is 164 m^3/day. During normal days about 300 m^3/day water is available from the feeder stream, but in the lean period (April- June) only72 m^3/day water will remain available. The total drain water from the trout rearing unit will be 147m^3/day after 10% loss in evaporation and seepage. In general, 20-30% fresh water is needed in any RAS unit to maintain the proper water qualities viz. temperature, pH and trace elements. 40 m^3/day out of available 72 m^3/day in the lean period would be used for trout unit and rest 124 m^3/day requirement would be met out by recirculatory water. Hence, 124 m^3/day drain water is to be recirculated for the proper culture operation especially in the lean period to get the targeted trout production.

Keywords: fish biomass, lean period, recirculated

E-mail: nityanfish@yahoo.co.in

WC-5

Water use optimization: Key to success of hill aquaculture

Raghvendra Singh[1]*, Monika Gupta[1], N.N. Pandey[2] and Santosh Kumar[2]
[1]Central Institute of Fisheries Education, Mumbai
[2]Directorate of Coldwater Fisheries Research, Bhimtal Uttarakhand

Water is the most widely distributed substance on our planet and plays a vital role in both the environment and human life. But today's world is facing a serious problem of water crisis. So, optimizing the use of water is need of the hour. Aquaculture systems always need huge quantity of water which is generally met with ground water and this ground water is a scare resource especially in hill region of Uttarakhand state. Although the state is bestowed with lot many natural water resources comprising rivers, lakes and reservoirs in which fish culture can be practiced effectively through cage culture systems to optimize the use of natural waters. Directorate of Coldwater Fisheries Research, Bhimtal is doing pioneer work on this and rearing golden mahseer and snow trout in cages installed in Bhimtal lake. Other innovative techniques like biofloc systems which run on the principle of zero water exchange by maintaining a certain C:N ratio can also be applied to optimize the use of water in aquaculture. Aquaponic, an integrated system of aquaculture and hydroponics is a wonderful technique for optimizing the use of water. In this system plants grown hydroponically clean up the water which is again sent back to fish culture unit. Rainwater harvesting in hill region can provide sufficient quantity of water for aquaculture practices which otherwise will be waste. In hill region of Uttarakhand soil profile is generally comprise of rocks and stones which cause heavy seepage loss from ponds which very often demoralizes farmers to adopt the fish culture practices. Construction of polytanks can be the best possible solution hence making it easy to adopt by poor farmers having limited resources. These various ways to optimize the use of water which not only solve the problem of water scarcity but will also speed up the pace of fish production in hill region. The things only needed are the conversion of these techniques into technologies and awareness among people to adopt them effectively.

Keywords: cage culture, biofloc, aquaponic, polytanks, awareness

*** E-mail:** shakya.raghav@gmail.com

WC-6

Water Management Measures for Better Agricultural Productivity

Ashok K. Nayak, S.K. Srivastava and Ashwani Kumar
Directorate of Water Management
Chandrasekharpur, Bhubaneswar – 751 023, Odisha

Water resources are important natural resources which are essential for living organisms and natural habitats. It is the most precious gift of the nature and a basic need for the human existence. It is used for domestic activities, agriculture, industry and other commercial activities. Out of the total freshwater available, which is around 3 percentage of the total water on the Earth, most of these lies in deep and frozen in Antarctica and Greenland, only about 0.26 percent is available in rivers, lakes and in soils and shallow aquifiers where as about 22.6 percent in the form of groundwater which are readily usable for mankind. The annual rainfall in India is 120 cm but due to its uneven distribution, demand for groundwater has increased for all purposes like drinking, irrigation and also in industries. The gross water demand for all users in India is expected to grow up from 750 billion cubic meter (BCM) in the year 2000 to 1027 BCM by 2025. The gross water demand for irrigation sector is estimated to be 730 BCM by the year 2025. This requires an efficient use of water to increase the water demand and water

productivity. The multiple use of water and its conjunctive use are essential to reduce the water demand. Drip irrigation and sprinkler irrigation are efficient water saving technologies for better water productivity. The water conservation refers to reducing the usage of water and recycling of waste water for different purposes such as cleaning, manufacturing and agricultural irrigation. The water harvesting structures are required to conserve the water resources for its better utilization. Recycling of industrial water and waste water treatment is necessary to avoid water pollution and to increase the water productivity.

