COLDWATER FISHERIES RESEARCH AND DEVELOPMENT IN NORTH EAST REGION OF INDIA

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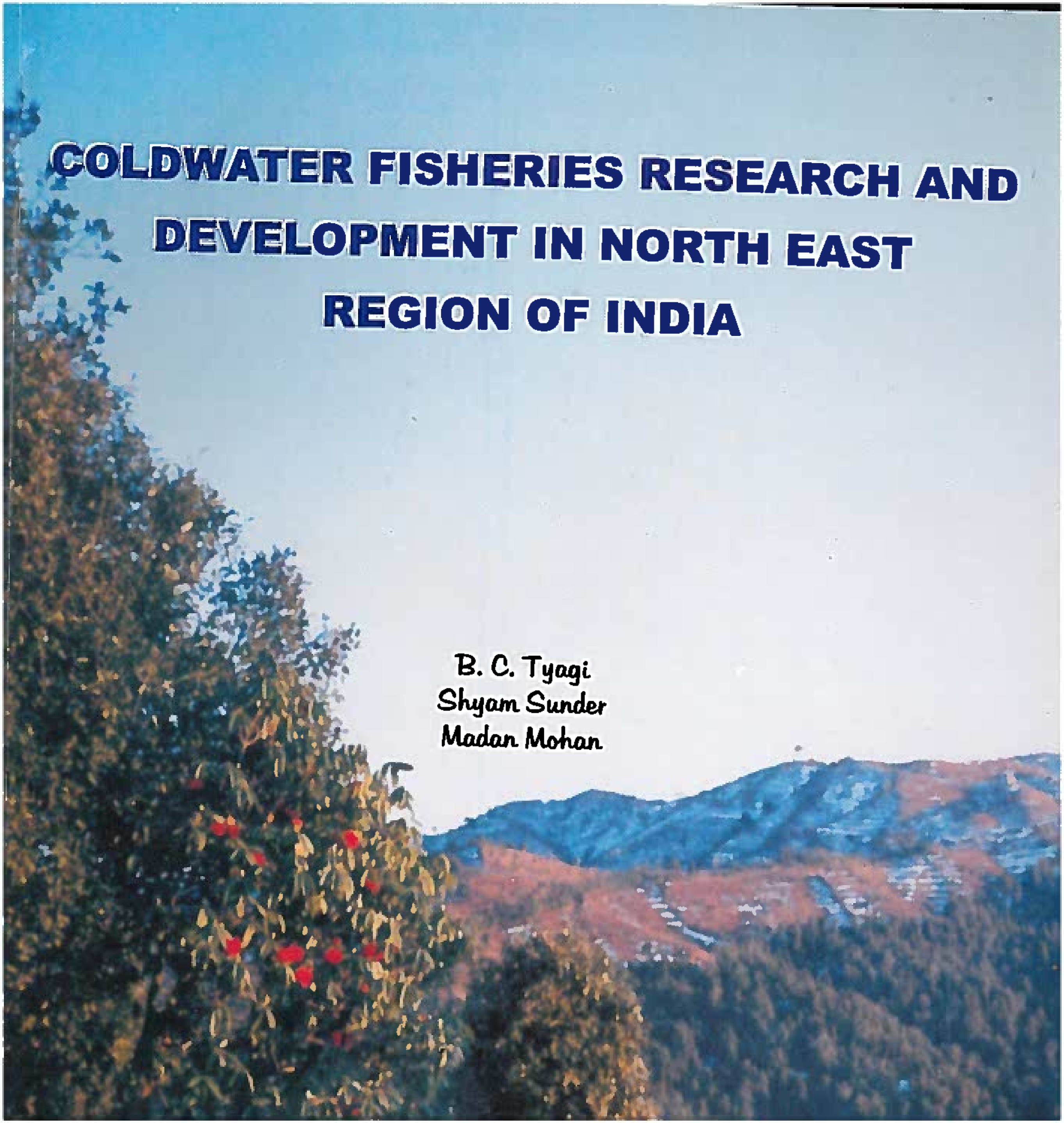

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Editors

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MESSAGE

The North East region occupies an important position in research and development programmes of Indian Council of Agricultural Research. The fisheries resources in general and coldwater sector in particular have immense potentials in the States of Arunachal Predesh, Manipur, Meghalaya, Nagaland, Sikkim and some parts of Assam and Mizoram. The population is predominantly tribal and more then 80% derive their livelihood from agriculture and allied activities. Majority of the population prefer fish in their diet. In order to augment the fish production in these States, it is essential to adopt latest fish culture cum capture fisheries technologies utilizing local inputs and skills. The National Research Centre on Coldwater Fisheries has developed composite carp farming system suitable for Himalayan region (800-1800 m asl), flow through hatchery for mass scale seed production of Himalayan mahseer and snow trout, breeding and culture techniques for rainbow trout and other coldwater fisheries related issues are also being investigated. These result oriented fisheries technologies can be demonstrated initially and implemented through the trained fisheries personnel.

I am very happy to know that NRCCWF is conducting need based off and on campus training programme for fisheries personnel and farmers from NEH region. The publication of the lectures delivered by the subject specialists in the form of a book entitled **Coldwater Fisheries Research and Development in North East Region of India** will be of immense value for the fisheries personal in particular and for others having interest in coldwater fisheries in

PREFACE

The North East region (Lat. 21.570 29.300 N; Long. 880 97.300 E) comprise the states of Arunachal Pradesh, Assam, Manipur, Mizoram, Meghalya, Nagaland, Sikkim and Tripura cover an area of 2.62 lakh sq. km. The total population is 39 million (2001) and more than 60% are scheduled tribes. The predominating tribal population lives in rural areas (88%) and exhibit extreme racial, social, cultural, linguistic diversity. Sources of livelihood are agriculture and allied activities. Majority of the population prefer meat or fish in their diet. At present there is a wide gap in production and demand of fish, therefore, fresh and dried fishes are being imported from other states and Bangladesh. The crop potentials are totally inadequate. 'The traditional way of agriculture', shifting cultivation and major areas under forest leave little scope for more tillage.

The North East India is mostly hilly and only about 30% area is plain on both sides of the river Brahamputra and Barak. Mountain and hills cover most of Arunachal Pradesh, Mizoram, Meghalya, Nagaland and Sikkim. Some part of Assam, Manipur and Tripura also are hilly. The topography of the region varies from few meters from sea level to Snow Line Mountains and has different kinds of agro climatic zones. This area receive highest rainfall during prolong rainy season from March to October. As a result aquatic resources in form of rivers, streams, lakes, reservoirs, bheels, swamps and ponds are vast and varied. Icthyofauna is rich and more then 267 fish species have been reported. Commercially important group of fishes are Mahseer, *Schizothorax spp.*, *Barils* and Carps.

In this background and context, it may be inferred that the region has vast potentials for fish production; people are interested in culture and open water fisheries and central and state agencies are eager to develop aquatic resources along with crop, forest and industrial development. It has been recognized that region need special attention because of strategic location and fragile ecological status. In order to maintain balance between regional identity of the population and pace of development it seems appropriate to adopt latest technologies based on local inputs and skill.

The coldwater fisheries occupy a prominent position especially in Arunachal Pradesh, Meghalya, Nagaland, Sikkim, Manipur, part of Assam and Mizoram. National Research Center on Coldwater Fisheries, Bhimtal recently has stepped in NE region and doing hard efforts to collect more and more information on coldwater fisheries, developing close liaison with the agencies, authorities and the locals who have common interest and stake in cold water sector development. The aim is to prepare a blueprint for coldwater fisheries development for the region

Likewise, the north east region also is facing the problems of unwarranted fishing, use of destructive fishing methods in open waters, ecological degradation /changes of aquatic habitats owing to river valley projects, changes in land use patterns, least regulatory measures thorough evaluation in light of scientific investigations. Of course, application of tools and techniques to enhance fish production in cold waters of North Eastern region is essential but it is also necessary to ensure that there is no loss to itchyobiodiversity. Putting all the research and development efforts together and creating and disseminating knowledge to the concerns may help in achieving the aim. More emphasis is to be given to HRD programme.

The scientists of NRCCWF are addressing these issues. The programme like qualitative and quantitative assessment of fisheries resources, up-gradation of farming practices, demonstration of latest culture, breeding and seed production technologies, off and on campus-training programme for fishery personnel and farmers are underway. The high altitude lakes in Sikkim are under investigation. This institute and Arunachal University are jointly conducting rapid survey of fish and fisheries resources of Arunchal Pradesh. Composite Carp Farming technology capable to produce 0.6-0.9 kg fish/m in mid Himalayan region has been developed. These result-oriented programmes can be implemented through the trained fisheries personnel. This institute, therefore, conducting various training programme for the fisheries personnel from North East region. The lectures delivered by the subject specialist in such training programme are based on scientific knowledge and research experiences. Such training material has great value and can be utilized not only by trainees but others also who are having interest in cold waters. Therefore, a decision was taken to publish the material in the form of a book entitled **Coldwater Fisheries Research and Development in Northeast Region of India**. We were assigned to complete this endeveour.

We have made all efforts to complete this job with precision. At this point we like to express our gratitude to Dr. S. Ayyappan, Dy Director General (FY), Dr. V. Chitransi, ADG, (FY), ICAR, New Delhi and Dr, K.K.Vass ex Director, NRCCWF, Bhimtal for constant guidance and encouragements. We deeply express our thanks to the Directors of Fisheries Arunachal Predesh, Manipur, Mizoram, Sikkim, Assam and authorities of North Bengal University who not only deputed their officers but took very keen interest in the programme. We also thank to all the trainees who actively exchanged their views and knowledge. Due thanks are expressed to our colleague scientists from NRCCWF, Bhimtal and CIFRI Center Guwhati for giving scientific inputs and guidance in organizing this collaborative training programme. Our special thanks are due to Dr. M. Choudhary, Officer In charge, NER center of CIFRI, Guwahati for rendering all kind of help in making proper arrangements for trainees and resource persons. We also thank to all the staff of Guwhati center of CIFRI for helping us in conducting this programme. In the last, we express our sincere thanks to Mr. A. Joshi who helped in typing this manuscript and M/s Vikrant Computers, Haldwani for printing this publication.

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COLDWATER FISHERIES IN INDIA - STATUS AND PROSPECTS

K. K. Vass

INTRODUCTION

The country has significant aquatic resources in terms of upland rivers/streams, high and low altitude natural lakes, man-made reservoirs, both in the Himalayan region and Western ghats, which hold large population of both indigenous and exotic, cultivable and non-cultivable fish species. The biological productivity in high altitudes is constrained by number of factors however, in the foothills the biological productivity is quite high which can suitably be harnessed into fish biomass. The per unit production of coldwater fisheries to the total inland production basket is not very significant but it has the natural resources to make a dent and contribute to the economy of our hilly regions and uplands. The term "Coldwater Fish" vaguely refers to the members of the family Salmonidae, much sought after by the anglers all over world. In India, however, Cyprinids belonging to sub-family Cyprininae which inhabit streams, lakes and reservoirs receiving snowmelt water directly from their watersheds are also included in this definition. There are a large number of indigenous and few exotic species of fish, which frequent the rivers and brooks. Minor carps are important as sport and food fishes. These species are widely distributed both in the Himalayas and the peninsular plateau.

RESOURCES

Fish diversity

In comparison to warm water fishery resources, even the estimated area under coldwater fishery is very less but at the same time, their sustainable development

Table 1. Estimated aquatic resources holding coldwater fisheries

River / Stream (includes upper reaches of 16 big and small rivers in Himalayan & Peninsular region)	3885 km
Natural Lakes (about 30 high mountain & valley lakes both in Himalayan and Peninsular region)	20,500 ha
Reservoir - man-made (about 12 located in Himalayan and Peninsular region)	2,65,000 ha

There are 258 fish species both indigenous and exotic, belonging to 76 genera, reported from Indian uplands which are spread over in Himalayas and the Peninsular plateau. However, the list of some of the important fish fauna are tabulated below (Table 2) :

Table 2. Number of important coldwater fishes both indigenous and exotic

A Indigenous species	**Number of taxa / species**
1. Snow - trouts	10
2. Mahseers	04
3. Minor carps	04
4. Lesser barils / Minnows / catfishes	08
5. Loaches	05
B. Exotic	
1. Trouts	03
2. Others	04

Fish & Fishery

Majority of the coldwater fishes are caught individually by local fishermen from the rivers and streams and do not form fisheries of commercial importance. A few, however, such as the snow-trout (*Schizothorax spp.* and *Schizothoraichthys* spp.), large scaled barbels (*Tor* spp.), common carp (different phenotypes of *Cyprinus carpio*) and a few minor carps (*Labeo dero*, *Labeo dyochelius*) are some of the one man unit, so community fishing is hardly prevalent, thirdly the terrain in uplands having meager transport facilities makes transporting catches from production / collection site to nearby markets difficult. Therefore, fishermen invariably do not get the remunerative price for their catch, which forces them to sell the catch in nearby villages / towns.

An importance aspect of coldwater fish of the uplands is the opportunity the species provide for sport. Brown trout (*Salmo trutta fario*) rainbow trout (*Oncorhynchus mykiss* and certain species of large - scaled barbels are the principal species of sport value in Kashmir, Himachal Pradesh, Uttaranchal, North Bengal, Nilgiris, Kodai hills and Munnar ranges where the Indian and Foreign tourists annually visit in large numbers. In certain regions, sport fishery constitutes an important source of revenue. In Jammu & Kashmir trout alone contributes to about 40-50% of the State's revenue from fisheries.

Mahseer Fishery

Anglers regard the mahseer species as one of the finest sport fishes. In the western and central sectors of the Himalayas, the principal species of mahseer are *Tor putitora*, *Tor tor* and *Tor progenies. Neolissocheilus hexagonolepis* or katli is the main mahseer of the Eastern Himalayas. *Tor putitora* (golden mahseer) is the main species of the Indo-Gangetic drainage, *Tor khudree* is available in Southern region. Mahseer is a migratory fish running in the main rivers for spawning and it's distribution has more to do with the water temperature prevailing in the streams rather than the altitudinal range. The fish avoid very coldwaters (below 10^{0}C). The experimental fishing undertaken in different river systems in Himalayas indicate wide variations in catches (Table 3) .

Table 3. Catch per unit effort (g / man-hour) in different river systems

River / Fishery	Ramganga (w)	Saryu	Beas	Giri	Tsong	Nayar

Trout Fishery

Brown trout (*Salmo trutta fario*) and rainbow (*Oncorhynchus 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. Since trout fishery is only for recreation and catching them by net is strictly prohibited in both the regions. To provide adequate stocks to anglers, the streams, lakes and reservoirs are planted with eyed ova and fry of the two species of trout. The creel census data revealed that in two regions, the angler catches have declined throught the years and now ranged between 200 - 100 g/rod/hour per day in one kilometer length of fishable stretch. The analysis of catch data indicate that the average weight of brown trout in Kashmir and Himachal Pradesh was 415 g and 265 g respectively. The average weight of rainbow trout in the southern region ranged between 100 - 200 g. These figures indicate that the trout waters in the country abound in small sized trout, that is an alarming situation. But since early nineties, the country has taken up farming of rainbow trout in Kashmir and Himachal Pradesh and the fish is now available for food and farming.

Snow Trout Fishery

Snow trout is endemic to the Himalayas. It occurs in streams and lakes which receive snow-melt water from the Himalayas. Most of the species are of Central Asian origin. Ten principal species belonging to two genera viz., *Schizothoraichthys* and *Schizothorax* inhabit the Himalayan region. *Schizothoraichthys esocinus* is endemic to Kashmir and Ladakh while *S. progastus* occurs in Eastern Himalayas. *S. richardsonii* is distributed almost all along the Himalayas. The other species of snow trout *viz. Schizothorax longipinnis, S.curvifrons, S. planifrons* and *S. micropogon* are endemic to Kashmir and Ladakh. The data on experimental fishing in some Himalayan river systems reflect quite a variation (Table 3).

Common Carp Fishery

Arunachal Pradesh, Nagaland, Meghalaya, Tamil Nadu and Kerala. The third phenotype (leather carp, *Cyprinus carpio nudus*) is of very rare occurence. A good amount of data has been generated that introduction of *Cyprinus* been responsible for decline in local snow - trout fishery in some of the upland lakes. The commercial catches of *Cyprinus carpio* have increased to 70-80% in most of the upland lakes reducing the contribution of local variety to nearly 10%. 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 yield. This practices in some cases has increased the per unit productivity but resulted in sharp decline in indigenous fishery. Majority of fish production from the upland regions is fundamentally based on the contribution made by these exotic carps. On this, one would argue about the choice between increased fish productivity and preservation / conservation of indigenous biodiversity, both issues are equally important.

Miscellaneous fishery

This fishery in upland regions is mainly constituted by Lesser barils (*Barilius bendelisis chedra, B. vagra* and *B. shacra*), Indian trout (*Barilius bola*), Minor carps (*Labeo dero*, *L. dyocheilus* and *Crossocheilus latius latius*) and sucker - head (*Garra gotyla gotyla*). Their contribution to total catches is very minimal. *Barilius bola* has significantly declined in natural waters.

Trend in estimated coldwater fish production

The recent inland fish production in the country is estimated at 30 lakh tonnes. However, taking into account the productions of different hill states in North-western and North-eastern region also incorporating about 10% production of states viz., Assam, Manipur and Tripura, the hill fisheries production is estimated at 60 to 80 thousands tonnes which comes to around 3% of the total inland production.

Fishermen Population

Table 4. Fishermen population engaged in fishing operations

Sector	Total population	Engaged in fishing operations	
		Full time	Part time
Fishery Sector	6730300	738400	713700
Coldwater sector	41400	2100	2500
(%) of Total in CW	< 1	< 1	< 1

Fish consumption

In India there is a sizeable population who are vegetarian but through the years the food habits have undergone a change. The data reveal that more consumption is in maritime and coastal states. Among the inland states, the fish consumption variation exists. It is observed that states in North-western Himalayas, the fish production is more but consumption is low while North-east Himalayan states show reverse trend (Table 5).

Table 5. Fish consumption pattern (Number of households per 1000 households reporting consumption range)

Region	Rural	Urban
North-western Himalayan states	7 - 10	9 - 19
North - eastern Himalayan states	150 - 690	318 - 800
Other states	1 - 942	5 - 962

ENVIRONMENTAL CONCERNS

Considering from the viewpoint of aquatic resource conservation, the uplands provide glaring examples of man's interferenece to reap temporary gains through over exploitation. Increasing human pressure has resulted in fast rate of eutrophication the fish species which it used to earlier. The species diversity has changed and catches too have declined. These serious environmental stresses coupled with limited resource base, slow rate of growth of indigenous species and lack of adquate infrastructure in the sector made coldwater fishery a subsistence fishery. It was primarily an open water subsitence fishery and sport fishing restricted to exotic trout.