Keywords: Water, Productivity, rainfall, industrial waste, recycling

Email: aknayak75@rediffmail.com

SE-1

Recreational Fishing as Tourism

Adita Sharma
Ph. D. Scholar, Deptt. of Fishery Biology, College of Fisheries, G. B. Pant University of Agriculture &Technology, Pantnagar – 263145 (Uttarakhand)

Rivers and lakes of the hill states harbour highly priced sport fishes like world famous mahseer and brown trout etc. Hence, there is need to develop sport fishery sites along the river stretches and in some lakes for promotion of sport fishery based tourism activities. There is still enormous potential exist for development of the sector in organized manner. Entrepreneurs can develop fish pond on the way to the tourist sites with stocking of mahseer and trout with other infrastructural facilities for the tourists. Fish culture based eco-tourism is emerging potential area for employment generation. Farmers in Kullu-Manali (H.P.) and some high altitude destinations in Sikkim have developed their trout farms located near highways or tourists places as a sport fishery enterprises. They 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. There is further scope for development of such sport fishery enterprises in the region.

Key words: Recreational fishing, Tourism, mahseer

SE-2

Sport Fishery & Eco-tourism in Uttarakhand

Anita
College of Fisheries, GB.P.U.A&T
Pantnagar, U.S. Nagar (Uttarakhand)

Uttarakhand state is endowed with the bounties of nature: lofty snow peaks, aesthetic bugyals or alpine meadows, imposing glaciers, scenic conifer forests, numerous rivers that offer opportunities for angling and water sports hence supporting rich biodiversity with a variety of flora and fauna, which attracts tourists. The state is the birth place of 4 major river systems Ganga, Yamuna, Sharda and Ramganga. Sport fishing is a source of recreation to millions of people from India and abroad and it deserves the status of family recreation. The recreation is an important element of enjoyment and satisfaction derived from the sport fishing. The medical authorities also say it is healthy for people to go fishing. Sport fishing satisfies diverse tastes and pursuits. Sport fishing includes fishing &

angling an adventurous sport. The sporting fish includes Mahaseers, trouts and large catfishes etc. The streams and rivers of Uttarakhand have many sport fishes such as the introduced rainbow trout *(Onchorynchus mykiss)*, snow trout (*Schizothorax richardsonii* found throughout Uttarakhand and *S. kumaonsis* endemic to Kumaon), Indian trout *(Barilius bola)*, goonch *(Bugarius bugarius)*, black mahseer *(Tor chelynoides)*, red-finned tor mahseer *(Tor tor)* and yellow-finned golden mahseer *(Tor putitora)*. Presently we can enjoy it in various wild life sanctuaries. Jim Corbett is famous wildlife reserve for angling along with variety of wild life. In Corbett, mahseer fishing is the place where we can easily find Goonch, silver mahseer& black mahseer although fishing is not allowed. Dodital (Uttarkashi) is a popular destination besides the high altitude lake and is approachable from sangamchatti by a 22 km trek at an elevation of 3045m. It forms popular site for trout angling. Sites on Ramganga, (kalagarh forest division) & Ganga attract a large number of anglers. Angling tourism has been promoted for the conservation of mahseer a popular game fish in the mountain rivers. Pancheswar, 40km from Lohaghat located at the confluence of Saryu and Kali river has camping sites & is an ideal site for mahseer angling. To promote angling areas replete with Mahseer, rivers like Ramganga, Kosi, Ganga, Kali, Nayar have been identified and conservation measures like ranching are being taken. Apart from this holding of community activity like seminars, fishing competition and educational camps, encouraging people involved in conservation methods by granting awards for successful performance, and promoting national and international tourism through sport fishing are steps towards conservation. Besides this issuing of fishing license by the state fisheries department is another task. Permits for angling are issued by the respective Divisional Forest officer. Furthermore, there are conditions that all fish caught must be released into the water, and anglers are restricted to catch a specified number of fish per day. It should be cleared off immediately whenever the angler need the license for game fishing, so that the department can encourage the participants as well as gain the revenue to the state simultaneously.