RESEARCH SUPPORT

The government support even at national level to the hill fisheries research, started very late, in comparison to the warm - water sector. The efforts at individual levels in the universities were undertakne by number of persons to workout some basic problems with regard to importante coldwater fishes in the the Himalayan states. But research with focus on applied fisheries started with involvement of ICAR system during late sixties, which subsequently culminated in creation of National Research Centre on Coldwater Fisheries in 1988. The NRC on coldwater fisheries is the only national facility in the country where research investigations are undertaken both on capture and culture aspects with a focus on exotic and indigenous coldwater fish species. Since its inception, NRCCWF in spite of constraints in terms of manpower and infrastructure has made significant contribution for proper appraisal of coldwater fishery resources and evolved suitable technologies to propagate important coldwater fish species in hills. Now the universities located in hill states are contributing in cold water fisheries research & development.

RESEARCH ACHIEVEMENTS IN THE SECTOR

Impact of Exotics

Different phenotypes of *Cyprinus carpio* were introduced in upland waters in late fifties. The reasons for their dominance to the tune of 70% over indigenous species were investigated. The main reasons identified were food overlap, higher fecundity, better spawning facilities in the lake itself, higher rate of fertilization and shorter incubation period to produce larvae in case of *Cyprinus carpio* have all contributed to the decline of indigenous Schizothoracids in the lake ecosystem. The stocking

Fish Biology & Ecology

Most of the snow-trout species belonging to Schizothoracid group were worked out for their feeding habit, fecundity, gonado-somatic index, peak breeding season, location of breeding grounds, growth behaviour and distribution. Significant variations were noted in biological parameters among different species within the group. Some of the species are endemic to their distribution while some are widely distributed. The generation of this information is helpful in formulating stock management norms.

Stream Ecology

Based on various ecological parameters involving water quality and status of benthic population in different streams, a classification of streams was developed which reflect an idea about the productive potential of each type of stream. The ecological classification of streams is essential for planning any fishery development in such water bodies. The potential of two Kumaon streams *viz.*, Gaula and Chirapani was evaluated in terms of their biodiversity. In the Gaula stream, fish biodiversity was mainly represented by indigenous mahseer (*Tor putitora*), snow-trout (*Schizothorax richardsonii*), *Garra gotyla*, *Barilius bendelisis*, *Nemachelius*, *Botia birdi*. The snow trout specimens in the size range of 160-250 g in weight and 150 - 260 mm in length were frequently encountered. The experimental fishing revealed the CPUE value to range between 107- 500 g man^{-1} h^{-1}. The contribution of *Schizothorax richardsonii* to total catches was nil - 67.3% and that of *Tor putitora* between nil - 59%. The reasons identified for sharp decline in fish catches in Kumaon streams is their mass killing by poisoning, dynamiting and using small sized mesh nets. Further, excess water abstracting and catchment disturbances have resulted in habitat loss.

Production dynamics of lakes

The water quality of typical lakes in the J&K valley and Kumaon region indicated that they are suitable for fish growth and stock enhancement. The status of biological communities in these lakes revealed the systems can sustain reasonable problem and energy transfer in natural flood - plain lakes / wetlands of Kashmir were investigated. Based on the data generated, judicious fishery exploitation strategy was developed for these ecosystems. Similarly biological indicator species for eutrophication were identified in the local lake systems, which will help in pollution and general health monitoring of lakes.

Based on the energy transfer investigations, a fish stocking action plan for temperate lakes was developed. For the first time in the country high altitude (> 3000 ml) glacial lakes were investigated in detail in order to develop a strategy for fishery development at those inhospitable areas of Kashmir Himalayas.

Exotic Trouts

Hatchery practices

Cultural practices for brown and rainbow trouts have been developed to perfection for breeding purposes and table fish rearing. Hatchery practices also have been improved to reduce the mortality at different stages *viz.*, ova, alevin, fry and fingerling. The percentage survival could be raised to 80% from the earlier record of hardly 20% between green eggs to early fry stage. Table 6 depicts trout farms and hatcheries in Indian uplands

Table 6. Trout farms and hatcheries in India

States	Numbers
Jammu & Kashmir	7
Himachal Pradesh	5
Uttaranchal	4
Sikkim	1
Arunachal Pradesh	2
Meghalaya	1
Tamil Nadu	1
Kerala	2
Total	**23**

longterm basis. Three trial diets, gave FCR of 2.2,2.0 and 1.8 which were very much comparable with any trout feed used in other countries at that point of time. The trials indicated that higher protein levels did not promote better growth in comparison to medium protein level of 35%.

The experiments with table rearing of brown trout revealed good growth even at low protein diet of 28% but it resulted in higher feed conversion ratio of 3.7 in comparison to 1.7 recorded in 47% protein diet.

Rainbow trout rearing

The investigations were initiated to evaluate the feasibility of rearing the rainbow trout (*Oncorhynchus mykiss*) at the agro-climatic conditions of Champawat district of Kumaon region in Uttaranchal state. It was the first attempt to be undertaken in the Kumaon region. The normal endowment for raising rainbow trout is at much higher altitudes than Champawat. The annual water temperature in the farm ranged between 4.5°C in January - February to a maximum 21.5°C in the months of May - June and for other eight months the temperature remained above 18°C which is not very congenial. Even the water quantity (flow) available at the farm for trout was also significantly low. Inspite of these constraints, a steady progress was achieved for the first time by NRCCWF to build the trout stock at the farm. This successful initiative resulted in start of first ever sale of table size trout to general public. Continuing these efforts, brood stock has now been developed and first successful artificial breeding was carried out in February 2002 at the farm. This will be a major step in making available the seed of rainbow trout to local farmers and enterpreneurs in the Kumaon region. These trials at Chirapani experimental farm carried out between 1999 to 2002 clearly indicated that with suitable modifications, it is possible to raise trout at marginally higher temperature prevalent at lower altitudes, what is normally not conceived. This opens up the possibility of taking

Carps

Monoculture

The J&K State Fishery Department in the year 1957 introduced three phenotypes of carp viz. *Cyprinus carpio communis*, *Cyprinus carpio specularis* and *Cyprinus carpio nudus*. After a couple of years, the introduction of the species showed an adverse impact on the indigenous species, their catches dropped to nearly 30% by eighties and average size of *Cyprinus* also declined.

To create awareness about aquaculture in the region, mono-culture of *Cyprinus carpio* was attempted initially. By exploiting the natural productivity of rural pond and regulating the kitchen refuse and other run-off from the village into the pond, an estimated production in the range of 2.5 - 3.0 tonnes per hectare was achieved in a period of 12 months. This simple technology could be profitably utilized in Panchayat ponds in the rural areas.

In the upland waters, the Indian major carps do not grow well due to low thermal regime. Therefore, trials to culture Chinese carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*) were made. From the data generated it is observed that eight month period between April to October is the most suitable for growing fish in the temperate climate prevalent in higher reaches of Kumaon. From large number of experimental trials conducted by the institute, a technology suitable for water temperature range of 5-29^{0}C in hills, based on these three species combination stocked in the density range of 3-4 fishes m^{-2} with recommended supplementary diet, has been developed. It has been possible to achieve a production range of 0.4 - 0.6 kg/ m^2 under low temperature conditions (Table 7). This technology opens up the possibility of promoting exotic carp culture in hills of western and eastern himalayas where existing production of indigenous fishery is very low.

Table 7. Growth of Chinese carps at varied temperatures at Chirapani farm

Month Temp (°C)	June/July 22-28	Aug. 27-29	Sep. 25-27	Oct. 18-22	Nov. 16-18	Dec. 5-10
Fish species			Growth per day (g)			
C.carpio	0.18	0.39	0.24	0.21	0.09	0.09
C.idella	0.20	0.37	0.30	0.18	0.13	0.00
H.molitrix	0.23	0.37	0.41	0.22	0.12	0.00

Snow - trouts

Majority of snow-trout species are indigenous and endemic to Kashmir inhabiting lakes and rivers/streams. Through the years of anthropogenic and environmental stresses their fishery is on the decline, which has been documented by the NRCCWF. The culture of this imporante group is still being developed but success has been achieved to conserve the species through artificial propagation. A success was achieved in obtaining pure and healthy seed of different species *viz.*, *Schizothorax niger*, *S. esocinus*, *S. curvifrons*, *S.micropogon* and *S.richardsonii* throught artificial fecundation. The institute at its Chirapani farm has now achieved the success in artificial breeding of *Schizothorax richardsonii* from the wild and farm reared spawners. The methodology developed has opened the possibility of raising *Schizothorax richardsonii* seed on large scale to ranch depleted waters for enhancement of fish stocks in Himalayan region.

Field incubator design

In the absence of full - fledged hatchery, a portable incubator was designed for production of Schizothoracid seed at the stream site. The working of the designed incubator has been tested and found to be satisfactory. A survival of 60-65% has been achieved in different species tested. Within a period of two weeks, this small sized incubator can produce 10,000 hatchlings, this capacity can be increased by suitably changing the size of the incubator. This miniature hatchery will greatly help

Mahseer : Artificial propagation

A flow - through hatchery has been designed and fabricated at Bhimtal for mahseer seed production by National Research Centre on Coldwater Fisheries. It has the capacity of incubating 0.25 million eggs, rearing 0.2 million swim up fry and production of 0.1-0.15 million advanced fry. This hatchery is very useful in producing stocking material of golden mahseer on large scale for ranching in natural waters. Table 8 indicates water requirement for various developmental stages in case of golden mahseer.

Table 8. Water requirement for various stage in mahseer seed production

Incubation of fertilized eggs & hatchlings	1.5 - 2.0 l/minute for 5000-10000 stock at water temperature of (20-25°C)
Swim up fry and early fry	2.0 - 3.0 l/minute for 3000-5000 stock at water temperature of (25-27°C)
Fry and advanced fry	3.0 - 5.0 l/minute for 1000-3000 stock at water temperature of (25-30°C)

Nutrition and Artificial feeds

The institute in its efforts to develop a balanced formulated feed for coldwater fishes especially for mahseer, has conducted large number of experiments, in which 1 - 6 diets were formulated and compounded. A positive correlation was observed between the dietary protein content and overall growth performance and conversion ratio. The formulated diet no. 5 gave the overall best performance. It is expected that already tested feed for trout showing good performance will be released to the industry very soon.

Biochemical Physiology

Different biochemical tools *viz.* hematological, serological and electrophoretic have been employed to evaluate the health status of *Schizothorax richardsonii* and *Tor putitora* in response to various pathogens, pollutants and environmental stress in hill

POTENTIAL AND CONSTRAINTS

The climatic diversity in entire Himalayan region induces ecosystem variability and wide spectrum of biodiversity. In terms of aquatic ecosystems, the range is from foot hills, mid-hill to high mountains. These are blessed with varied aquatic as well as fish species, some of which tolerate mild temperature, some live under marginally warmer temperatures during winter and while a few can withstand freezing temperature. Therefore, for aquafculture we have many choices in terms of species selection. The hills also have world's famous sport fishes *viz.*, trout and mahseer, and are in a position to exploit this area in a big way. The fish can support the nutrition security in hills and help in removing protein deficiency. It has the potential to supplement the farm income, because in hills even the agriculture productivity alone cannot economically sustain a small and marginal farmer, he will have to rely on crop diversification.

DEVELOPMENT ISSUES

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 during the last two decades have made significant progress both 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. In the state of Uttaranchal, till two years back hill fishery did not receive adequate attention and most of the facilities are not in place. Then there is the 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 due to lack of support at planning and financial levels. But of late, it is being realized and demonstrated that coldwater fishery can contribute to food and nutrition security in hills and remote regions. In hills the fishery development through aquaculture, sport and conservation should be promoted and supported in order to introduce crop - fish diversification in hills, so that natural

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 aquatic ecosystems in hills for fishery development on a sustainable basis, the following issues need attention :

- **Ownership of resources :** Practically all the water resources suitable for hill fishery in the state are owned by the forest / irrigation / revenue / other departments. For implementation of fishery developement programme, there is a need to place them under management of fishery department.
- **Infrastructure development :** Develop modern facilities in the form of construction/renovation of existing fish farms and hatcheries on a priority to promote aquaculture activities.
- **Lake fisheries** need a balanced strategy for tourism and fishery development.
- **Hill fisheries conservation** in streams *vis-a-vis* sharing by other users.
- **Development of sport fishery** in linkage with tourism involving angling facilities and ranching of mahseer and trout in streams.

MANPOWER AND HRD

Hill fishery is a specialized sector and cannot be compared with warm water fisheries, so expertise in this sector need to be developed. States should make efforts to train staff of Fisheries Department belonging to different categories through various programmes. A comprehensive HRD programme on Coldwater Fisheries is lacking. This important issue needs to be addressed on priority.

FUTURE PERSPECTIVE

The Hill Area Development is now being focused as priority in the country. It can protein requirement to poor people. Therefore, adequate research and development support in fisheries sector is very important and critical to the region. Infrastructure development in this direction is the most important aspect for achieving success in this sector.

ACTION PLAN

Depending upon the natural aquatic resources in the hills states, species variability, technology support and scientific data base available, fishery if developed on scientific lines will go a long way in contributing to the rural economy in remote hilly zones of the state. It is suggested that fishery development shuold be initiated with available exotic and indigenous fishes as the resource base. Higher reaches where water temperature and other conditions are suitable should be exploited for trout to promote sport fishery and culture of rainbow trout on commercial lines. While at lower altitudes, Himalayan mahseer and snow-trouts seed production centres should be established to cater the demand for stocking natural water bodies for food and sport. Establishment of carp hatcheries and farms at lower altitudes is another pre-requisite to meet the demand of local farmers who are engaged in small scale fish farming. In addition, the regions situated between 1,000 to 1,800 m asl. have a tremendous potential for exotic carp culture, this should be encouraged by providing know-how and seed to the farmers, which will supplement the income of farmers earned by him through crop - fish diversification. To promote all these activities, a time bound action plan has to be initiated on priority. The NRCCWF at Bhimtal can provide the necessary technical support to carry out the stipulated programme activities.

RIVERINE FISHERY RESOURCES OF NORTHEAST INDIA

M. Choudhury

FISHERY RESOURCES

The northeastern region of India abounds in natural water resources in the form of rivers streams, floodplain wetlands and reservoirs. These water bodies are the habitat of diverse flora and fauna. Most of the rivers coming down from the hills and mountains cross the region and have a combined length of 19150 km. being Assam (5050 km), Arunachal Pradesh (2000 km), Manipur (2000 km), Meghalaya (5600 km), Mizoram (1700 km), Nagaland (1600 km), Tripura (1200 km). The 52 major rivers in the region are the abode of a large number of commercially important food, ornamental and sport fishes. The rich icthyobiodiversity comprises 297 fish species belonging to 114 genera under 38 families and 10 orders. It forms about 33% of the total Indian fresh water fishes. State wise distribution of species are as follows:

State	Arunachal Pradesh	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura
Species	167	218	121	165	48	68	134

The northeastern region of India is considered as one of the hot spots of freshwater fish biodiversity. The mixing of drainage and their fish fauna in the geological past has made the region very important from faunistic point of view. The region shares its fish genetic resources with that of Indo-Gangatic plains and to a lesser extent with the Myanmar and south Chinese fauna.

RIVERS

The predominantly hilly region such as Arunachal Pradesh, Nagaland, Mizoram, Meghalaya and Manipur harbour many fishes that live in cold waters. Mention may

Assam	:	Manas, Behi, Ai, Jia Bharali, Kapili, Kalong
Meghalaya	:	Kapili, Shella, Darreng, Simsung, Jinjiram
Manipur	:	Minan, Khuga, Thoubal, Iril, Imphal, Manipur
Mizoram	:	Tlawang, Tiurial, Mat, Kolodyne, Karnaphulli
Nagaland	:	Dayang, Dikhu, Sidzu, Tezu, Itanki

HILL STREAM FISHES

Some of the important hill stream fishes of the rivers mentioned above are *Tor tor, T. putitora T. progenies, Neolissochilus hexagonolepis, N. hexastichus, Schizothorax richardsoni, Schizothoraichthys progastus, S. escocinus,, Schizopygopsis stoliczkae, Labeo dyocheilus, Raimas bola, Rasbora rasbora, Garra nasuta, G. rupecola, G. kempi G. gotyla gotyla, G. lamta, Cyprinion semiplotum, A. kempi, N. botia, N. bevani, G. kempietc. Hara hara, Badis badis, L. devdevi, L. boga B. bendelisis, L. dero, B. barilius, Canta canta, P. sophore, P. ticto, P. sarana sarana, Labeo rohita, L. gonius, L, calbasu, L. bata , L. nandus, L. nandina,, Cirrhinus mrigala, C. reba, Glyptothorax cavia, G. coheni, Chanda nama,etc.*

COLDWATER FISHES

The high altitude fish species are *Schizothorax richardsonii, Schizothoraichthys progestus, S. escocinus* and *Schizopygopsis stoliczkae.* Besides *Garra* spp., *Glyptothorax* spp., *Noemacheilus* spp., *Euchiloglanis* spp., *Pseudechenis sulcatus, Labeo pungusia, Labeo dero, Semiplotus semiplotus* and mahseer constitute other coldwater fishery

Arunachal Pradesh has taken several steps for the development of the cold-water fisheries. There is trout hatchery farm in Tawang district. Beside culture in farm the trout fry and fingerlings are release in to the river water.

ORNAMENTAL FISHES

B. dario, N. nondus, T. cutcutia, C. bacaila,, S. gongta, C. ranga, A. coila, A. morar, O. cosuatis, B. tengana, H. jerdoni, B. daria, Chaca chaca etc.

PRESENT SCENARIO

The rich fish fauna of the states are unfortunately under constant stress and strain due to over exploitation and habitat alteration. Fish poisoning, dynamiting and other destructive fishing practices have caused immense harm to the stock. The present situation is very alarming. Four species as critically endangered, 17 endangered, one extinct, 40 vulnerable, 34 at lower risk / near threatened and seven at low risk/least endangered have been enlisted.

Fish production from these states is very low and cannot meet the domestic demand of the states. Per capita availability of fishes from all sources in the region ranges from 2.19 kg/yr (Arunachal Pradesh) to 9.19 kg/yr (Tripura) leaving a wide gap between supply and demand. The main reason for the low production may be attributed to inhospitable terrain, prevailing low temperature and uneven river bed, fast water current and shortage of expert fishermen in the hilly states.

CONCLUSION

Database assessment of fishery resources in North east region is a prerequisite. A well thought action plan having economical viable fish production and exploitation technology which are socially acceptable with least changes in ecological status need to be drawn for the region.

ECOLOGY AND FISHERIES OF COLDWATER RESOURCES OF ASSAM

B. K. Bhattacharjya

INTRODUCTION

Assam is the second largest state of the northeastern region of India. The state covering about 30% of the geographical area of the region is known for the richness and heterogenity of its fishery resources including fish germplasm resources. It is situated in the heart of the eastern Himalayan region (Lat. 24^0 - $28^0$18' N; - Long. $89^0$50' - $97^0$40' E) and covers an area of 78, 438 sq. km. The state is surrounded by the sub-Himalayan mountain ranges of Bhutan and Arunachal Pradesh and the hills of Nagaland, Meghalaya and Mizoram on three sides. These hills and mountains give rise to numerous fast flowing streams flowing down the gradient and ultimately joining the Brahmaputra and Barak rivers. The combined length of these rivers of the state is 5050 km. The river Brahmaputra alone has 42 important tributaries in the state; 27 on the north bank and 15 on the south bank. The upstream stretches of all the north bank tributaries of R. Brahmaputra north of National Highway No. 52 and those of the south bank tributaries south of NH 37 qualify for coldwater rivers since the water temperature regimes are suitable for coldwater fishes like mahseer and snow trouts during some or most parts of the year. Based on studies conducted by CIFRI in R. Brahmaputra and its important tributaries during 1996-98 and past reports, nine river stretches of Brahmaputra Valley *viz.*, Jiabharali, Manas, Kapili Lohit, Kulsi and Borgung have been identified as important coldwater rivers of the state.

ECOLOGY AND PRODUCTIVITY

Soil quality

Soil of the six rivers had sandy (87.5-98.5%) texture, acidic to alkaline pH

$100g^{-1}$). Lohit, Beki and Manas rivers had alkaline soils (pH 7.3-7.5), whereas the others had acidic soils.

Water quality

Water of the rivers was characterized by cool temperature (11.5-22.7° C), alkaline pH (7.0-7.9), medium to high total alkalinity (34.3- 207.7 mg l^{-1}), medium to high total hardness (25.4-155.8 mg l^{-1}), high dissolved oxygen (6.95-10.20 mg l^{-1}) and low free carbon dioxide (1.68-2.22 mg l^{-1}) concentrations. Specific conductivity (24.9-345.5 µmho cm^{-1}) and total dissolved solids (24.9-173.8 mg l^{-1}) fluctuated widely among the rivers. The rivers recorded moderate levels of nitrate-nitrogen (0.014-0.025 mg l^{-1}) and phosphate-phosphorus (0.004- 0.010 mg l^{-1}), while silicate-silica levels were high (5.1- 6.8 mg l^{-1}).

Biotic communities

Plankton population was low (49-177 u l^{-1}) in the selected rivers except in river Borgung where a considerably higher population (753 u l^{-1}) was recorded. Phytoplankton dominated the plankton population in all the rivers and zooplankton was recorded only in Borgung (20 u l^{-1}) and Manas rivers (11 u l^{-1}). Phytoplankton population was dominated by Bacillariophyceae in all the rivers. Zooplankton population was dominated by copepods. Macrobenthos population varied widely, ranging from 110 no. m^{-2} (R. Kapili) to 1412 no. m^{-2} (R. Jiabharali). The macro-benthic fauna was dominated by chironomids in most streams followed by gastropods, insects, oligochaetes and bivalves.

Primary productivity

The net primary productivity of phytoplankton was estimated to be in the range of 178.4- 314.4 mg C m^{-2} d^{-1} in Jiabharali, Lohit and Manas rivers. Fish production potential estimated based on the primary productivity in these four rivers ranged from 61 (R. Jiabharali) to 107 kg ha^{-1} yr^{-1} (R. Manas).

commercial fisheries of the six rivers. Important coldwater sport fishes recorded in the six rivers were mahseers (*Tor putitora, T. tor, T. progenius, T. mosal, Neolissocheilus hexagonolepis*), snow-trouts (*Schizothorax richardsonii, Schizothoraichthys progastus, S. stoliczkae*) and the Indian trout (*Raiamas bola*). In addition to sport fishes, these rivers harboured a good number of commercially important food fishes like *Labeo dero, L. dyocheilus, L. calbasu, Barilius bendelisis, B. barila, B. barna, B. vagra, B. shacra, Crossocheilus latius latius, Garra annandalei, Chagunius chagunio, Glyptothorax* spp., *Puntius sarana sarana, Aorichthys aor, Wallago attu, Mastacembelus armatus, Bagarius bagarius, Nangra nangra, Mystus* spp. and *Amblyceps mangois*. In addition, *Botia dario, Mystus tengara, M. vittatus, Pseudambasis ranga, Chanda nama, Badis badis, Nandus nandus, Channa barca and Xenentodon cancila* also have considerable ornamental value.

Established coldwater fisheries

The river Jiabharali has become the most famous eco-tourism centre of the state where the Assam Bhoreli Anglers' Association organise angling competitions every year during the winter season. The river is formed by the confluence of R. bishom and R. Tenga in west Kameng district of Arunachal Pradesh. It originates in Okka hills of AP and flows for about 190 km in the state where it is known as R. Kameng. It enters Sonitpur district of Assam at Bhalukpung after which it flows for 56 km in the plains befor joining R. Brahmaputra near Tezpur. The upper stretches of R. Jiabharali from Bhalukpung to Balipara (under Nameri Reserved Forest) in Sonitpur District spanning about 100 km provide excellent spots for sport fishing. Important sport fishes recorded from the River at Bhalukpung during 2001 - 02 are *Tor putitora*, *T. tor*, *Schizothorax richardsonii*, *Schizothoraichthys progastus*, *S. stoliczkae*, *Neolissochielus hexagonolepis*, and *Mastacembelus armatus*. In addition a good number of commercislly important food fishes including *Labeo dero*, *L. dyochielus, L. calbasu, Crossochielus latius latius, Barilius bendelisis*, *B. barna*, *Garra* sp., *Aorichthys aor* and *Bagarius bagarius* were also landed. A number of small ornamental fishes like *Botia dario*, *B. rostrata*, *Acanthocobitis botia, Xenentodon cancila* and *Channa barca* were also observed at Bhalukpung.

and Xangchu in eastern Bhutan. After entering Barpeta district of Assam, it flows through the Manas Wildlife Sanctuary before branching in to Beki and Manas rivers. The 50 km long stretch of R. Manas located within in lower Assam was a good angling destination earlier. It has lost its importance temporarily during the past decade due to insurgency problem. With the reopening of the sanctuary to tourists in recent years the river is again becoming popular among the anglars. Important fish species of the river at Mathanguri are *Tor putitora*, *Schizothorax richardsonii*, *Schizothoraichthys progastus*, *N. hexagonolepis*, *C. latius latius*, *Garra* sp. *Barilius* spp. and *Lepidocephalus* sp.

River Kopili is the only established sport fishing centre among the south bank tributories. The upstream stretches of the river near Umrangshu in N.C. Hills district of Assam were a favorite angling destination. The river has lost its past attraction among the anglars in recent years due to insurgency problem. The river and the Umrangsu reservoir support a rich variety of fish species including *N. hexagonolepis*, *T. putitora*, *T. tor*, *L. calbasu*, *Chagunius chagunio*, *Puntius sarana sarana*, *Puntius* spp., *Mystus* spp., *M. armatus*, *Macrognathus* spp., *Channa* spp., *L. guntia*, *X. cancila*, *M. aculeatus* and *Channa barca*.

R. Kulsi a south bank tributary of R. Brahmaputra originates from the hills of central Meghalaya. It was ideally located for development of sport fisheries since Kukurmara landing centre is only about 40 km west of Guwahati city. It was known for its mahseer fisheries (mainly *T. tor*). However, mahseer catches from the river has greatly declined at the centre because of over exploitation and now they are rarely caught. The river still supoorts a good number of food fishes including *M. armatus, A. aor, Ompok* spp., *Mystus* spp., *Puntius* spp., and ornamental species like *B. dario, Gagata cenia* etc.

River Bargung is also south bank tributary of R. Brahmaputra originates from Daphala hills in Arunachal Pradesh at an elevation of 2073m. After flowing for about 9 km, the river receives its tributary Namorah at Devmukh and its second

Important fish species of this stretches are *N. hexagonolepis, L. dero, Glyptothorax* spp., *Garra* spp., *Puntius* spp. and *Barilius* spp.

River Lohit is one of the three forerunners of R. Brhamaputra. It flows through the hills of Arunachal Pradesh before joining R. Brhamaputra near Shadiya in upper Assam. A survey of the river during March 1997 at Alubarighat in AP indicated that the commercial fisheries of the river mainly comprised six species *viz. N. hexagonolepis, L. dero, L. dyocheilus, T. putitora, S. richardsonii* and *B. shacra*. The occurrence of *N. hexagonolepis, T. putitora* and *S. richardsonii* in good numbers indicate that the river can be developed as an important sport fisheries in addition to the known sport fisheries of the state described above. *L. dero* and *L. dyocheilus* supported the bulk of the catches whereas *B. shacra* was a small fish of minor fishery interest.

Fishing season

The fishing season in all the above rivers starts from October when fishes start migrating downstream from the mountains/ hills of Bhutan, Arunachal Pradesh and Meghalaya to foot-hill regions and continued throughout the winter season till March with peak fishing observed during November to February.

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UTILIZATION OF FISHERY RESOURCES IN ARUNACHAL PRADESH, INDIA: AN OVERVIEW ON SOCIO - ECONOMIC DIMENSION

D. N. Das

INTRODUCTION

Aquaculture as a production system serves variety of roles for man kind *viz.*, supply high nutritional value food for consumption; contribute to rural economy and employment through farming and related activities; preserve aquatic biodiversity through restocking; reduce pressure on natural aquatic resources; improve judicious use of water resources etc., The practices of aquaculture naturally evolve in a locality based on both biophysical and socio economic nature of the community. With the growing importance of fishery, there is an expanding need for socio-economic information on the part of policy-makers and planners for its development. The issue has received little importance in India more particularly in North Eastern region including Arunachal Pradesh. Indian research projects in this regard are found mainly to support technology-oriented (bio-technical) research with less priority on its socioeconomic dimension. The present article, therefore, is merely a concept paper highlighting the potentiality that lies with the scope of judicious utilization of fishery resources of a biodiversity rich mountainous tribal state of India.

STATE OF ART FOR RESOURCE UTILIZATION

The aqua farming implies some form of intervention in the rearing process to enhance the production as well as ownership of stock being cultivated and thus aquaculture is more akin to husbandry than to fishing as it involves the rearing of living aquatic resources in a restricted environment. Where as fishing and harvesting of aquatic resources from open and common access resources generally do not involve tenure and ownership. The tenure of production facilities and property

The existing fishery practices in Arunachal Pradesh as whole are a land based facilities where it is practiced in ponds of varied sizes and rice fields or other such systems built on dry land only. The water based culture systems in the form of enclosures, pens, cages rafts in inland waters are hardly found. Organized water based facilities has not been developed due to i) age old family tradition of fishing and hunting. ii) abundance of resource availability in rivers and streams for capture iii) land lock geographical position and mountainous topography of the state . Arunachal Pradesh is predominantly a tribal state with 26 major tribes and a number of sub-tribes who are non-vegetarian in diet and mostly depend on aquatic resources for their daily food. This area (NEFA) was granted statehood in 1987. However, fisheries programmes were initiated far back in the year 1958-59 on a very modest scale. The reasons behind the slow progress have not been analyzed so far from socio-economic point of view whereas the community linkages and demand for piscatorial diets is more in comparison to many other states of India.

Fishery and People's involvements

Fishery resources of Arunachal Pradesh are distributed in three distinct ecological zones (Table 1). The lower altitude or tropical zone (covering 10% of state's total area) extends up to 300 m from the mean sea level covering the foot hills and plains with warm water aqua resources bordering Assam and Nagaland. The middle altitude or subtropical zone (covering 70% of state's total area) includes areas within 300-1200 m msl having maximum fish diversity with both cold and warm water aqua resources of varying production level. The high altitude or alpine zone (covering 20% of state's total area) including the areas above 1200 m msl suited ideally for coldwater fishery. On the basis of the trend of aquaculture activities of the people and initiatives taken by the state fisheries department, the existing scopes and facilities on aquaculture of Arunachal Pradesh may be classified broadly as mentioned in Table 2. The estimated extent of fisheries resources in the state includes pond and tanks -2200 ha., beels and lakes-2000 ha., potential areas under ricefields-2800 ha. and about 110 ha of cold water lakes in land based system.

districts of the state for the development of aquaculture. Further, the state fisheries owned a total of 31 ha of government, fish farms alongwith 9 hatcheries for fish production and supply of fish seeds to different areas of the state. It is reported that the rivers and streams of Arunachal Pradesh shelters enormously rich fish fauna representating about 167 species. Among them, Mahseers (*Tor tor, Tor putitora, Neolissocheilus hexagonolepis* etc.,) Snow trouts (*Schizothorax richardsonii, S. progastus*, etc.), carps (*Labeo pangusia, L. dero, Cirrhinus reba* etc.) are most important food fishes in the open water of the state. Besides, a huge population of berrils, catfishes, loaches, eels, barbs and minnows constitute a unique piscine biodiversity resource of the state.

Fish farming and Production levels

The estimated year wise production and other fishery related development over the period 1989-2000 in the state has been presented in Table 3. The catches were accounted from 643 ha of ponds and tanks, 107 ha beels and lakes, 872 ha of paddy fields and only100 km of rivers/streams. Rest of the resources are still unexploited barring traditional fishing by the local people. Indian major carps and exotic carps contribute 66.5% of the total estimated production of the state. Harvest of the other live fishes including murrells and catfishes from the developed area contributed 15.4% of the total production. The coldwater sector including trouts and others add only15.0% to the total production of the state. The land based systems of pond and rice field aquaculture respectively achieving production rate of 1218.6 kg/ha and 252.30 kg/ha. In contrast to such practices developed in other states of India the overall production rates are relatively poor. The annual fish seed (fry) production in the state is 24 million but this level is grossly insufficient to meet the present demand. The gap is being bridged by import from outside the state. There are 9 hatcheries involved in seed production of Indian major and Chinese carps in the state presently. On the other hand about 1.45 million cold water fish fry including that of trout seeds are produced in state from high altitude fish seed farms and trout hatcheries located in the district of West Kameng and Tawang. The

Impact on other interrelated sectors

The availability of wild ornamental fishes in the drainage systems of Arunachal Pradesh is very high and diversified even though consciousness in regard to their ornamental value and market potential is very less. These wild fishes are very alluring as they are very beautifully coloured. The research for conservation and development have not yet been launched on wild ornamental fish resources inspite of the good demand of these fishes. Other related sectors *viz.*, fish feed supply and production, aqua chemicals, net mending, manures and oil cakes, fishbye products, dried and smoked fish product etc., are hardly been uplifted with parity in the state for which people have to depend on neighboring states. Except in certain district headquarters, markets in relation to aquaculture products are still very poorly developed.

Practically, fishery is an organized activity like agriculture, therefore, it's promotion needs intentional involvement through professionalisms which may be possible only when human resources are adequately developed. This sector need attention.

Socio-economic impact

The socio-economic aspects of aquaculture and the available natural resources are interdependent and mutually interactive (Fig 1). These two together, induce people's decisions and reflect their success in application of any techniques as well as related development. Any tribal community of the state hardly developed any professionalism on fish culture in the context of their livelihood because of their common social habit of open fishing and hunting from natural waters. As per the social culture among the tribals, there hardly exists any special caste distinction within the social hierarchy to be linked with fishing and hunting activities. Arunachal Pradesh lacks fulltime fishermen in profession except need based fishing activities at family level for meeting the family needs. The people of the state are enriched with most of the requisite capitals (Table 4) linked with community structure and functions for

SOCIO ECONOMIC IMPACT OF AQUACULTURE

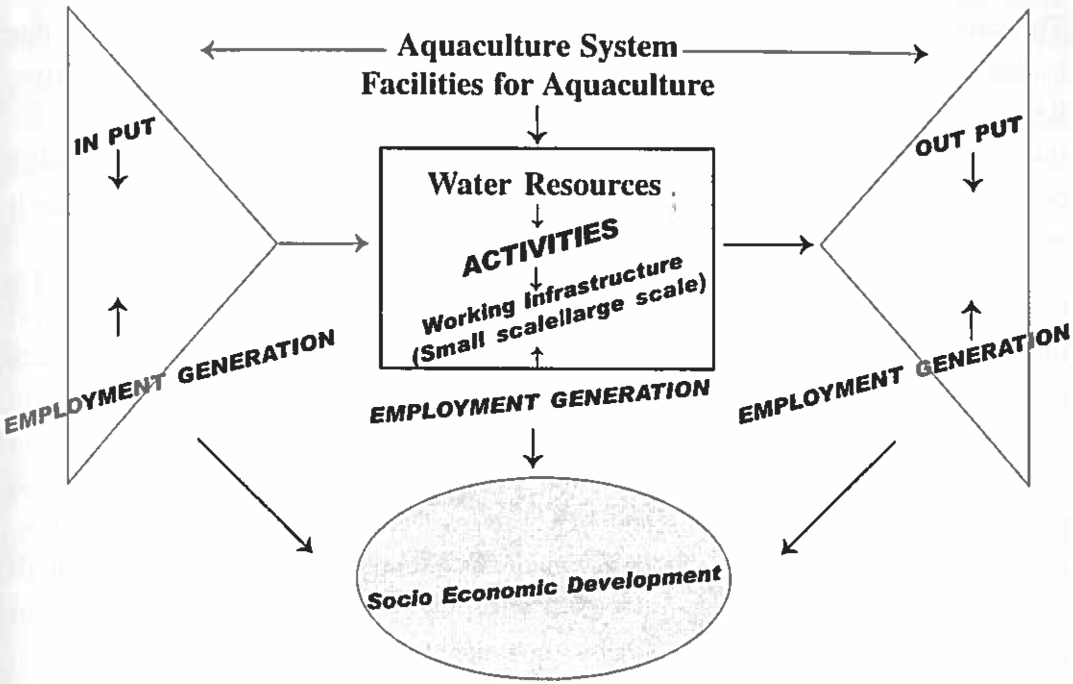

Fig 1 Aquaculture linked socio-economic factors

mainly family level involvement of skill with traditional knowledge for extensive aquaculture. In such a case, either the exchange of trained labourers or training of the people is one of the essential pre - requisite for enhancing human capital further. The physiographic and socio-economic features (Table 5) clearly indicated certain determining factors are playing important role regarding people's involvement in fisheries sector of the state. The factors that influence the natural development of aquaculture depends on i) perceived need or desire for aquatic product ii) suitability of available resources for supplying aquatic products and the availability of complementary factors of production iii) knowledge of techniques possessed and

SCOPE FOR R & D TOWARDS FUTURE DEVELOPMENT

The capture fishery in the state (Table-6) are now facing high level of stress due to habitat degradation, water pollution, construction of bunds and dams, over fishing and destructive fishing practices. On the other hand, demand for fish are increasing. To minimize the pressure on capture fisheries, the system of scientific culture is to be strengthened in all the available ecological zones of the state. It would be possible only when small scale aquaculture sector is strengthened.