Keywords: Sport fishing, mahseer, trout, Jim Corbett, angling

LG-1

Pond Based Integrated Farming System: An Important Approach towards Sustainability of Agriculture in Uttarakhand Hills

Deepa Bisht
G B Pant Institute of Himalayan Environment and Development
Kosi-Katarmal, Almora – 263 643 (Uttarakhand)

The hilly region of Uttarakhand is characterized by rugged, undulating terrain, small isolated villages, an agro pastoral economy, small, fragmented land holdings and dry farming with little irrigation. Land is the major resource in the region and agriculture is the mainstay of the people and farming has been subsistence-oriented. However, very low productivity of cereals and millets from the age old farming system is no longer sufficient to ensure subsistence, particularly to small and marginal farmers' family. Further, average farm size is shrinking and there are limited possibilities of increasing additional area under cultivation. Under the circumstances, efficient utilization of available meager resources and maximization of production of diversified products from a minimum area seems to be imperative. Pond based integrated farming system (IFS) models evaluated in the mid hills during recent past has shown promise. Efficient integration of fishery with livestock, poultry, vegetable crops, fodder grasses and other complementary enterprises like mushroom production, vermicomposting etc. clearly showed advantage over conventional system of cropping under rainfed conditions. Besides household consumption, income of Rs 31048 was generated annually through Integration of composite carp culture with hybrid layer variety Kuroiler (3ooo birds/ha), vegetable cultivation (600m2), mushroom production and vermicomposting by the beneficiary farmer. Besides income and employment generation, diversified farm produces improved nutritional status of household.Based on this and various other case studies in the region, it is concluded that IFS

approach is better than the traditional farming system in its contribution to productivity, profitability, employment generation and nutritional security for small and marginal farmers. Diversification of existing farming system by developing suitable integrated farming system models seems to be need of the day to cope up with ever increasing demand for diversified agricultural products.

Keywords: productivity, kuroiler, vermicomposting

E-mail: deepabisht1234@rediffmail.com

LG-2

Assessment of women's participation in fishery sector in two North Eastern States of India

BibhaChetia Bora[1], Ranjita Bania[1], Rupak Nath[2], Rimjhim Gogoi[1], Sunmoina Bhuyan[1]
[1]Fisheries Research Centre, Assam Agricultural University, Jorhat, Assam
[2]St. Anthonys College, Shillong, Meghalaya

Participation of women in agricultural and allied activities is an issue of global concern. In developing countries like India, rural women are the major workforce in agricultural activities. However, their contribution to the mainstream agriculture does not get the desired recognition. So women are often referred to as the 'invisible hand' in these activities. Although, in recent years there is substantial upliftment in the socio-economic condition of women folk, the gender imbalance is still noteworthy not only in corporate or govt. sector but also in agriculture and allied activities like fishery, livestock farming etc. With that background a study had been under taken to assess the women's participation in fishery sector in two North Eastern states viz. Assam and Meghalaya with two different types of societal pattern i.e. patriarchal society in Assam and matriarchal society in Meghalaya. In government sector of these two states, there is remarkable gender imbalance in staff pattern. In Assam fishery sector, with female staff occupies only 2.06% of the technical staff, 0.93% of the field staff and 5.24%of the total strength against 97.94% male technical staff, 99.07% field support and 94.76% of the total. At the same time the statistics of women in Meghalaya is much better with 25.81% technical staff and 5.88%f field staff. The study exposed the fact that women's participation in fishery activities related to capture varied with the pattern of society. In matriarchal society, women take major role in marketing and small scale fish capture. However, in majority cases of the patriarchal society, men take the lead in capture and marketing of fish. Women participation in scientific culture practices in both the cases is found to be quite negligible. While scientific fish farming is recognized to be a women friendly livelihood option, women participation in this sector is quite unsatisfactory. It is therefore essential to address this serious imbalance in terms of gender. Mainstreaming of gender will definitely contribute substantially to bring about the desired transformation of the scenario of fisheries and aquaculture of the region. So it is the need of the hour to formulate some strategy to bring the women folk to the mainstream aquaculture which will ensure not only better production but also employment opportunity to the womenfolk of this region.

Keywords: womenfolk, patriarchal, matriarchal, gender imbalance

E-mail: drbchetia@yahoo.com

LG-3

Enhancement of Women's role in Fisheries

Akansha Bisht
College of Fisheries, G.B.P.U.A&T
Pantnagar (Uttarakhand).