On the background of the existing status, the aquaculture scenario of the state is just in its infantile stage of development. As the state is the owner of the fishery waters of diversified zonations, the aquacultural package of practices developed elsewhere in the country need to be refined for adoption. Therefore, for achieving success in exploitation of aquatic resources of the state proper R&D work and extension planning is required. The districts like Tawang, West Kameng, Dibang Valley, Lower Subansiri, Lohit, West Siang and East Siang hold the grounds for high altitude fishery development. In these districts lie possibilities of improving trout production from its existing level by intensifying seed production rate through establishing more hatcheries. Common carp, grass carp and silver carps can also be cultured in high altitude zones. Besides, research and development programmes should immediately be initiated for adoption of culture technologies for snow trouts like *Schizothorax richardsonii, Schizopygae progastus, S. esocinus*, mahseers like *T. tor, T. putitora, N. hexagonolepis*, carps like *Labeo dero, L. pangusia, Semiplotus semiplotus, Chagunius chagunio* etc.

Another important way of harnessing running water resources of the state is the adoption of cage or pen culture in the streams or rivers. The state is blessed with about 2000 km of potential riverine/stream water resources which offer possibilities of cage and pen culture output.

The state has an area of 643 ha under pond and tank culture developed in recent

The seed production is an important link which should be improved first because the development of culture system is mostly dependent on this. During 1997-98, 22.55 millions of carp seed and 1.45 million trout seed was produced. Though seed production has been showing an increasing trend, it is unable to meet the demand for seed for culture as well as for stocking of the cold water streams. The status of such farms, therefore, need to be updated and standardized to attain a higher level of production which also calls for research attention.

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Table 1. Aqua ecological zones in Arunachal Pradesh

Characteristics	Ecological Zonation		
	Lower altitude or tropical	**Middle altitude or subtropical**	**High altitude or alpine**
Altitude from mean sea level	up to 300	Within 300 to 1200	> 1200
Area Covered (km^2)	8377	58639	16754
Distribution	Foothills and plain land bordering Assam and Nagaland	Hilly tarrain and valley areas with in core areas of the state	All the areas under high altitude of each district
Districts	East Kameng, West Kameng, Papume pare,Lower Subansiri, West Siang and East Siang	Major areas of each district falls under this zone	East Kameng, West Kameng, upper Suban siri, lower Subansiri, Kurung kume , West Siang and upper Siang
Aquatic habitat	Warm water only (Ponds, Lakes, Rivers ,Streams, Reservoirs, rice fields and other wet lands)	Warm and coldwater both (Ponds, Lakes, Rivers, Streams, Reservoirs, rice fields and other wet lands)	Cold water only (Lakes, Rivers, Streams)
Diversity status	Moderate	High	Moderate only with cold water species
Fish culture activities among tribal people	Normal Practice in home stead ponds on small scale level	People mostly depend on rivers , lakes, streams etc.,through adoption of diverse types fishing techniques	Culture fisheries hardly exists, fishing involves both indigenous and modern methods

Table 2. Aquaculture facilities and activities in Arunachal Pradesh

I.	**Land Based Culture Facilities** A. Pond aquaculture - LA,MA & HA (PD) B. Rice fish culture- LA &HA(PD) C. Integrated pond culture- LA & HA(UD)
II.	**Water Based Culture Facilities** A. Beels and lakes farming- LA & HA(UD) B. Cordoning the part of streams and rivers- NA(ND) C. Reservoir farming- LA,MA.& HA (UD)
III.	**Cottage based culture& seed production facilities** A. Aquaruria and Ornamental fish culture - NA(ND) B. Seed production for ornamental fishes- NA (ND)
IV.	**Fish Breeding and Seed Production Facilities** A. Eco-hatcheries for Indian Major Carps - LA & MA(PD) B. Trout hatcheries- HA(UD) C. Catfish seed production facilities- NA(ND)
V.	**Marketing facilities(only local markets)** A. Fresh table fishes from farming and capture of all levels-A(PO) B. Hatchery products from private and govt., levels - A (PO) C. Sun dried/Smoked/Fermented fish and fish products from family levels-A(UO)

[PD= partially developed; UD= under developed; ND= not developed; D= developed; LA= Low altitude; MA= medium altitude; HA= High altitude; NA = Not available; PO= partially organized; UO =unorganized]

Table 3. Fishery related development over the period of 1989-2000

Year	Fish production (tonnes)	Value at current price (Rs. in lakhs)	Fish seed production (Nos. in million)	No. of farmers trained in fishery)
1989-90	998		15.0	1286
1990-91	1246	498	18.0	309
1991-92	1499	599	19.1	341
1992-93	1505	642	19.9	401
1993-94	1705	741	19.7	738
1994-95	1801	784	20.0	623
1995-96	1852	834	21.0	491
1996-97	2002	898	21.8	655
1997-98	2130	1147	24.0	100
1998-99	2301	1247	24.5	280
1999-2000	2395	1291	24.4	40

(Source: Final Report, 2002. Arunachal Pradesh state biodiversity strategy and action plan)

Table 4. Socio-economic capitals for aquaculture developments in Arunachal Pradesh

Capitals	Examples	Availability Status
Natural	Water, soil, fish stocks etc.	Water, soil, fish stocks etc
Human	Leadership skill, artistic talents, labours etc	Leadership skill, artistic talents etc. (lack of skilled labours)
Produced	Houses, roads, machines, money, financial resources	Houses (others are developing gradually)
Social	Relationships and trust, networks, organizations	Relationships and trust organization (net work is developing)
Cultural	Beliefs, shared world views, folklore	Beliefs, folklore (shared world views are growing)

Table 5. Physiographic and Socio economic features of different districts of Arunachal Pradesh

Districts	% Area of state	Cultivable land(ha)	Forest Cover (ha)	%Population of state	Literacy Rate (%)	*Human Development Index♣	Infra-Structure Development Index♣	Villages connected by road♣ (%)
West Kameng	8.86	9799	45 94	6.84	61.67	0.506	2.76	46.97
East Kameng	4.94	21047	2482	5.23	40.89	0.403	1.43	26.52
Lower Subansiri	12.1	36934	6697	8.95	45.01	0.493	2.56	33.17
Upper Subansiri	8.40	32720	3618	5.04	50.89	0.443	2.16	28.18
West Siang	9.13	65712	10487	9.49	60.31	0.551	3.01	45.72
East Siang	5.60	38101	5123	8.01	61.22	0.577	4.04	73.68
Upper siang	7.39	19096		3.04	49.80	0.488	2.01	56.00
Papume pare	3.43	20374	NA	11.16	70.89	0.595	4.96	23.58

* It is the arithmetic mean of indices of three variables i.e. life expectancy at birth, education and income (HDR, 2003 Arunachal University, Ronohills, Itanagar)

♣ Data adapted from Human Development Report of Arunachal Pradesh, 2003, Arunachal University, Rono hills, Itanagar

Table 6. Major fish habitat, private fish farming units, forest, national parks & sanctuaries in Arunachal Pradesh

Districts	Major Fish Habitat (Captural Resources)	No. of Private farming Unit	⊗Area Under Reserve Forest (Sq.Km)	⊗Sanctuaries/ National Park (Sq.Km)
West Kameng	River Kameng and its numerous tributaries	N S	708.35	317.0 Eagle nest WLS and Sessa orchid sanctuary (2 nos)
East Kameng	River Kameng and its 11 main tributaries	NS	1063.86	861.95 Pakhui WLS(1)
Lower Suban siri	5 tributaries of River Subansiri and River Dikrong	22	437.07	337.0 Talley ValleyWLS(1)
Upper Subansiri	River Subansiri and Ranga and their tributaries	23	672.2	NIL
West Siang	Numerous tributaries of River Siang	47	249.1	NIL
East Siang	More 100 km of River Siang and its numerous tributaries	60	467.83	245.0 Kane WLS, and D'Ering WLS(2)
Upper Siang	Major tributaries of River Siang	55	—	483.0 Mouling NP(1)+ Part of Dihang Dibang Biosphere reserve (5112 sq.Km)
Papume pare	River Pare, Dikrong and river Panior and their streams and tributaries	—	810.5	140.3 Itanagar WLS(1)

⊗ Excluding 694.3 Sq.Km Protected Forest (PF), 329.38 Sq. Km Anchal Forest Reserve (AFR), 300.24 Sq.Km Village Forest Reserve (VFR) and 30965 Sq.Km Unclassed State Forests (USF); NA= Not Available NS =Not Surveyed, WLS= Wild life Sanctuary

FISHERY RESOURCES AND FUTURE PROSPECTS OF UPLAND LAKES AND WETLANDS IN INDIA

H. S. Raina

BRIEF BACKGROUND

India holds third position in the world in terms of total fish production and first among Commonwealth countries yet it is 136th among 162 countries in terms of per capita consumption of fish being 3.12 kg against the world average of 12.11 kg. Out of 23% of India's total animal protein supply in the diet, the fish contributes merely 2.3%.

The Fisheries sector has been playing a very important role in the Indian economy through employment generation, contribution to food and nutrition security, and earning valuable foreign exchange through export. Since the launching of the first five year plan in April, 1951, fisheries and aquaculture in the country have witnessed an impressive transformation from a highly traditional activity to one based on a well developed and diversified infrastructure with immense potential for industrialization. The contribution of fisheries sector to the net domestic product has shown an eight-fold increase from Rs.8.06 billion in 1980-81 to Rs. 67.5 billion in 1993-94 at current prices as compared to the four-fold increase in agriculture during the same period.

Wetlands are dynamic ecosystems, comprising of vast areas of floodplain lakes, swamps, bheries (estuarine wetlands), etc. available along the riverine and estuarine stretches in Himalayan and Peninsular region of India. Apart from bearing a rich fish production potential, these water bodies are biologically sensitive areas, having a bearing on recruitment of population to the riverine, estuarine and marine sector. These wetlands constitutes an area of over 2.0 lakh ha. in the country particularly in Ganga and Brahmaputra basins in Himalayas, besides about more than 0.50 lakh ha. Bheries.

The Himalayas forms the main watersheds for the Indo-Gangetic region having innumerable rivers, streams, natural lakes/wetlands and reservoirs (man-made lakes). The aquatic resources of Himalayas are vast, rich and diversified and significant from socio-economic viewpoint. Once, these resources were thought to be inexhaustible and considered adequate enough to support the human population residing in these upland areas. But with the passage of time, the various natural and man-made disturbances with ever-increasing human pressure on these fragile ecosystems, a considerable shift in certain valuable species has been observed. There is a sharp decline in catches of few economically important fish species. Viewing such a state of affair, among 33 important highland fish species are under depleted stocks in commercial and sport catches, three species have been categorized as endangered, eight as vulnerable and seven as rare ones based on the micro level analysis on their abundance and availability.

Resources And Potentials

Lakes and wetlands are among the most productive life support systems in the world and are of immense socio-economic and ecological importance to mankind. They are of critical importance for survival of natural biodiversity and are recognized as sources, sinks and transformers of chemical and biological matter. These ecosystems have significant importance as they have a vital bearing on the fisheries production as well as ecology of the river system, provides livelihood to a large number of fishermen and contributes significantly to the total inland fish production. These systems harbour richest fish genetic resources comprising major carps, several coldwater fishes, minor carps, catfish and an array of anadromous fish and prawn. In broad ecological terms, the lakes/ wetlands in the country can be grouped in three categories :-

- Himalayan lakes/ wetlands
- Indo-Gangetic lakes/wetlands
- Coastal lakes/wetlands

Himalayan lakes/wetlands

Himalayas Karakorum lakes in dry Ladakh and lakes in Himachal Pradesh, hilly regions of Uttaranchal, Sikkim and other north eastern states.

Indo-Gangetic lakes/wetlands

The wetlands/lakes in the Ganga and Brahmputra basin locally called *jheel, beel, mans* and *pats* represent lucrative source of fisheries in the states of eastern Uttar Pradesh, northern Bihar, West Bengal, valley districts of Assam, Manipur, Tripura and foothills of Arunachal Pradesh and Meghalaya.

Coastal lakes/wetlands

All along the cost, wetlands are dominated by mangroves, backwaters, brackish water lakes, salt marshes, lagoons etc. The most important ones being the Sunderban mangroves, Chilika lake, Kolleru lake, Pulicat lake, Vembnad lake and many others which have localized importance.

Flood Plain Lakes

The flood plain lakes, which form an integral component of the Ganga and the Brahmaputra basins cover an areas of 2.0 lakh ha. . The lakes are important as they regulate the water regime and nutrient exchange, act as natural filters, have vital bearing on the recruitment of population in the riverine ecosystem and provide excellent nursery grounds for several fish species, besides a host of other fauna and flora. The flood plain lakes by virtue of their productive potentiality constitute one of the frontline areas capable of yielding more then 1.2 million tones of fish per year.

Floodplains are alluvial plain or the flat land bordering rivers, subjected to periodic inundation by floodwaters, which tend to be most expansive along the lower reaches of rivers. Hence, according to the Ramsar classification of wetlands, 'floodplain wetlands' are wetlands associated with rivers and streams along their floodplains. The floodplain wetlands usually represent the lentic component of floodplains *viz.* ox-bow lakes, sloughs, meander scroll depressions, residual channels; the back swamps and excludes the lotic component (the main river, the levee region monsoon rains. The floodplain wetlands located in different parts of India are locally known as *beels, chaurs, mans, boars, hoars and pats.* Many of these are either continuously submerged or intermittently inundated by seasonal flooding. Those floodplain wetlands, which are connected to their parent river are open type and those have no connection are closed type. Whether they are connected to their parent rivers or cut off, the structure of their flora and fauna are largely defined by water depth, current, sediment composition, nutrient status, water temperature *etc.* These water bodies exhibit enormous diversity in size and shape, according to their origin and geographical location, physical structure and chemical composition. They are important fishery resources in India, especially in states like Assam, West Bengal, Bihar and Manipur, where thousands of poor fishers depend on these water bodies for daily livelihood.

Table 1. Distribution of floodplain wetlands in India

States	District	River basin	Local name	Area (ha)
Arunachal Pradesh	East Kameng, Lower Subansiri, East Siang, Lower Dibang valley, Lohit, Changlang & Tirap	Kameng, Subansiri, Dibang, Lohit Dihing and Tirap	Beel	2,500
Assam	Brahmaputra & Barak Valley districts	Brahmaputra & Barak	Beel	1,00,000
Bihar	Saran, Champaran,Saharsa, Muzaffarpur, Darbhanga, Monghyar and Turnea.	Gandak and Kosi	Maun, Chaur and Dhar	40,000
Manipur	Imphal, Thoubal and Bishnupur	Iral, Imphal and Thoubal	Pat	16,500
Meghalaya	West Khasi hills and West Garo hills	Someshwari and Jinjiram	Beel	213
Tripura	North, South and West Tripura districts	Gumti	Beel	500
West Bengal	24-Parganas North and South, Hooghly,Nadia, Murshidabad, Burdwan,	Hooghly, Ichhamati, Bhagirathi, Dhurni, Kalindi, Dharub,	Beel, Chaurs and Baor	42,500

Fisheries in lakes & wetlands

The fisheries of Indian uplands both in the Himalayan and Deccan plateau are poorly developed. In both the regions big commercial fishing is absent. Reasons invariably are the slow rate of growth, low catch and difficult terrain. Inadequate access between fishing and consuming centers. The fishery in these ecosystems are dependent on trout, snow trout, mahseer, common çarp, minor carps and berils.

Trout fishery

Brown trout *(Salmo trutta fario)* and rainbow trout *(Oncorhyncus mykiss)* are the two species among salmonids which constitute trout fishery of the streams, lakes and reservoirs in the Indian uplands . In the Himalayas, brown trout contributes to sport fishery, while in the southern region, it is the rainbow trout. In Kashmir apart from snowfed streams, a few high mountain lakes in which the species was introduced record sizeable population of brown trout. Of late, the population is showing a declining trend caused mainly by disturbances along the catchment, which affects the stream ecology in a significant way. In the high Garhwal Himalayas, the Dodital supports good population of brown trout. At such altitude the fish breeds in the adjacent streams and migrate back to the lake. In the reservoirs of Kerala and Tamil Nadu sizeable catches of rainbow trout are recorded. The catch structure of two species indicated small sized populations. In case of brown trout in Himalayan region the size range being 275-450 g/rod/day. Contrary to this, the average weight of rainbow trout in the Deccan plateau range between 150-225 g/rod/day.

In the Indian sub-continent two main species of trouts *viz.* brown trout -*Salmo trutta fario* and rainbow trout - *Oncorhynchus mykiss* were transported from Europe by British settlers around the beginning of twenty century primarily to satisfy their needs for sport fishing. In the Indian uplands the cultivation of fish contributes little to the overall freshwater fish production. Virtually every facility created for fish cultivation in the uplands produces fish for stocking the natural wild waters primarily to meet the requirement for sport fishing. Until recently, brown existing populations in the well-established habitats of the species, and also for introductions in new habitats (lakes/streams/rivers) to meet the ever-increasing requirement of sport fishing. In Western Ghats, the intensive seed production of rainbow trout for ranching in suitable waters for sport and recreational fishery is still a constraint. Establishment of modern hatchery with rearing facilities for production of fry and fingerlings to release in streams, reservoirs and lakes, requires immediate attention. At present the infrastructural facilities like hatcheries, nursery and adult rearing trout ponds, raceways etc. are inadequate and do not meet the demand for ranching the wild waters and for farms.

The concept about the trout as a highly expensive fish to cultivate in the farms and a luxury food fish beyond the reach of the common man is gradually changing as trout farming are coming up in cold water areas. Both the varieties of trouts are considered as high value food fishes and good for sport.

Snow-trout fishery

The Schizothoracine fishes (snow - trouts or the Schizothoracids) are the indigenous fish fauna of the Himalayan and sub-Himalayan regions of the Indian sub-continent. The principal species of the group inhabiting Himalayan waters are entirely dependent on natural recruitment and are economically important. The environmental degradation in lacustraine and riverine ecosystems in Himalayas holding snow-trouts has resulted in sharp decline in their population and genetic variability. In this context, their conservation in upland waters becomes imperative. In the past, studies have been made on systematics, eco-biological behavior and propagation of different snow-trout species in temperate and sub-tropical regions of uplands, but the information on its fishery in open waters is still widely scattered.

In Himalayan uplands, Schizothoracine species and other fishes inhabiting these waters are small sized being slow growing and fast swimmers. However, not all the fishes in the rapid waters are swimmers, many maintain themselves close to the bottom or take shelter under the stones (certain species of cyprinids and catfishes). The fishes in torrential streams of the Himalayas maintain their position by physical water temperature, nature of substrata and availability of food represented mostly by organisms clinging to and growing on stone and rocks surface in fast current.

Amongst the Schizothoracine group, species of *Schizothorax* and *Schizothoraichthys* are predominant and distributed in the regions having altitudinal range of 750 to 2500 m asl; *Diptychus*, on the other hand has a slightly higher distribution in the range of 2500-3750 m. However, other species of the group *viz. Gymnocypris, Ptychobarbus* and *Schizopygopsis* are distributed in the higher zones (3500 m and above). Most of the species are Central Asian in origin. The tectonic processes and glaciations have played an important role in the distribution of snow-trout fish fauna in high altitude cold watersheds of Indian sub-continent. In Indian uplands, amongst the Schizothoracinae, *Schizothorax richardsonii* is the most widely distributed and common in rivers and is held in high esteem by the local people.

Snow-trout resources in Indian uplands consist of river systems, lakes and reservoirs. The natural fisheries in the mountain streams are of subsistence type. In the lakes and reservoirs all along foothills however, commercial fishery is in operation. In addition, majority of the upland aquatic ecosystems provide game fishery, which attract only local anglers. Based on the estimated analysis of survey data undertaken by various teams, the length of rivers and other water bodies holding coldwater fishes especially Schizothoracine fishery are :

Freshwater streams/rivers	8,243	km
Freshwater lakes/wetlands	20,500	ha
Man-made lakes (Reservoirs)	50,000	ha

Research support

Farming of commercially important snow-trouts, if successful, will have good potential in all the Himalayan states. But so far attempts have not been very encouraging, probably due to its slow growth. A number of countries are pursuing the development of hatchery technologies for indigenous snow-trout fishes in their respective regions. In India initial success in artificial breeding of wild stocks of with minimal economic benefit. So far no attempt has been made to promote its culture in this region. The studies revealed that the entire group is amenable for artificial fecundation and its fishery can be easily revived through artificial propagation.

Mahseer fishery

Mahseer provides a sizeable fishery in the lower reaches of the Himalayas and Decan plateau wetlands. *Tor putitora ,Tor tor and Neolissocheilus hexagonolepis* are the important Himalayan species, while *Tor khudree* is the inhabitant of Peninsular waters. Mahseer are known as a migratory fish moving upstream in the main rivers of Indo-Gangetic and Decan drainage for breeding . Overall catches of mahseer in all most all the lentic waters have declined drastically. Even sizes have reduced significantly. This change is due to the construction of hydraulic structures downstream of the rivers. Similarly this fishery in Kashmir lakes has lost completely, due to the construction of hydraulic dam at the river Jhelum in the portion of occupied Kashmir. Similar situation has been recorded in lakes/wetlands and reservoirs in Himachal Pradesh, Uttaranchal, and Northeastern region of the country. The main causes of depletion apart from destructive methods for fishing are damming of stream, discharge of domestic and industrial affluent into lakes and streams, siltation of breeding grounds and paucity of natural food in the wetlands suitable for the mahseer. Therefore, conservation of upland wetlands and rehabilitation of this important fishery are interrelated issues.

Research support

The mahseer flow-through hatchery designed by NRCCWF has a great impact on the building up of healthy and disease resistant stocking material of mahseer species on mass scale under controlled conditions for rehabilitation the natural waters on required basis and for aquaculture purposes. But still research needs immediate attention on :

- raising brood stock for artificial propagation and intensive production of stocking material of this group in captivity ;

- selective breeding and stock improvement of various species of mahseer ;
- exploiting the possibilities to culture mahseer in combination with other cultivable species, exotic carps and Indian major carps;
- effective utilization of coldwater ecosystems both for biomass enhancement as well as for sport.

Common carp fishery

Common carp mainly includes two phenotypes *viz., Cyprinus carpio specularis* (mirror carp) and *Cyprinus carpio communis* (scale carp) which contribute the bulk of the commercial fishery of certain lakes and reservoirs in Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Uttaranchal, North Bengal, Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Tamil Nadu and Kerala. Now the fish has invaded most of the upland waters, resulting in some kind of an ecological imbalance. It is believed that in upland wetlands/ lakes, this fishery contribute more than 60% in the general catches. The stocking of this exotic variety has pushed up the fish yield from these systems but negative ecological impacts are quite apparent.

The introduction of the common carp in wetlands about 5-6 decades back was obviously to increase fish production. Today it occupies a prominent position in these systems, therefore, to control or ban for the sake of native germplasm seems to be illogical, if not to defeat the very purpose for which introduction was carried out. This aspect needs critical evaluation. Since, this species have proved as useful introduction for the upland waters to provide cheap source of protein to the hilly people, their better growing strains should be welcomed in these areas in view of genetic fatigue in the existing strains.

Fishery Management in Wetlands/ Lakes

The water quality investigations of typical lakes in uplands have indicated that they are suitable for fish growth and stock improvement. The status of biological communities in these systems revealed that these can sustain reasonable fishery. The estimated fish production in the systems range between 10-30 kg ha^{-1} yr^{-1}, practices can differ from system to system and region to region. The management approach in case of high mountain wetlands will differ from those located in the valley. The mountain lakes are ecologically short food chain systems, mostly oligotrophic and a few record significant zooplankton, insect and zoobenthos populations during ice-free summer periods. A comparative food chain pathway study has shown that introduction of brown trout *(Salmo trutta fario)* in these lakes is quite successful, which is indicated by sustained trout population available in some of the mountain lakes in Northwestern Himalayas. Similarly such mountain systems need conservation due to presence of indigenous fauna especially *Diptychus maculatus* (Jammu & Kashmir) and *Neolissochelius hexagonolepis* (Arunachal Pradesh).

On the other hand, in valley lakes where the climatic conditions are not very harsh and range from *mestrophic* to eutrophic in nature can be exploited for sustainable fishery. It is felt that comparative higher rate of primary production in these wetlands can be channelized into fish biomass by proper stock adjustment. The stocking density and species mix can be based on production potential and food spectrum of each lake. Since the species diversity with respect to the growth performance and food range in these lakes is limited, some useful introductions can be helpful. At the same time effort should be made to conserve the breeding grounds of the local varieties and plan in such a manner that introductions do not cause any harm to the stocks of the local endemic fauna. For enhancement of upland fishery in wetlands, following measures are proposed.

Weed control

Infestations of submerged and free-floating weeds have reached stupendous proportions in most of the floodplain lakes, hastening the process of swampification. While submerged weeds (*Hydrilla, Vallisneria, Najas* etc.) can be biologically controlled, the floating weeds, chiefly water hyacinth have to be eradicated through other means. Whereas manual/ mechanical methods of removal are relevant in small lakes (< 100 ha.), the technology for large ones demands a combination of both mechanical and chemical means. Application of 2,4-D sodium salt formation (80 % a.i.) is effective in weed - kill to the extent of 90% in the case of the water hyacinth.

utilization. The lakes having no connection with the riverine source have to be assiduously segregated before release of exotic carps. If stocked in others, their escape into the drainage may endanger the indigenous species. The recent success attained in control of water hyacinth in Loktak lake (Manipur) through introduction of a weeveil *(Neochetina eichhorniae)* in the area, opens up new prospects of control of this menace weed through biological method.

Auto - stocking

The sustainable development of commercial fisheries in the lakes would involve a recurring expenditure on the procurement of spawn and its transport for stocking. Autostocking of Indian major carps during floods in such lakes, therefore, is the only viable alternative for their quick and profitable development. For this, the desilting of connecting channels and their effective management is a pre-requisite. The operation of sluice gates, wherever installed, is to be oriented in such a way as to facilitate entry of brood fish and juveniles into the lake proper. This would entail suitable legislation to overcome the conflict between agriculture and fisheries.

Culture-based capture fisheries

With the advent of culture-based-capture fisheries, culture and capture systems are merging into one integrated whole. The present strategies for optimum exploitation of floodplain lakes fisheries revolves around the concept of keeping the deeper central portions as exclusive zones for capture fisheries and renovation of margins/ pockets for culture fisheries. Desilting of channels and construction of perimeter dykes are pre-requisites for such exercises. Most of the lakes are dendritic and have pockets retaining water throughout or part of the year. By way of micro dams/ sluices, these pockets can be converted into tanks. Intensive aquaculture practices are suggested for such waterbodies. It is also suggested to adopt integrated fish farming rather than composite fish culture alone. A multi-community farming system is more advantageous to the farmer, if the community mixes fits well into the available resources and needs, than the mono-cropping system. The integration of pig and duck husbandry with fish culture is gaining popularity due to high returns.

tested for fry and fingerling rearing in reservoir and to culture table size fish in beels, which provide suitable habitat for such culture operations. Such captive fish culture, on a commercial/industrial scale, should be avoided. As it leads to nutrient enrichment and eutrophication of the system. Recent success achieved by CIFRI to culture fresh water prawn in pens installed in wetland in west Bengal opens great scope for this type of activity in a wetland.

Biomanipulation

A proper understanding of the complex relationship of the food chain and the pattern of the energy flowing in lakes is required. In general, there are two main routes through which the energy flow in aquatic ecosystems- *viz.*, grazing chain and detritus chain. We may expect a continuous high rate of production of detritus. The fishes such as *Cirrhinus mrigala, C. reba, Labeo rohita,* and *L. bata* may fill the gap. The cascading effects of biomanipulation at different trophic levels is to be evaluated carefully.

Environmental trends

A perusal of data on the ecological variables of floodplain wetlands in India not only indicates aberrations in water quality, but also growth of unwanted biotic communities. Some of the important trends are

- Massive growth of aquatic macrophytes (submerged, floating, emergent),
- Inadequate population of plankton communities,
- Domination of molluscs at the benthic niche,
- Greater dominance of forage fish and those of less economic value and relatively poor market acceptability,
- Sizeable presence of exotic species exerting pressure on the native species and
- Water quality deterioration with the presence of heavy metals etc.

Most of these water bodies are either 'drained' for arable land or 'drowned' due to human interference in catchments and connecting rivers. Dumping of waste

Sustainable fisheries in wetlands

The sustained fisheries in wetlands require both micro- and macro planning. As the micro - planning approach is essentially project oriented, the macro - planning is devoted to sector development. The major issues are :

- Development of production system
- Changes in lease period, credit and subsidy policies
- Development of marketing system
- Human resource development
- Socio-economic acceptability
- Enforcement of fishery regulatory measures with participatory approach

Action Plan

Depending upon the natural aquatic resources (lakes/ wetlands/ reservoirs) in the hill states, species variability technology support and scientific database available, fishery if developed on scientific lines will go a long way in contributing to the rural economy in remote hilly zones of the state. It is suggested that fishery development should be initiated with available exotic and indigenous fishes as the resource base. Higher reaches where water temperature and other conditions are suitable should be exploited for trout to promote sport fishery and culture of rainbow trout on commercial lines. While, at comparatively lower altitudes species of mahseer and snow-trouts seed production centers should be established to cater the demand for stocking wild waters including lakes and wetlands for sport and food. Establishment of carp and Indian major carps (alongwith exotic carps) hatcheries and farms at lower altitudes is another pre-requisite to meet the demand to stock natural ecosystems and farmers who are engaged in small scale fish farming. To promote all these activities, a time bound action plan has to be initiated on priority. ICAR institutes can provide the necessary technical support to carry out the stipulated programme activities.

CONCLUSIONS

weed infestation and human encroachment. These problems may be tackled by identifying issues faced by lakes/wetlands and use of appropriate viable measures keeping in mind realistic goals. The wetlands and lakes are valuable national resources and aquaculture is an acceptable use for economic development but this activity should not be permitted without prior knowledge about the ecological status of a particular wetland. There is no serious ecological impact in allowing sustainable fishery based on sound management principles in wetlands. A wise use policy for freshwater lakes and wetlands is needed. A symbiosis between humans and their environment using existing Science and Technology is of paramount importance.

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SNOW-TROUT FISHERY AND CULTURE PROSPECTS IN HIMALAYAN WATERS

Shyam Sunder

BRIEF BACKGROUND

Snow-trouts, belonging to sub-family Schizothoracinae, constitute a specialized group among carps contributing a much relished indigenous fishery of himalayan uplands in Indian sub-continent. Only 17 species have been on record from the country. Schizothoracids mostly occur from rapid coldwater zones to rapid turbid zones besides lacustrine systems. They are well adapted to torrential streams of high altitudes in respect of stream-lined body shape, reduction of scales, modification of lower lip, paired fins large with their muscular bases and outer rays thick and muscular, short or complete absence of barbels and long caudal peduncle etc.

Out of 17 species, *Schizothorax* (*richardsonii* and *kumaonensis*) and *Schizothoraichthys* (*niger, esocinus, longipinnis, planifrons, micropogon, curvifrons, nasus, hugelli, labiatus* and *progastus*) are the major once. The others include *Diptychus* (*maculatus*), *Ptychobarbus* (*conirostris*), *Schizopygopsis* (*stoliczkae*), *Gymnocypris* (*biswasi*) and *Lepidopygopsis* (*typus*). The last one is restricted to Western Ghats whereas the other ones are the denizens of himalayan uplands wherein *S. richardsonii* is widely distributed. Majority of snow-trout species are restricted to Kashmir himalaya.

MAIN BIOLOGICAL FEATURES

Trials have been made to delineate the available information on important biological parameters of different snow-trouts species. Such information could be useful in framing conservation and management strategies in open waters besides artificial propagation in captivity. Some important features are :

- Most of the members of snow-trouts are herbi-omnivore having a tendency

- Age and growth parameters reveal low growth pattern at high altitudes and *vice versa* since water temperature plays an important role in fish growth
- Fecundity generally varies between 8,000 - 45,000 eggs/ kg body weight
- Fish normally matures at 2+ age in males while at 3+ in females.
- In Kashmir valley, Schizothoracids are annual breeder (April-June) whereas in other himalayan regions some species are reported to breed twice in a year.
- Barring *S. niger*, other members of snow-trouts are known to undertake spawning migration from the main basin to the adjoining streams/tributaries during the breeding season and many species show sexual dimorphism by developing secondary characters which disappear after the spawning phase is over.
- The spawning takes place in low flood areas having well oxygenated water in sand, gravel, pebbles, debris, creeks of large stones etc. in lotic system, whereas mostly in aquatic weeds in lentic environment.

DECLINING TRENDS

It is observed in general that there has been an over all depletion of snow-trout stocks from himalayan region particularly from the lentic waters, the details are as under :

- Catches of snow-trouts have been reported to the tune of 67-74% from north-western himalaya; 59-67% from Himachal himalaya and 58-90% from Uttaranchal himalayan streams/rivers; however, by and large, their overall size frequency has gone down by 10-20% over the years
- Average catches of Schizothoracines are usually 25-30% at < 1000 m asl while about 70% at > 1000 m asl
- Generally the fish specimens caught are 200-500 g . Specimens > 1 kg are observed rarely in catches that too from some selected pockets
- The fishery of snow-trout varies from 20-32% in Kashmir lakes; 1- 5% from Himachal lentic systems and almost insignificant from Uttaranchal lakes
- A decline in the catches of *S. richardsonii* and *S. pragastus* has been reported in R. Beki (Assam) from 3100 kg (1991) to1500 kg (1996)
- In Kashmir lakes, detailed investigations over the years have indicated dominance of introduced common carp over the endemic Schizothoracids ...

- Much higher fecundity of common carp
- Spawning facilities in the system itself
- Better fertilization rate and shorter incubation period
- Better growth rate

Factors relating to decline

The major causes put forth for the declining trends of various species of snow-trouts from the Indian scenario are i) ecological degradation, ii) indiscreminate land use patterns, iii) destructive fishing methods, iv) river valley projects, v) large scale abstraction of stream water and building material and vi) introduction of unplanned exotic fish species besides various inherent factors :

Inherent factors

- Ascending and descending migratory phases in snow-trouts can no longer remain unmolested; the journey could be safe or fraught with risks and dangers
- Low fecundity and long hatching period
- The fertilized eggs / hatchlings and subsequent young stages of snow-trouts laid at the stream bottom remain under stress of mortality on account of a slight flood causing rolling action of the bottom material or through perdition
- Entrapment of young fry in isolated boulder pools along longitudinal axis of the river during dry spells which eventually perish

CONSERVATION NEEDS

It is a well established fact that for the prosperity of human being, dams need to be constructed, fool-proof pollution can not be checked, tourism industry can not be ignored, poaching and illegal fishing can hardly be stopped especially in the far flung areas and long stretches of rivers/ streams, growing human population can not be undermined and developmental activities cannot be checked. Inspite of all these, factors, immediate action plan is needed for rehabilitation of Schizothoracid fishery, which could prove practical and beneficial. Besides the safety and conservative measures adopted by respective states, the immediate approach needed would be

In- situ Conservation

Based on the resource assessment of Schizothoracine seed potentials from various himalyan aquatic systems, it is well ascertained that a huge quantum of young population gets entrapped in small natural pools, ditches and side waters which get cut off from the main fluvial systems during dry spells. Majority of such pools disappear eventually leading to the mass scale destruction of the valuable germ-plasm primarily on account of :

- Direct sun- light resulting quick change in water temperature
- Over-crowding
- Water stagnation causing low dissolved oxygen and high free carbondioxide concentrations
- Decrease in natural food availability
- Unwanted growth of weed, pathogens and predators etc. This leads to insignificant recruitment in the main biotopes; hence collecting and salvaging snow-trout seed in certain suitable water areas on scientific lines for repopulating them can save this stock to a great extent.

Ex- situ Conservation

The most pragmatic and holistic approach as suggested by fishery experts from time to time is the captive breeding of important snow-trouts. The healthy suitable sized stocking material so produced in hatcheries/farms could be stocked in open waters on continual basis, which would be beneficial in repopulating the declining snow-trout fishery.

ARTIFICIAL PROPAGATION

Scientists of NRC-CWF have made significant trials on the artificial propagation of important and common species of snow-trouts initially in Kashmir during eighties and subsequently in Kumaon Himalaya in nineties; further work in this direction is in progress.