Women play key role in the development of fisheries sector in addition to their role of sole household managers in most fisher families. Although the involvement of women is limited in capture fisheries, their supportive role in active fishing has increased man folds with the advent of mechanization and enhancement of multi-day fishing in marine fisheries, The upcoming of women into the labour driven segments of fishing sector has increased over the years The irregularities in the earning pattern of their men counterparts, coupled with need for 1ivellhood sustainability, forces most of the worn en to earn from a variety of fishery relate d activities. The course of changes in the role of fisherwomen has traversed during the major phases of technological transformation in household management as well as pre and post-harvest activities in the fisheries sector. The indirect role women play are concerning decision making, financial management, family welfare, net making, running petty shops and mobile food supply for the workers at the landing centers and fish markets. The more direct involvement of women are in post-harvest related activities viz. prawn peeling, curing, fish trading, net making, fishing in the canals, picking of clam shell, fish trading, export oriented works, small scale entrepreneurship, fish sorting, grading and processing thus making value - added products. Apart from these women are actively involved in seaweed collection, aquaculture and coastal aquaculture. Coastal aquaculture involves the culturing of marine animals in the open sea as well as brackish water areas. Thus the occupational pattern of women has undergone a structural change with the shift from net mending to fish culture, marketing and processing. This is attributed to the overall development of aquaculture and increase in the exports of marine products. Women add a lot to fisheries sector amidst their various roles played by them. A number of measures are proposed to deal with social insecurities and obstacles confronted by women and to improve their economic, social and cultural status. Firstly by identifying ways and means for the promotion of equal opportunities for women in the fisheries sector and providing awareness campaigns on alternative income generating activities, savings and investment, mobilizing women and helping them to take up self-employment activities, provision of technical know-how, micro-finance and market links, training women on 'leadership' and promoting women's participation in development decision making are some of the measures that could be adopted towards this end.

Keywords: active fishing, coastal aquaculture, fisheries sector

E-mail: muskaan-bisht2yahoo.com

LG-4

Role of Women in Fisheries

Meenakshi Kumari
Department of Aquaculture, College of Fisheries, G.B.P.U.A&T
Pantnagar-263145, Uttarakhand, India

The fisheries sector plays an important role in the alleviation of poverty, achievement of food security and enhancement of economic growth and women constitute an important workforce in fisheries and contribute to the sustainable use and management of fishery resource.Women play significant roles in all aspects of fisheries both in the artisanal, small scale sector and in commercial sector,roles that remain unarticulated and unrecognized.The productive roles of women in fishing collecting seaweed and other aquatic resources,processing and marketing the

fish catch,making and repairing nets and gears, baiting long lines,helping in the preparation for fishing trips and in unloading and sorting the fish, fish selling is almost exclusively the domain of women. They play a larger role than men in aquaculture but lesser role in capture fisheries. Women contribute significantly to household incomes and economies.Despite their presence at all levels and in all areas of the sector, invaluable contribution ofwomen is remained unnoticed. Their contribution to the sector reaches far and wide yet this contribution have hardly been acknowledged,thus hampering targeted development assistance to improve women's contribution.Women add a lot to fisheries sector amidst their various roles played by them. The emphasis should be on helping women to participate in production activities without any hindrance to their community management role.Women must have roles in resource management as this becomes more participatory and inclusive. Location specific and need based training programme for fisherwomen should be organised to enhance the awareness and technical know-how enabling them to start self-generating gainful employment ventures in aquaculture and post harvest sector of fisheries.

Keywords: Socioeconomic development, Employment, Technological upgradation, Aquaculture management

Email: meenuhld@gmail.com

LG-5

Paddy-cum-Fish-Millet-Vegetable Farming "a sustainable approach for resource conservation and livelihood generation" in Apatani valley of Arunachal Pradesh

V.K.Misra[1], A.Pratap[1], N.D. Singh[1] and A.N.Tripathi[2]
[1]Krishi Vigyan Kendra West Kameng, Dirang, Arunachal Pradesh – 790 101
[2]Krishi Vigyan Kendra Lower Subansiri, Arunachal Pradesh