- Emergence of swim-up fry and initial feeding
- Raising of fry and fingerlings on formulated artificial diets

By adopting the above programme, it has been possible to artificially strip the sex-products (without any hormonal manipulation) of important Schizithoracid species *(S. niger, S. esocinus, S. curvifrons, S. longipinnus and S. richardsonii)* in Kashmir valley (J & K State) and *S. richardsonii* in Kumaon himalaya (Experimental fish farm, Cherrapani, Distt.Champawat).

Hatchery requirements

The basic concept of a snow-trout hatchery is almost on the same lines similar to mahseer hatchery with certain modifications. Well oxygenated (8-10 mg/l), clear with least silt load continuous flowing water supply having an ideal temperature of 8.0 -25^{0}C should be ensured before setting up a hatchery. The hatchery should be under a roofed house to avoid direct sun light with concrete or bricked floor. The fertilized eggs are normally incubated in specially designed concrete/ FRP hatching troughs (2.0 x 0.33 x 0.10 m) having four to five wooden / FRP trays ((0.34 x 0.32 x 0.08 m) with nylon netted bottom and small windows at two sides for regular flow of water. Hatching troughs are mounted on angle-iron stands of suitable height to ease the working. Each hatching tray has a capacity to hold 3000-5000 fertilized snow-trout eggs/tray. Besides, maintenance of continuous water flow, each hatching trough is provided with showers to augment the water supply in case of oxygen depletion. The water from supply tank flows into the head hatching troughs up to the tail end trough in a series, which are generally four in number.

The fertilized eggs can also be incubated under different conditions in the hatchery/ laboratory *viz.* stagnant and flowing water conditions, enamel and wooden trays and in specially designed incubator. However, it is noticed that fertilized eggs incubated in enamel trays under still water conditions in the laboratory register heavy mortality compared to hatching trays and especially designed incubator with running water facilities in the hatchery.

0.85 m ;height, 0.35 m and diameter, 0.25 m) with an inlet near the bottom and an outlet near the top. Inside the drum, six metallic circular hatching trays are arranged in a tier system. Each tray (circumference, 0.6 m; height, 0.05 m and diameter, 0.20m) has been fitted with nylon netting (approx. 196 meshes/cm^2) at the bottom of each tray. The incubator can easily be installed slightly at a lower level by the side of a stream. From the inlet fitted with a rubber/plastic pipe, a continuous flow of water directly from the stream is maintained. The fertilized eggs of Schizothoracines (2000-2500) are gently placed in each tray. Within a period of 1-2 weeks, this small unit has the capacity to produce about 10,000 hatchlings with a survival of > 60%. The other advantages of this miniature seed factory are: a) no possibility of oxygen depletion b) it's dimensions can be changed suitably c) insignificant mortality fluctuations in various trays from top to bottom.

Stripping and fertilization

The stripping of sex-products from gravid snow-trout specimens is conducted by "dry method" on the availability of either sex simultaneously either by one-man method or two-men method. The eggs are taken from the gravid female specimens by slightly pressing the belly downward in clean plastic/enamel bowls. The milt from the male brooders is spread over the eggs by similar manipulation. The sex products are mixed gently by moving the container sideways or with the help of a bird's quill. The fertilization takes place instantaneously. The eggs are washed repeatedly and allowed to stand in shadow for about half an hour for 'hardening' process. Total number of fertilized eggs after they are water hardened is estimated either by volumetric method or gravimetric method, however care needs to be exercised in handling them since they are sensitive to mechanical shocks. Rate of fertilization can range from 65-90%. The fertilized eggs are generally spherical, demersal, adhesive and pale yellowish to orange coloured and range between 3.0-3.5 mm in diameter.

Incubation and hatching

Snow-trout eggs undergo continuous developmental changes until hatching. The incubation period normally ...

ready to accept artificial diets. The cumulative survival from fertilized eggs to swim-up fry stage ranges between 35-60%.

Precautions during egg production and incubation

During incubation/hatching of Schizothoracids, some major precautions to be taken care of are :

- The hatchery units should be washed with 5% solution of Potassium permanganate prior to use
- Proper sanitation conditions to be maintained in the hatchery
- Daily culling of dead eggs and egg shells from each hatching tray with a glass dropper or by siphoning without least disturbing the neighboring eggs
- Proper water supply should be monitored regularly and in case of oxygen depletion, provision need be made for water fountains in individual units
- Prophylactic measures need to be taken against fungal attacks and other diseases
- Since the incubation of snow- trout is fairly long, all possible measures are required to keep a vigilant regular watch on the developing stages

Fry rearing

Subsequent to emergence of swim-up fry, the hatchery troughs can be used for rearing of young fry and for initial feeding purpose prior to stock being shifted outside the hatchery into nursery/rearing ponds. Results of rearing and feeding young fry of *S. richardsonii* with various artificial compounded diets in captivity (12-20 mm; av. wt., 0.060 g) in running water cemented nursery ponds (10x3x1m) with different densities at Experimental fish farm, Champawat (Uttaranchal) exhibited that in a period of about three years, the fish attained a growth of 3-5 g, 8-12 g and 30-40 g during first, second and third years, respectively with an overall survival rate of 30-50%. It was further observed that fish stocked at higher density (5/m^2) had comparatively less growth and survival (15-20%) compared to a stocking rate of 2.5/ m^2. The artificial feeds used during the rearing period were formulated and prepared both from animal and plant sources, feeding oil supplemented with

Water requirements at various developmental stages

The water requirements at various developmental stages for snow-trouts under captivity are :

Stages	Stock	Water requirement (l / min.)	Water temp. (°C)
Incubation of fertilized eggs	3000-5000	0.5-1.0	8.0-15.0
Fry to fingerlings	1000-2000	2.0-3.0	15.0-20.0
Fingerlings (1+ yr.)	500 - 1000	2.5-3.5	< 25.0

Achievements during artificial propagation at Champawat Fish Farm (U.A.)

- Rate of fertilization ranged between 65-90%
- Incubation period varied from 10-15 days
- Cumulative survival from fertilized egg to swim-up fry recorded 35-60%
- Survival of fry recorded 55-75% with various treatments (mud ponds, cemented ponds, nylon cages, hatchery troughs under static and flow- through systems) at varied densities
- Lower stocking densities coupled with running water facilities gave higher survival rate (16-27%) up to early young fry stage
- Fry grew to a size of about 5 g during the first year and about 30-40 g in a period of about 3 years in cemented nurseries with artificial diets
- Various ingredients used in compounded artificial feeds in different proportions and combinations included Soyflour, GOC, rice polish, wheat bran, fish meal and silkworm pupae supplemented with feeding oil besides min.-vit. pre-mixture
- Initial success has been obtained in conducting artificial fecundation, hatching and rearing of young ones from pond raised *S. richardsonii*

Initial reports from other sources

- In Garhwal himalaya, initial breeding experiments through hypophysation using pituitary extract and Ovaprim on *S. richardsonii* are reported to have

- In Himachal Pradesh, in an experimental trial the use of homoplastic pituitary extract resulted complete ovulation in *S. richardsonii*

AFFRONTING ISSUES

From the basic information generated so far, it can be safely inferred that schizothoracine species are easily amenable to breeding either through hypophysation and / or stripping method and can be further reared up to stockable size (> 5 g) in a period of one year; However in the mud ponds, a significant growth could be expected with well balanced artificial diets. The healthy seed, thus produced in large numbers can be ranched to rejuvenate the open waters on continual basis besides collection and stocking of natural seed from the drying pools to save the valuable germ plasm of this fine fishery which unnecessarily go waste. It is evident that growth of snow- trouts is certainly not very encouraging in captivity, probably due to inherent genetic characters. This could be one of the main reasons that culture activity has not attracted attention of other countries. In a period of 7-11 years, the fish is known to attain a size of about 500 g in colder zones.

In spite of various constraints, it is desirable to continue our best possible efforts to evolve a complete culture system for Schizothoracines which would require more detailed investigations as regards to selective breeding, digestive physiology, improvised nutritive diets, use of growth promoters etc.

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ARTIFICIAL PROPOGATION OF HIMALAYAN MAHSEER *TOR PUTITORA* (Ham.)

C. B. Joshi

INTRODUCTION

In recent past, a sharp decline in the catches of mahseer has been experienced. The reasons behind this unabated declining trend are many, mostly related to the man and the environment, which in the pace of development has severely damaged the eco-systems holding mahseer and allied fisheries. Besides environmental stresses, indiscriminate killing of adults and juveniles has been recognized as a major factor responsible for declining of mahseer in Himalayan biotops. Ever increasing pollution in lakes and streams, degradation of breeding grounds, prolonged spawning period, use of pesticides, poisoning are some of the factors also accounted for depletion of mahseer fishery. Hence, to circumvent the declining trend of mahseer and, further to replenish its stocks in the natural waters, artificial propagation is a viable and effective approach which by means of quality seed production and ranching can ensure the rejuvenation of its fishery and sustenance of population.

ARTIFICIAL PROPAGATION

The artificial propagation for seed production of golden mahseer involve the collection and selection of brood stocks among the natural population, egg taking from selected ripe spawners, fertilization of eggs, hatchery practices, rearing the seed to the size suitable for stocking. Prior to seed production activities, selection of suitable site for installation of hatchery with sufficient availability of fresh oxygenated water must be completed and the facilities like eggs, incubators, hatchery troughs/trays, seed rearing tanks must be ensured.

BROOD FISH STOCKS

not restricted. The gravid fish leave the sanctuaries and migrate to the streams for spawning. Aside these pious sanctuaries where mahseer gets protection on religious grounds, the deep pools in mountainous gorges, the rivers in the foot hills and some upland lakes are known to hold the mahseer and can be the dependable sources for the brood fish.

SELECTION OF SPAWNERS

With the approach of spawning season the brood fish leave their safe haunts in deep river pools and ascends shallow unprotected streams for breeding. The mature fish are then trapped from these spawning streams and on the availability of both the sexes are stripped for eggs and milt. The collection of the brood fish from the lakes and deep pools is normally done by the gill nets. At Bhimtal, the gill nets of size 75.0 x 8.0 m dimensions with mesh ranging from 75.0-125.0 mm bar to bar are used to catch the spawners from the lake. Secondary sexual characters in *Tor putitora* are quite pronounced during the spawning season. The male and female fishes can be distinguished by their, shape, size and body colouration. Normally, the males are bright in colour with elongated bodies as compared to the females having deep and dull coloured bodies with bright orange tinge on the anal fins. This, differentiation is not always helpful to distinguish the sexes. However, it can be used with other diagnostic characters. The anal fin in the female fishes is opaque and shorter than pectoral fins. The pectoral fins of males are rough and harder as compared to those in the females. To feel the roughness of the pectroal fins good amount of field experience is required. Tuberceles are rarely seen in the male fishes. Most of the male fishes develop dark gray or black colouration on their bellies during the breeding season.

Prior to taking the eggs and milt from the spawners they are examined for their readiness. The ripeness of the female fishes is observed by feeling the softness of the distended abdomen, pink colouration of the vent and the gravidness of the fish by exerting slight pressure on their bellies to confirm easy release of the eggs,

EGG TAKING AND FERTILIZATION

The process of obtaining eggs from female fish and milt from male fish is called stripping and is carried out by 'dry' method to ensure total fertilization. In 'dry' method both the products, the eggs and the sperms are stripped into dry pans or receptacles. In this process the micropile of the eggs remain open for a longer duration as compared to the 'wet' method and hence the entry of sperm is easy and the fertilization is ensured in all the eggs.

To obtain the eggs, the fish is grapsed with one hand round the caudal peduncle in such a way that its vent faces downwards over the pan, while the head remains upward support of the body and arm of the egg-taker. The free hand is now used to squeeze the belly of the fish for extruding the eggs. A gentle pressure is continued by fingertips on one side and by the thumb on the other side below the lateral line of the fish till the eggs come out freely from the vent. Sometimes during stripping operation blood stains are seen with the eggs in the receptacles. The continuous oozing of blood from the vent may be either due to injury of the interal organs or extruding of unripe eggs by heavy pressure exerted during stripping operation. Such practice may be stopped immediately and fish should be released in fresh oxygenated water. After the eggs are stripped the male is stripped of milt by the similar manipulation as done for female spawner. Only few drops of milt are enough to fertilize a large quantity of eggs. Hence, to fertilize the eggs collected from 3 to 5 females, 2 to 3 young and healthy males are sufficient. The production of ripe eggs in *Tor putitora* varies greatly from fish to fish irrespective of their size and weight. The spawning in mahseer is prolonged and extends from June to the end of September in the Kumaon waters. However, mid-monsoon period from, July to August is considered as the peak period for breeding of *Tor putitora*.

The fertilization takes place instantly when mixing of eggs and milt is done by some soft implement like a feather, brush etc. The eggs after mixing of milt are allowed to remain in this condition for 2-3 minutes to ensure total fertilization and matter and other waste is flown out. The rate of fertilization is determined by keeping the fertilized eggs for 24 hours in 5% acetic acid solution. The viable eggs become transculent while the unfertilized eggs are transparent.

INCUBATION AND HATCHING

The mahseer eggs are incubated in specially designed longitudinal hatching troughs of the size 220 x 60 x 30 cm with four to five hatching trays having squar mesh synthetic netting cloth (20 mesh per square inch) in the bottom. Nearly 5000 fertilized eggs can be spread over in a single layer in each of these hatching trays with the supply of neat and fresh oxygenated water at a flow rate of 1.0 - 2.0 liter/ minute. The time required for mahseer eggs to hatch varies widely based on temperature. Normally the hatching of golden mahseer eggs takes place in 80-96 hr at 22-24^{0}C.

The occasional flushing of hatching troughs and trays with malachite green in the ratio of 1:200000 for about one hour as to check fungus, picking of dead eggs and larvae from the hatching trays are the measures to be applied for obtaining higher survival rate during incubation. The newly emerged larvae of *Tor putitora* lie movementless for few hours on the bottom of hatching trays and start congretaing after 24 hours at the corners in search of safe and darker place. Their size ranges 7.4 - 8.6 mm with large yellow coloured oval shaped yolk - sac which is normally absorbed within 1 - 2 weeks time.

FRY REARING

The rearing of mahseer fry is done in two phases. The first rearing stage takes place in the hatching troughs itself where the incubation has taken place and the second phase in small circular or rectangular nursery tanks. These circular or rectangular nursery tanks can be made of cast iron sheet/ thick tin sheet/fibre glass with proper inflow and outflow arrangements. The plastic pools or small cages made of oxygenated water is allowed to flow. The newly emerged fry are fed on boiled yolk of hen's egg in an emulsified condition or with formulated feed every two hourly at the rate of 10-20% body weight depending on water temperature. The fry are fed on these diets for about 20-30 days till they attain a size suitable for shifting into the nursery tanks. The size of the fry at this stage is normally 10-12mm in length and 0.008-0.10g in weight.

The second phase of fry rearing takes place in circular/rectangular nursery tanks with the grown up fry of the size 10-12 mm in length. The size of circular nursery tanks should be 1-2 m in diameter and the rectangular nursery tanks should be 200 x 60 x 50 cm or 250 x 50 x 40 cm. in dimensions. The stocking densities can be calculated as per the water flow and capacity of each rearing tank. Normally the water flow at the rate of 1.0-1.5 l/min. is maintained for incubation and rearing of 25000 hatchlings at 20.0-25.0^{0}C. For 3 months old fry stocked @ 20000-25000, a water flow @ 3.0 - 4.0 l/min. is maintained. The stocking density per tanks can reduce futher to 5,000 - 6,000 fry as they grow. The fry at this stage are very active and easily maintained on dry artificial diets having crude protein level of 30-45%. After rearing of fry for about 2-3 months, these are fed @ 10-15% of the total biomass twice daily. The size gradation of the fry is also done periodically and the bigger sized fry are shifted and stockes in bigger tanks.

ARTIFICIAL FEEDS AND FEEDING OF FRY

Artificial diet plays a vital role for enhancing the fish fry production.

Generally the conventional feed item like mustard oil cake, wheat bran, wheat middling, rice polish, rice bran etc. are used for raising the mahseers. The feeding of mahseer, *Tor putitora* with mustard oil cake and rice polish (1:1) is a common practice. Formulated artificial diets from locally available feed ingredients containing 33.5% crude protein was efficient for feeding young *Tor putitora*. The ingredients used in this feed included dried silkworm pupae (10%), Maize flour (15%), Barley

DISEASES AND THEIR CONTROL

Apart from environmental stress and ecological disturbances, many causative factors are identified for severe loss of eggs and young ones of mahseer during hatchery operations. The mortality of eggs and fry of mahseer is mainly on account of sudden changes in water temperature and the water quality parameters in the hatchery, injury to fertilized eggs while transporting them to the hatchery troughs, white spot disease, egg-cleavage, egg clumning, fungal disease , weak progeny, body deformities etc.

To combat with the diseases encountered during hatchery operations, proper sanitary measures and use of prophylactics are the practices normally followed in the hatcheries. Supply of fresh oxygenated water with optimal temperature range in sufficient quantity, handling of hatchery material, eggs, juvniles fry with due care and frequent use of chemical/disinfectant like $KMnO_4$ for washing and sanitation of hatchery equipment and flushing of rearing material with malachite green as fungicide are some of the remedies suggested for better return during hatchery operations.

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BIONOMICS AND CULTURAL PROSPECTS OF KATLI, *NEOLISSOCHEILUS HEXAGONOLEPIS* (McCLELLAND) IN DARJEELING DISTRICT OF WEST BENGAL

S. Barat[1], Prithwiraj Jha[2] and R.F. Lepcha[3]

INTRODUCTION

Neolissocheilus hexagonolepis (McClelland), the snub-nosed Chocolate mahseer, commonly known as Katli, is an economically important food fish in the Darjeeling hills of West Bengal. It is generally captured from the wild, namely, the Teesta River and its tributaries, for propagation in the 'jhora' (spring water fed) ponds.

DISTRIBUTION

The Copper or Chocolate mahseer, is a candidate hill stream sporting and food fish available upto a gradient of 1500 m asl. The specific name, *hexagonolepis*, is due to the hexagonal shape of the exposed portions of the scales. It is reported to be distributed in the hill streams of West Bengal, Assam, Arunachal Pradesh, Meghalaya, Nepal, Myanmar, Bangladesh, etc. It is also found in the river Cauvery in Tamil Nadu. This species is said to be adapted to stagnant pools and ponds in Tamil Nadu.