The Apatanitribes of Arunachal Pradesh, who is the only agrarian tribe of the state practicing sedentary agriculture in the form of paddy- cum fish farming in the valley lands, and linked this system with animal husbandry comprised of mithun (*Bosfrontalis Lam.*), cattle, swine and poultry etc. which provides an example of highly evolved indigenous farming system. The Apatani valley (26°50′-98°21′N latitude and 92°40′ and 94° 21′E longitudesat) is placed between River Panior and Kamla at an altitude of 1554 m. in the Lower Subunsiri district of Arunachal Pradesh comprising seven large villages; viz. Hong, Biila, Dutta, Hija, Hari, Mudang-Tage and Michi-Baminwith a temperature range of 14-35ºC favouring both warm and cold-water fisheries. The paddy fields are opposite of the village following terrace after terrace each other in uninterrupted succession where men and women both take part in agricultural works. The total water area of Apatani Plateau is 715.7 ha and rice-fish culture covers approximately 592.0 ha. Where some local fishes as well as all the strains of Common carp *(Cyprinus carpio)* are grown along with local rice cultivars, *viz. Amo, Mypia* and *Pyapee* in addition to millet and various type of vegetables on the field dykes. This type of farming system provides not only the fresh supply of vegetable and fish for their own use to improve the nutritional status but also helps in socio-economic upliftment by selling the surplus production of paddy and millet along with fish and vegetable.Beside these benefits this system is helpful to reduce the use of various pesticides especially in paddy crop, decomposition of rural organic waste, recycling of crop residue, protection from the soil erosion and land slide by tending of plots by means of bamboo and pinewood. The above facts indicate that this type of agro-ecosystem is a good example of ecologically sound and sustainable farming system for the farmer's community of hilly states of the other part of country where the temperature is suitable for such type of farming.

Keywords: Sedentary, sustainable, crop residue, agro-ecosystem,succession, Common carp

Email: Vipin_misra_81@yahoo.com

LG-6

Contribution of women for food and livelihood security in hills through aquaculture activities

Monika Gupta[1], N.N.Pandey[2], R.S.Haldar[2] and Raghvendra Singh[1]
[1]Central Institute of Fisheries Education, off Yari road, Versova, Andheri (W)- 400061, Mumbai
[2]Directorate of Coldwater Fisheries Research, Bhimtal-263136, Nainital, Uttarakhand

An attempt was made to assess the participation of woman in hill aquaculture and its impact on the food and livelihood security to the hill dwellers. Study was conducted in 7 hill states namely J&K, Himachal Pradesh, Uttarakhand, Sikkim, Manipur, Meghalaya and Arunachal Pradesh. Fisheries and aquaculture, a fast emerging sector of the mountain region has immensely contributed for food as well as nutritional security in hills. Agriculture based activities with smaller land holding is a major source of occupation. A large number of poor women are engaged in traditional aquaculture activities and make an important contribution to the rural economy.Women participate directly in fish feeding, retail marketing and processing of fish and performed 46-80% of the total job. They are also indirectly involved in net meanding, boat rowing, pond construction etc. Women earn a significant supplementary income from these activities and increase the family income considerably. In North East states, women are fully engaged in traditional "Jhora fishery" as well as in retail marketing of fresh fish in their petty shops. J & K and Sikkim states are leaping forward for trout farming due to the active participation of women. In North East states, 48% integrated fish units and trout raceways are ownered by women. Therefore, women are a largest workforce behind the aquaculture production in hills. Most of the income of these fisher women is being spent for running their family. Women are instrumental for aquaculture activities in hills, which provide fish for food and opportunity of livelihood. In order to ensure better participation of women, awareness, training and infrastructural development is required.

Keywords: livelihood security, Jhora fishery, women, awareness

E-mail: monika_gupta22@yahoo.com

LG-7

Role of Manipuri women in fisheries and their detrimental way of fishing

Shaikhom Inaotombi Singh
Department of Zoology, DSB Campus, Kumaun University
Nainital-263002

The Manipuri people depend greatly on fish and shellfish for protein. Women in Manipur were directly or indirectly engaged in capture and culture fisheries activities such as making fish nets and gear, preparing fish feed, catching fish, processing (including drying and fermentation), transporting and marketing fish, etc. They contributed in generating income for the survival of the family.Unlike other parts of the India, Manipuri women were involved in smaller scale capture fisheries activities without the support of men. *'Nupieen'* (means women's dip net) and *'Long'* (traditional trap) are common fishing gears used by women only. Fish vendors working for their families are almost run by women. The available fish markets *'ImaKeithel'* (means mother's market) are only for women and are well developed. 24.20 % of the total staff working in fishery department is women which is quite high as compare to overall female staff strength in India (8.96%).The uncontrolled mesh size of traditional gears uses by women that captured all sizefishes lead to detrimental in fisheries. This paper presents the tasks carried out

by women and discusses the issues related to overfishing due to traditional fishing techniques. It is completely necessary to create an environment in which ethnic women were able to effectively participate in economically important activities such as taking loans, and learning culture and fishing techniques and awareness.