DIAGNOSTIC MORPHOLOGICAL CHARACTERS

The hexagonal scales and barbels longer than orbit distinguishes the Katli from other mahseer *Tor* spp. and *Barbus hexastichus*. Another positive distinction is the presence of a double or triple row of even sized globules below the eyes of Katli. As per the records, the fish grows upto 5.5 kg (60 cm in length). Lips are comparatively thin and never hypertrophied. Cheeks are covered with tubercles. Two pairs of barbels are ...

belly. Each scale above the lateral line is copper-coloured at the edge deepening to bronze green at the base. Fins are mainly dark-gray paling towards the margins. Iris is bright coppery red in colour.

BIOLOGY : Food and Feeding Habit

Basically, the Chocolate mahseer is a voracious omnivorous feeder subsisting on gastropod shells, filamentous and planktonic algae and vegetable debris. Sand and mud are also encountered in the stomach. The fish has a bottom – feeding habit browsing near the marginal shallows. In the early fingerling stage, this species feeds mainly on insect larvae, aquatic beetles and flies. Aquatic vegetation and marginal grass constitute the main food, found in the gut of advanced fingerlings and adults.

Neolissocheilus hexagonolepis feeds mainly on filamentous green algae, the lesser food components being chironomid larvae, crustaceans and water beetles in the wild. In a 'jhora' culture experiment in Darjeeling district, it was found that low fish meal or no fish meal in the feed achieved better growth than feed with higher percentage of fish meal. The content of filamentous green algae also seemed to the very low in the 'jhora' water.

Katli is also considered a game fish. However, for fishing, artificial baits are of no utility. It usually prefers flour dough with aroma. Sweet balls (Bundia) are given as baits and are found to be very effective. It also prefers dead fish fingerlings, earthworms, and shrimps given by means of hooks. The preferable time for fishing Katli is from 6 to 8 am and from 2 to 4: 30 pm.

Breeding Habit

The breeding site is mainly situated at the confluence of two rivers or streams where there is a mixture of clear and turbid waters. With the onset of monsoon the fish migrates upstream, the larger ones following the smaller ones. The breeding season of Katli has been reported to range from May – June to August – September with

Eggs are translucent, yellowish to whitish in colour, spherical in shape, demersal in nature measuring from 2.3 to 2.5 mm in diameter. The yolk is devoid of oil globules. Spawning has been observed to extend from mid-March to mid-September. The newly hatched out larva is almost colourless, possessing deflecting head, elongated yolk sac, bud-like pectoral fins, gill-slits and otocysts. Breeding of Katli can also be done artificially in ponds. Induced breeding using pituitary gland extract is also being experimented in the Reang farm in Darjeeling district.

PRESENT STATUS

Amongst the 131 fish species identified from Darjeeling and Jalpaiguri districts in West Bengal only 21 are presently reported from Darjeeling uplands. A multitude of anthropogenic factors have resulted in stress to aquatic biodiversity causing adverse impact on the fragile ecosystems and fish populations. According to the records of the State Fisheries Department, most of the coldwater fish species of Darjeeling district namely, *Tor* spp., *Labeo dero* and *Schizothorax* spp. are affected. However, the Chocolate mahseer, *Neolissocheilus hexagonolepis*, continues to be widely distributed in the entire Darjeeling hills. In an earlier documention, we reported the presence of Katli in river Mahananda near Siliguri city of North Bengal. This finding is significant since it indicates the availability of Katli in water bodies of Terai region, where due to changes in climatic and environmental conditions, cold water species are rarely reported now a days. This dominance of *N. hexagonolepis* over other cold water species could be attributed to a variety of reasons, ranging from a very long spawning period, to its unique and swift migratory habit and its ability to withstand stress and undergo spawning in different environmental conditions.

CULTURAL PROSPECTS OF KATLI

Fish culture in 'jhora' ponds was initiated by the Fisheries Department, Government of West Bengal in 1981. The principle is to culture cold water fish in their familiar environmental conditions by stocking them in small excavated ponds (jhora ponds)

Darjeeling hills together with exotic carps, because of its high market value (about Rs. 80/- per kg) and its easy adaptability in jhora ponds compared to other indigenous fishes. Growth of the Katli in jhora ponds can be as high as 250 gm in six months (stocked at 8-10 cm size) and table size fish upto 2 kg size can be reared in jhora ponds.

The Fisheries Department, with the help of Darjeeling Gorkha Autonomous Hill Council (DGAHC) has constructed a fish seed farm at Reang, near Rambhi Bazar in Darjeeling district. Different aspects of breeding and rearing of the Chocolate mahseer are being carried out in this farm. Presently, the brooders are being caught from the rivers, but there are plans to set up a proper brood fish bank for different coldwater species in this farm. Through the different transit centers located in Bijonbari, Pandong, Sittong, Kalimpong and Simana, fish fingerlings are being supplied to jhora beneficiaries.

Although the present status of jhora fishery research and extension in the Darjeeling uplands is far from satisfactory, hopefully, with sincere efforts on the part of researchers and extension officials, the culture technologies for Katli would be standardized and made available to jhora beneficiaries in the next couple of years.

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TROUT FARM DESIGN, CONSTRUCTION, OPERATION AND EQUIPMENTS

Yasmeen Basade

INTRODUCTION

The trout of the greatest importance in aquaculture is undoubtedly the rainbow trout *(Oncorhynchus mykiss)*. Native to the Pacific Coast drainages of North America from Alaska to Baja California, the rainbow trout has been introduced in the first decade of the 19th Century as a sport fish almost to all suitable waters in the northern hill states and southern upland regions of the country.

Of all the Salmonids, rainbow trout is perhaps the best suited salmonid for commercial production for table since it is amenable to captivity, accepts artificial feed readily and is tolerant to different temperatures, salinities, population densities and diseases. Moreover, rainbow trout has a shorter incubation period and faster growth rate. Rainbow trout is more adaptable to higher temperatures and utilizes higher water temperatures for rapid growth rate, which enables its cultivation under a wider range of climatic conditions.

There appears to be considerable possibilities for developing large as well as small-scale trout culture farms in the upland areas of the country. The most difficult obstacle in the way of the aspiring trout farmer is finding and acquiring a satisfactory site for a fish farm. The two basic essentials for this are that there must be a sufficient supply of clean water of the right chemical quality, not only to provide for initial development but to allow for expansion; and the site must also be reasonably accessible. A farm that is a long way from markets and from sources of food for the fish may too easily become uneconomic to operate because of the raising cost of transport, labour and other overheads.

The original system of trout culture consisted of hatchery propagation and rearing

Trout culture, whether it is for producing stocking material for sport fishing waters or for food, involves spawning or egg-taking from healthy brood fish, incubation of the eggs, rearing of young fry in nursery ponds, raising of fingerlings in growing ponds and producing yearlings in raceways, circular ponds, etc. These operations have to be carried out in a fish farm which essentially has to have running water supply of specific characteristics. In fact, the qualitative and quantitative requirements of the water of a trout farm are so rigid that success or failure of the farm mainly hinges on this single factor.

SITE SELECTION

Table 1. Aspects needed to be taken into consideration while choosing a site for construction of trout ponds/ tanks

Parameters	Requirements
Topography	It should be slightly elevated type of land. If the planned elevation from water source to the farm and its discharge point is prepared accurately it will reduce the cost on cut and fill on the farm construction. In the absence of elevation the design will be defective.
Soil type	It should be clayey, sand, gravel, pebbles, sludge, silt mix.Seepage should be minimum.
Slope	It should be between 4-6%, may not be needed in certain topographic situations.
Catchment	It should be undisturbed, no agricultural activity, village life or any such activity in the proposed area should be minimum.
Industry	No industrial activity in the upper reaches of the farm should be permitted or any existing one should be critically evaluated for its impact so that source of water does not get contaminated.
Land	In order to design a viable trout farm the minimum land required for the fish rearing should be 2500 m^2 and for hatchery there should be 300 m^2 area.

SOURCE OF WATER

its much wider fluctuation in temperature. For rearing ponds of a trout farm water from the hypolimnion of a lake or reservoir can be considered suitable.

Quantity of water

Based on the quantity of water available in a spring or stream in different seasons to raise trout determines, the type and size of a trout farm that can be constructed.

Table 2. Requirement of water for different developmental stages of trout

Stage of trout development (Unit)	Water flow per minute per 1000 units
Incubation of eggs	½ liter
Rearing fry from 0-3 months	1-3 liters
Rearing fingerlings from 4-8 months	4-8 liters
Rearing fingerlings from 6-12 months	6-12 liters

Hence, on an average for trout culture 1 liter of water per minute per month of the age every 1000 fry and fingerlings is required.

Quality of water

The water for trout culture must be pure and fresh, free from silt.

Table 3. Physico-chemical characteristics of water for trout culture

Parameters	Values
Appearance	Clear and transparent
Water temperature	Range between 8 - 20°C Egg to swim-up fry 10°C Fingerlings and bigger 10 - 21°C Optimum for farming 15 - 17°C
Suspended solids	< 25 ppm
Dissolved oxygen	6 – 12 ppm
pH	6.5 – 8.5
Free carbon dioxide	< 2 ppm

GENERAL ARRANGEMENT OF A TROUT FARM

For industrial trout cultivation set up the size of the farm should be about 2 ha of pond surface. If there is sufficient water it is possible to start a farm for intensive production by using artificial food.

The layout and installation of a farm for industrial trout cultivation varies according to local topography and the aims of the exploitation (like whether the production of fish is for restocking open waters or for table or both). If the objective of fish culture is for restocking open waters, in this case the farm will have ponds for parent fish, an incubation and handling building, nursery and fattening ponds and finally storage ponds. In case fish culture is only for eating purpose, the farm will include only those ponds necessary for one or two of the rearing stages.

Pond culture

Pond culture is originally the Danish system consists of earth ponds excavated on a level site. Most of the trout farms receive water from a nearby stream by gravity or it is pumped from nearby lake or river. A pumped water supply should be last resort as it incurs an additional pumping cost. In these farms fish are kept and fed to gain weight for, to make a profit. On-growing rainbow trout to market size in earthen ponds is still a rewarding method of commercial fish culture.

The basic arrangement of a typical Danish farm consists of a water supply channel at the highest level which feeds into ponds. The ponds then discharge into the back channel at the lowest level. The water from the back channel returns to a river or drains away from the fish farm. Each pond has an individual water supply which can be separately controlled and each pond can be separately drained. The back channel has the combined flow from all the ponds. The intake to ponds is controlled by stop-boards, valves, etc. The intake pipe must be large enough to carry the maximum required water supply to the pond. The downstream end of the pipe should be covered by a screen in such a way as to prevent the escape of fish.

The standard Danish earth pond is 30m in length by 10m in width. The bottom of

The site for earth pond excavated should be level and the soil reasonably impervious with a high water table. Pond excavation on a level site requires a minimum depth of soil of approximately 2.5 m. If the subsoil is reasonably stable a batter of 1:1 can be left between ponds. The top of the dividing embankment must be wide enough to walk upon easily. The batter at the intake end of a pond should be wide and shallow. The batter of the embankment between ponds and back channel, depending upon the consistency and stability of the subsoil, can be 1:1.5 for good soils or 1:2 even 1:3 may be needed. Surface vegetation in the top soil should be removed and not included in dam material otherwise the embankment will become porous.

Rainbow trout fry should not be reared in earth ponds due to the danger of contracting whirling disease (myxosomiasis) and should be kept under controlled conditions in concrete or GRP tanks until ossification is complete and they become immune to infection. This occurs approximately 10-12 weeks after feeding starts, when the fish have reached a length of 7-8cm. It is preferable to buy fingerlings of 5-6g and then grow-on or over-winter in tanks until they are about 45-46g before they are transferred to ponds.

Standard size Danish earth ponds stocked to grow-on abcut 1.5 t of trout should have an available flow of approximately 1300 l/min. Less water will be needed in cold weather and when the fish are growing. Most of the rainbow trout are marketed as and when they reach an average weight of 200-230g.

Ponds are emptied at fairly frequent intervals for cleaning. The sludge collected at the bottom is removed, the ponds left to dry out and then disinfected with the fresh slurry of slaked lime.

Raceways

The raceway was the original North American system developed for rearing trout to restock rivers and lakes for angling. The name indicates the principle that the water flows quickly through a channel. Raceway channels are usually constructed in reinforced concrete and are sunk into the ground on a level site. Raceways can

A rate of water interchange of 2.5 l/min with a stocking density of 4-5 kg/m^{-2} of raceway surface is fairly standard for restocking farms. The fish have to be kept at greater densities in relation to the available flow on farms producing rainbow trout for the table market. Wider and deeper raceways can hold a greater density of trout but there may be insufficient oxygen in the water to supply the fish in the lower sections of a slower-flowing raceway. This problem can be overcome by installing aerators.

Tank farming

Many trout farmers in the British Isles and in rest of Europe use circular tanks for on-growing fish from fingerlings to market size. The tanks are usually about 1.6m deep and from 4-10m in diameter. They can be formed on-site in concrete or prefabricated in curved sections using GRP. The sections are then bolted and cemented together with mastic to form circular walls on a precast concrete base. Glass-fiber tanks can also be used. Inexpensive tanks can be made by bolting together curved sections of galvanized, corrugated iron sheet. The tanks have separate water intakes at the top taken from the main, controlled by valves. The outlet is in the bottom placed centrally. The most economic source of water supply to a trout farm is by gravity from a nearby clean river. To overcome the scarcity of water supply during lean periods the possible method is recycling of water.

For tank farm construction, the first step is to survey the site accurately and level it. The intake pipeline, tank layout and outfall are then drawn out to scale in plan and section showing the levels. The holes for the tanks and tracks for pipes are excavated with a digger according to the plan. The pipelines for water and fish extraction are laid down. The outlet flow pipe is extended up outside the tank into a sump beside the tank. The water flowing from the sump back into the outlet main passes through a screen. The tanks are then assembled on a level base in the excavated holes. Stand pipes are push-fitted into the open ends of the water supply and fish pipes in the middle of each tank base area. A layer of hardcore is leveled into the tank base areas and concrete is poured to provide an overall depth of 0.15 m. Further concrete is added to provide a sloped base of about 1 in 7 from

Ordinary tanks with a water supply of 12-15^{0}C could be stocked at densities of 25-35kg fish m^{-1} of water. If higher temperatures can be expected, initial stocking may have to be at reduced density or a proportion of the fish moved into spare tanks. In water at 15^{0}C an available flow of approximately 125 l/min should be available if the water temperature is likely to reach 20^{0}C.

EQUIPMENTS

Operational equipments

At the designing stage the methods of operation should be taken into consideration as some essential equipment will be needed to be incorporated in the construction. These equipments include: aerators- to provide additional air or oxygen to the water, screens- to exclude debris on the intake channel, filters- to filter the flow of each pond/tank/raceway/hatchery.

Hatchery equipments

Electronic/manual (by displacement method) egg counter, automatic/ manual (ordinary suction bulb) egg pickers to take out dead eggs and manual means of assessing fry biomass by taking a sample in a plastic bin along with water and then weighing it on a weighing machine. The increase in weight is read and the number of fry is worked out from their average weight already calculated by taking out several samples of known number of fish (at least 20 fish) and weighing them accurately. Heating of water to speed up the growth of fish: 9 kw immersion heater is the simplest way to raise the temperature of the water for incubating eggs and rearing fry in the first six to eight weeks after swim-up. Solar heating systems can also be used.

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TROUT FARMING IN INDIA WITH SPECIAL FOCUS ON PRODUCTION OF STOCKING MATERIAL AND TABLE FISH

H. S. Raina

BRIEF BACKGROUND

During the past century the pristine range of trouts, especially the brown trout and rainbow trout in Europe and North America has been extended through introduction to include waters on all continents except Antarctica. The trout and Salmo are the most important as amateur sport fishery as well as food fish of the world. The term coldwater fishes is usually employed to the members of the Salmonidae and particularly to trout, which prefer thermal regime between the snow-melt waters of the slopes of the Indian Himalayas and waterbodies draining the southern slopes of Western Ghats.

The farming or husbandry of trout has a relatively long history in Europe and North America. In the Indian sub-continent two main species of trouts *viz.* brown trout - *Salmo trutta fario* Linn. and rainbow trout - *Oncorhynchus mykiss* (Walbum) were transported from Europe by British settlers around the beginning of twentieth century primarily to satisfy their needs for sport fishing. In the Indian uplands, the cultivation of fish contributes little to the overall freshwater fish production. Virtually every facility created for fish cultivation in the uplands produces fish for stocking the natural wild waters primarily to meet the requirement for sport fishing. Until recently, highly domesticated brown and rainbow trouts have been utilized for fish culture and for fish seed production, and to a much lesser extent for table fish production. Culture of trouts, particularly brown trout in the Indian upland waters has largely concentrated on the production of stocking material for rivers, streams, and some lakes to enhance existing populations in the well-established habitats of the species, and also for introductions in new habitats (lakes/streams/rivers) to meet countries holding trout waters, including Indian sub-continent. Amongst all the freshwater fishes, presently both the varieties of trouts are considered as high value food fishes and for sport.

INTRODUCTION OF TROUTS IN INDIA

Northwestern & Central Region

The first attempt to introduce the brown trout in the Kashmir Himalayas was made by Mr. F.C. Mitchell as far back as 1899 but it proved failure, subsequently another attempt in 1900 proved a success. This attempt of transporting eyed-eggs from Howetein hatchery in Scotland to Kashmir and production of trout fry after incubation and rearing was the first step in trout culture. It was from Kashmir that brown trout spread to other Himalayan states of the country especially in Central and Eastern Himalayas, but due to lack of care and technical support, the species did not thrive well in these regions. But in Himachal Pradesh and Jammu & Kashmir, population established well in local hill streams. Mr. Mitchell continued his efforts and brought rainbow trout variety *Salmo gairdneri / irideus* to Kashmir and succeeded in hatching and rearing the rainbow eggs in 1912.

In 1963, eyed eggs of brook trout (*Salmo fontinalis*) were imported from Canada and subsequently in 1968 land-locked Salmon (*Salmo salar)* was introduced in Kashmir hatcheries as their breeding and survival being the main problem.