Keywords: Fisheries, Roles, Manipuri women, Income, Fishing techniques.

Email: Saikhom_inao@yahoo.co.in

LG-8

Economic analysis of integrated Poultry-Cum- Fish culture under mid hills conditions

U.P. Singh[1], H.C.S Bisht[1] and N.N. Pandey[2]
[1]Department of Zoology, Kumaon University, Nainital-263001, Uttarakhand
[2]Directorate of Coldwater Fisheries Research, Bhimtal-263136, Nainital, Uttarakhand

Study was conducted in ponds having polyculture of exotic carps with or without integration of poultry in Champawat district of Uttarakhand. A net production of the poultry birds was achieved as 22kg from the integration of 10 birds and 44 kg from the integration of 20 chicks. The highest average expenditure incurred on feed which accounted for 64.7%, 65.34%, and 66.7% for the non integrated pond and integrated pond with 10 chicks and 20 chicks. The total returns from the ponds were Rs. 8712/-, 15648/- and 23745/- in non-integrated pond and integrated pond with 10 chicks and 20 chicks, respectively. Net profits of fish production in the present experiment was found as Rs. 5002/-, 10598/-, and 17455/- from 100m2 pond area in non integrated pond and integrated pond with 10 chicks and 20 chicks, respectively. The net return over the operational cost was calculated as 134.8%, 209.9% and 277.5 % in non-integrated pond and integrated pond with 10 chicks and 20 chicks, respectively. The polyculture of exotic carp species is technically viable and economic feasible with integration of 20chicks/ $100m^2$ fish pond area with an optimum fish stocking density of 3 fish/m^3. The integrated poultry cum fish farming offers the better opportunity of the nutritional as well as livelihood security with better economic return as compare to fish farming alone for the rural people of hills.

Keywords: polyculture, exotic carps, operational cost, stocking density

E-mail: upendrapsingh@yahoo.com

LG-9

Economic analysis of Carp farming in mid hills of Kumaon region of Uttarakhand

K.S. Mehta[1], H.C.S Bisht[1] and V.K. Singh[2]
[1]Department of Zoology, Kumaon University, Nainital, Uttarakhand (India)
[2]Krishi Vigyan Kendra, Lohaghat. District- Champawat, Uttarakhand (India)

The study was conducted with the major objective of determining the production performance of Polyculture of exotic carps with appropriate stocking density and species combination. Cost and returns of production from the experimental ponds were calculated per $100m^2$ area in 10 months duration. The total operational cost was recorded as Rs. 3200/-, Rs. 4150/-, Rs. 1980/- and 3200/- for the pond having stocking density of 3 fish/m^3, 5 fish/m^3, 10 fish/m^3 and farmers pond of 3 fish/m^3 density. The net return over the operational cost was calculated as 114%, 44.4%, 78.5% and 1005 from the ponds having stocking density of 3 fish/m^3, 5 fish/m^3, 10 fish/m^3 and farmer's pond of 3 fish/m^3 density, respectively. Data on the economics of experimental and control ponds reveal that the polyculture of exotic carp species is economic feasible with stocking density of 3 fish/m^3 in species combination of 30:40:30 for silver carp, grass carp and common carp respectively with a net return of 114% over the operational cost.

Keywords: exotic carp, Cost and returns, operational cost

E-mail: kishore-mehta26@yahoo.com

National Seminar on

Mountain Fisheries: Challenges and Opportunity for Livelihood Security

Organized by

Directorate of Coldwater Fisheries Research

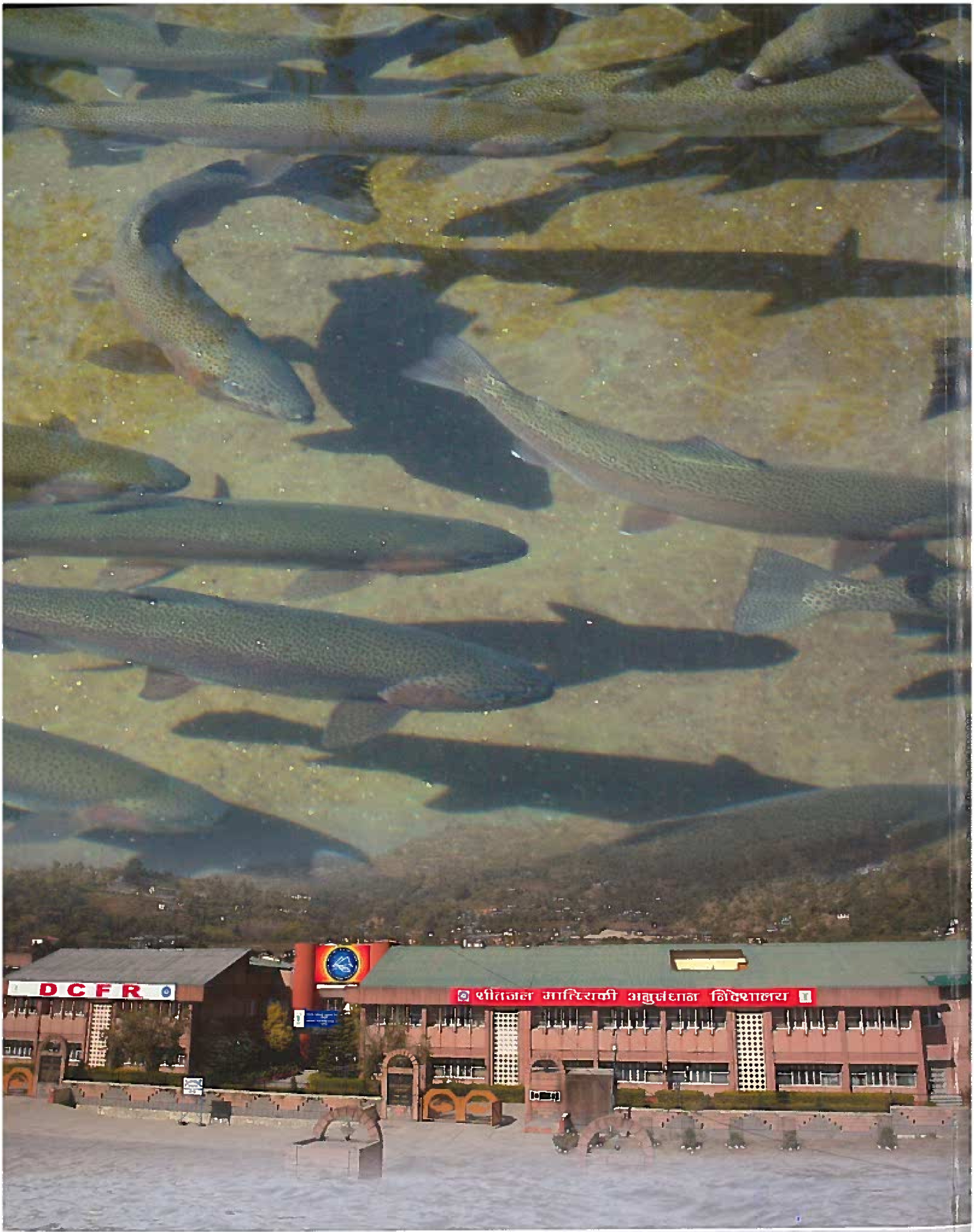
5-6 November, 2012

PROGRAMME

Venue: DCFR, Auditorium

Day I	November 5, 2012
Silver Jubilee Flag Hoisting	
Registration	
Inaugural session	
Silver Jubilee presentation by Director, DCFR	
Technical Session – I **Theme: Recourse Assessment**	
Lunch Break	
Technical Session – II **Theme: Aquaculture**	
Tea Break	
Technical Session – III **Biotechnology and Fish Health**	
Cultural Programme	
Dinner	

Day II	November 6, 2012
Technical Session – IV **Theme: Water Management and Conservation**	
Tea Break	
Technical Session – V **Theme: Sport Fishing and Ecotourism**	
Technical Session –VI **Theme: Livelihood Security and Gender Issues**	
Lunch Break	
Plenary session and Recommendation	
Valedictory	
Tea break	



Directorate of Coldwater Fisheries Research

(Indian Council of Agricultural Research)

Bhimtal -263 136, Nainital (Uttarakhand)

Phone: 05942- 247280/247279, Fax: 05942- 247693

Email: director@dcfr.res.in, Website: www.dcfr.res.in