North-eastern Region

Attempts at establishing brown/rainbow trouts in the northeastern Himalayas in the early part of the 20th century met with little success. The main reason was that a majority of the streams carry a heavy silt load. This part of the Himalayas is a heavy rainfall zone. Arunachal Pradesh is the only state in the northeastern Himalayas in India in which brown trout is cultured (Bomdilla) and stocked in streams for sport purposes. The seed was supplied to Nagaland where it was released in one stream in 1970s, and later on to Meghalaya. Brown trout is also established in Sikkim, which has

Peninsular Region

Among the southern states, the introduction efforts were made at the Nilgiri hill streams in Tamil Nadu and Munnar hill ranges in Kerala. Initially number of attempts made from 1863 onwards did not met with success but it was only in 1909 when Nilgiris Game Association through the efforts of Mr. H.C. Wilson achieved success. By various experimentation it was observed that the southern upland waters were more suitable for rainbow trout than the brown trout, thus rainbow trout established in southern states. The strains of rainbow trout for these regions were imported from Sri Lanka, Germany and New Zealand from time to time. In 1968 eyed eggs of golden rainbow, ordinary rainbow, tiger trout, brown trout and Kokanee salmo (*Oncorhynchus nerka*) were brought from Japan. Of these new releases, only golden strain of rainbow survived and established itself as a dominant strain of rainbow in anglers catches. In order to develop sport fishery of trout the seed of rainbow produced in local hatcheries was stocked in upland reservoirs/ lakes/ streams located in Nilgiris and Munnar ranges. Subsequently, Kodaikanal lake in Kodai hills was stocked with fingerlings transplanted from the Nilgiris.

CULTIVABLE SPECIES

Zoogeographically, salmonids of the world can be categorized into two groups:

The European: There are four principal salmonids of European origin including brown trout (*Salmo trutta fario);* Atlantic salmo *(Salmo salar*); Arctic char *(Salvelinus alpinus*) and Danube salmo (*Hucho hucho*).

The American : Salmonids of American origin are eight (8) species of *Oncorhynchus* and three (3) of *Salvelinus* .

However, among the two, the culture of brown trout (*Salmo trutta fario*) from European group and rainbow trout, *Oncorhynchus mykiss* among the American group is more popular.

GENERAL CHARACTERISTICS

exhibits migration up-streams to breed in shallow waters of the typical trout zones. This variety of trout from Western Europe was initially transplanted to other continents and released in suitable salmonid waters at the end of the nineteenth century. Since then the process has continued. Recently new better growing strains of brown trout have been developed and gradually replacing the old strain in European wild waters.

Rainbow trout in its natural environment of Western mountain of USA thrives best in temperature range of $4^{0}C$ in winter to $21^{0}C$ in summer. It can, however, withstand higher or lower temperatures, if it is acclimatized gradually. But its growth is impeded in extreme temperatures of its tolerance. The species *Oncorhynchus mykiss* is now cultivated in many coldwater region across the globe. It spawns from January to February in Indian farms but some varieties start spawning even early *i.e* in December.

Rainbow trout is perhaps the best-suited salmonid for commercial production for the table. The availability of fast growing strains of rainbow trout *Oncorhynchus mykiss*, availability of balanced artificial diets and improved technology have all helped in promoting aquaculture in various states in India. During last couple of years, a significant increase in seed and table fish has been recorded. The fish also commands high price, which will give remunerative price to the farmer whose production site will be in remote hill region. In India, in the recent past, the trout culture of fast growing strain of rainbow trout has gained lot of importance since a sizeable urban market has come up in big cities to buy this high price fish. Its cultivability arises from the following characteristics :

- easy to domesticate
- accepts artificial feed
- withstands to higher temperature
- withstand to low dissolved oxygen content for some time
- more resistant to certain diseases
- incubation period is comparatively shorter
- records faster growth rate

STATUS OF TROUT FARMING

The coldwater fishes in the country have restricted distribution mainly in northwestern, northeastern and southern upland regions. This fishery by and large has remained a sport activity and subsistence fishery for a small community of local fishermen, who mostly fish in openwaters, since fish farming is not wide spread. Among the exotics, brown trout (*Salmo trutta fario*) is the main species, contributing to sport fishery in the brooks, streams and high mountain lakes in the Himalayan region. While the earlier stock of rainbow trout (*Oncorhynchus mykiss)* remained restricted to a few farms only in Jammu and Kashmir and southern uplands. It was only during nineties of the previous centuary, that with help of foreign aided projects through Govt. of India, in the states of Jammu and Kashmir (EEC) and Himachal Pradesh (Indo-Norwegian), the rainbow trout farming has progressed and the fish is now more frequently available through Govt. marketing. To promote trout farming, the NRCCWF has also initiated trial farming of the same rainbow strain at its Chirapani fish farm located in Central Himalayan region of Kumaon, Uttaranchal State. The objective was to raise brood stock for seed production and its distribution to various users in the region. The attempt has proved a success and opens a new possibility of commercial farming of trout in Kumaon Himalayas

The brown trout culture ever since its introduction is being continued in the manner as when was transplanted. In the recent past, the paucity of right size of stocking material has been the main constraint for maintaining and increasing the trout population both in streams and farms because of conventional mode of annual planting of wild waters with eyed-eggs or fry which had little effect on trout catches. The reason appears to be lack of ability of the tender juveniles to fend themselves in natural waters from enemies.

PRE-REQUISITE OF TROUT FARMING

Following aspects need to be taken into consideration while establishing a trout farm, which includes hatchery, nursery and adult rearing tanks and brood stock tanks/raceways etc. :

- ***Geological characteristics***: Safe from landslides and other geologically disturbances.
- ***Quality & quantity of water source***: Rheocrene springs/snow-melt/ glacier-fed streams are most suitable. Trout facility could be guaranteed with water supply that never rises beyond 16.0^{0}C.
- ***Free from environmental pollution and social angle:*** Should be undistributed, no agricultural activities in the catchment, source of the water does not get contaminated.
- ***Accessibility to the farm :*** Well connected with the road.
- ***Marketing of the produce***

Biological features

The trouts are basically carnivorous fishes feeding on aquatic larvae and nymphs of Ephemeroptera, Plecoptera, Trichoptera, and Diptera and other minor organisms. Natural spawning and the egg taking of brown and rainbow trout is related to the changing of the photoperiod. In Kashmir and Himachal Pradesh, brown trout attains maturity in mid - November to mid - December in farms receiving glacier/ snow fed water. In spring fed farms it matures in December-January. In Central Himalayas too, the brown trout matures in December-January. Rainbow trout matures in mid-February to March. The new strain of the rainbow trout in Indian normally matures in February. The average number of eggs per kilogram of female body weight varies between 1250-1350 in brown trout and 1650 -1850 in rainbow trout. This number can be slightly enhanced (about 10%) if brood stock is kept in good condition and on proper nutritive diets.

Farm Practices

For production of healthy and stockable size fingerlings and table fish, it involves following phases:

- Infrastructure facilities and trained farm hand
- Availability and maintenance of brood stock
- Artificial fecundation (Stripping operation)
- Incubation of fertilized [illegible]

- Raising of 1+ age group trout fish (Table fish) in growing ponds and raceways
- Raising of brood stock in raceways
- Preparation of trout feeds for different stages
- Control of diseases and farm health monitoring mechanism
- Marketing of the produce

Fingerling and table fish production

- Good maintenance of brood stock on a nutritious diet, careful handling of fertilized eggs, prophylaxis against fungus by flushing troughs/trays with malachite green, providing enhanced water supply, thinning of hatching trays at eyed and alevian stages have resulted in 95% survival from green eggs to swim-up fry.

- The wide application of the improved techniques from fry to fingerling stages has resulted in achieving 80-90% success in production of fingerlings.

- By adopting proper farm management practices table fish can be easily achieved in 1+ year of rearing.

Recent rearing experiments conducted on fast growing strain of rainbow trout - *Oncorhynchus mykiss* (Walbum) at Chirapani fish farm of NRCCWF, Champawat (80^0 7' N Long., 29^0 30' E Lat.). located in sub-temperate climatic conditions revealed that fish can attain an average growth of one kg (750 - 2,100 g range) by 3rd year. Fishes were fed on two formulated diets having approximate 47 and 57% protein levels. The details of the results are depicted in below tables :

Table 1. Increment of rainbow trout reared in various seasons

Period	Average weight increment (g)	Weight range (g)	Water temperature range (^{0}C)
March- May	5.700	0.500 - 11.000	7.4 - 17.5

Table 2. Yearly growth increment of rainbow trout

Year	Duration	Average weight (g)	Weight range (g)
1st	Feb. 2000 - Jan. 2001	95	56 - 200
2nd	Feb. 2001 - Jan. 2002	225	180 - 1,100
3rd	Feb. 2002 - Jan. 2003	950	650 - 2,100

From the above tables, it is concluded that i) mass scale stocking material of rainbow trout (fingerlings) can be easily achieved with a period of 3-4 months (2.250 -12.00 g in weight at temperature range of 12.0 to 16.0°C); ii) rainbow trout farming can be taken up for production of marketable size trout of 250 - 350 g weight in a period of 12-15 months at a temperature range of 10.0-16.0°C. Apart from the required rearing facilities, good quality and quantity of fresh water with balanced feed are the important pre-requisites for success of trout farming. This opens up a possibility to produced healthier stocking material and further trout farming on a pilot scale either in Government sector or through private entrepreneurs, in different Himalayan states and Peninsular India having vast resources of good quality water.

PRODUCTION AND DEMAND

Trout production in Jammu & Kashmir state has reached 100 tonnes per annum. There is full-fledged technology available for breeding, intensive seed management and aqua farming. There are four seed production units and about 27 rearing units spread in various districts of the state. In Himachal Pradesh, at its Katrian farm, the trout production is about 70-80 tonnes per annum alongwith production of rainbow trout seed on intensive scale. Now large-scale production of table size rainbow trout is possible, ensuring its sustained supply in market will create a demand among people in different up-market outlets. This demand is bound to increase with more and more people wanting to buy the quality fish. Further, coupled with it is a significant demand from hotel industry that want to put the trout in their menu. But all this requires assured production and supply. In order to meet such targets

TRANSFER OF TECHNOLOGY

Trout farming unlike other warm water fishes is very delicate and professional activity. The success of its farming depends upon the expertise and knowledge that a farmer has about different phases of its farming. Any lapse at any stage will severely affect the stocks and production resulting in loss to the farmer. Thus, it needs full care and attention. This makes imperative that transfer of technology with regard to trout becomes an essential component of farming activity. In this connection, there should be a strong linkage between a trout farmer and on the line department at every stage. Regular, hands on training programmes are necessary to promote trout aquaculture in our hill states.

CONCLUSIONS

The Country has vast resources in high as well as in mild altitude areas which are geographically spread over at different thermal regimes extending from Northwestern Himalayan to Northeastern region, and are quite suitable for aquaculture of brown trout for sport and rainbow for food. The introduction of brown trout in upland Himalayan regions in the beginning of last century was obviously made for sport purposes and occupied a prominent position in these systems for considerable period. Presently the population of this species in general has declined considerably due to many reasons and defeated the very purpose for which introduction was carried out. There is urgent need to evaluate this aspect critically, in view of genetic fatigue in the existing strain. Better growing strain of brown trout should be welcomed in Indian upland to boost the sport fishery. With the introduction of new strain, it would be certainly possible to produce large number of strong, healthy, acclimated fingerlings for use in natural stock enhancement and commercial farming too. The Indian uplands both in Himalayan and Peninsular regions with spring/snow-fed waters can be profitably utilized for development of small-scale rainbow trout farming in rural areas with fast growing strain. Economically viable technologies for propagation of rainbow trout have been developed, even transferred to farmers and both Govt. and NGOs are establishing hatcheries and farms in

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BROOD STOCK MANAGEMENT AND EGG PRODUCTION OF EXOTIC TROUTS

Shyam Sunder

BRIEF BACKGROUND

Trout farming has a long history in Europe and North America. In the Indian sub-continent, two main species of trout *viz.* brown trout *(Salmo trutta fario)* and rainbow trout *(Oncorhynchus mykiss)* were transplanted from Europe by British settlers around the beginning of previous century primarily to satisfy their needs and pursuits for sport fishing. Earlier, the main interest of trout farming in the country was rearing eyed eggs and fry for introductions in new areas or enhance the existing populations in well established habitats of species to meet the ever increasing requirement of sport fishing. The general concept of trout as highly expensive fish to cultivate in the farms and as a luxury food beyond the reach of common man still holds good amongst the fisheries planners. However, it is a healthy sign that a lot of attention is being paid to this lordly fish in various upland states to propagate and establish the fish for ranching natural biotopes as well as table delicacy.

It is bare fact that brown trout has a better fighting quality for the anglers compared to rainbow trout. However, rainbow trout is perhaps better suited for commercial production for the table due to i) more easy to domesticate, ii) accepts artificial feed efficiently, iii) better withstands higher temperature iv) more resistant to certain diseases, v) shorter incubation period and vi) shows faster growth rate.

Besides old stocks of brown and rainbow trouts introduced from abroad, in the last two decades, fast growing varieties of rainbow trout have been brought through EEC at Kokernag, Srinagar (Kashmir) and from Norway at Patlikuhl (Himachal Pradesh). The fish has established very well and both the states are raising handsome quantum of fish for brood stock maintenance and for sale in the open market and supplied to hotels locally or in the metros.

1905-1906 at Harwan in Kashmir. At present, about 23 trout farms/ hatcheries are in operation in the country while many more are coming up:

States	Numbers
Jammu & Kashmir	7
Himachal Pradesh	5
Uttaranchal	4
Sikkim	1
Arunachal Pradesh	2
Meghalaya	1
Tamil Nadu	1
Kerala	2

REQUISITIONS FOR TROUT CULTURE

The main cause for wide dispersion of trouts in cold waters throughout the world are the facility and advantages of their artificial propagation and possibility of fattening them by artificial feeding. The principal merits of artificial propagation are i) a considerable number of fertilized eggs, fry and fingerlings are obtained with ease, ii) protection of eggs and growing fish against natural calamities and enemies is possible, iii) even such open waters where natural spawning does not takes place can be populated and repopulated by the fish.

The trout culture, whether it is for producing stocking material for sport or for food, involves i) brood stock maintenance, ii) spawning or egg taking from healthy brood fish, iii) incubation of eggs, iv) rearing of young fry in nurseries, v) raising of fingerlings in growing ponds and vi) producing yearlings in raceways, circular ponds etc. These operations have to be carried out in a fish farm, which essentially has to have running water supply of specific characteristics. In fact, the quality and quantity requirements of the water of a trout farm are so rigid, that success or failure of the farm mainly hinges on this single factor. Acceptable source of water supply for a trout farm are springs, streams, rivers and lakes. Amongst these, water supply from a *rheocrene* (running spring, which on emergence from rocks, the water flows down the valley or towards it) and *limnocrene* (spring located in ...

mg/l; free carbondioxide < 1.5 mg/l and alkalinity 40-50 mg/l. The water requirement of different rearing stages of trout are:

Stage of trout development	Water flow l/min. for 1000 units
Incubating eggs	0.5
Fry up to 3 months old	1-3
Fingerlings 4-8 months old	4-8
Fingerlings 8-12 months old	6-12

In general for trout culture, one litre of water per minute per age month is needed for every 1000 fry and fingerlings.

Care of brood stock

In order to obtain healthy viable eggs, the brood fish must receive adequate care including nutritive diet. In majority of trout farms in India, prior to breeding neither the sexes of parent fish are segregated and reared separately nor is any care taken to administer nutritive diet. Such practices result in poor seed production in most of the hatcheries. It is essential that all brood trout stock need to be segregated for about 2-3 months in separate ponds and reared on nutritive diet for production of healthy viable eggs. In Kashmir hatcheries by applying such practices, a marked improvement in quality and quantity of eggs (17-20%) has been observed. Moreover, it is found that fertilized eggs from segregated and well fed parent sock resulted in about 90% cumulative survival from green egg to swim-up fry stage as against below 50% in control. In some hatcheries, still raw fish without deviscerating is given as a feed to the trout stocks, which is not a healthy practice. Such fish posses a thermolabile enzyme called thiaminase, which is responsible for causing deficiency of thiamine chloride (vitamin B-1) in trout as a result trout shows symptoms of whirling accompanied by melanotic appearance of the body causing sometimes heavy mortality. So dry feeds are the best solution, the merits of which are a) simple to use and dispense, b) easy to store, c) maintain hygienic conditions in the pond, d) better utilization and e) higher conversion rate.

of water shrew (rodent) with sulpher are some of the methods to get rid of them. The kingfisher *(Alcedo athis)* and herons prey upon the fish for which, the ponds can be covered with wire netting.

A wide variety of diseases are known to afflict the trout, may be viral, bacterial, fungal or due to nutritional disorders. A trout culturist has to be on the look out of the symptoms of diseased conditions since timely prophylactic measures could save the lives often of the whole stock held in different ponds of the farm or may be in the entire farm.

Sexual dimorphism and spawning periodicity

Both brown and rainbow trouts exhibit sexual dimorphism but the relevant characters become more pronounced when sex attain maturity.

Characters	Brown		Rainbow	
	Male	Female	Male	Female
Body shape	Laterally compressed	Rounded & distended	Normal	Normal
Snout & lower jaw	Lower jaw hook more prominent in mature specimens	Lower jaw not hooked	Lower jaw hooked, more conspicuous in older specimens	Lower jaw not hooked
Body colouration	A white stripe at outer margin of the anal fin	White stripe absent	Increase in vivid red stripes on the lateral side	No increase in vivid red stripes
Genital papilla	Absent	Present in fully ripe specimens	Absent	Present in fully ripe specimens

The spawning season of two varieties of trout varies to some extent depending upon the water temperature in different parts of the country. In some of the

Name of the hatchery	Period of spawning	
	Brown trout	Rainbow trout
Laribal (Jammu & Kashmir)	Nov.	Feb. end - early March
Achhabal (Jammu & Kashmir)	Dec.- Jan.	Jan. - Feb.
Patlikul (Himachal Pradesh)	December	Jan. - Feb.
Chirgaon (Himachal Pradesh)	Mid-Nov. - mid- Dec.	Feb. end- mid - March
Barot (Himachal Pradesh)	Dec. end - mid- Jan.	Feb.
Sangla (Himachal Pradesh)	Mid-Nov.-mid- Dec.	Feb. end- mid - March
Kaldyani (Uttaranchal)	Dec. - Jan.	-
Talwari (Uttaranchal)	Dec.- Feb.	Feb. end- mid - March
Bairangana (Uttaranchal)	Mid. Nov. - Dec.	Feb. - March
Sheragaon (Arunachal Pradesh)	Nov.	Feb.
Nurang (Arunachal Pradesh)	Late Nov. - Feb.	-
Avalanche (Tamil Nadu)	-	Sept. - Feb.
Rajamally (Kerala)	-	Sept. - Feb.

Egg taking

The female trout generally attains maturity in third year while the male one in second year. Prior to commencing egg taking operation, two large tubs of resource water, one each for female (hen fish) and male (cock fish) specimens, are placed alongside the pond and freshly washed plastic/ earthen/ enamel stripping container of enamel or polythene is placed in shade. By netting through the pond, the brood fish are retained in slightly submerged net and examined rapidly one by one. If by applying gentle pressure, eggs and milt flow freely from the vent, the brood fish of either sex are kept in separate tubs and the water is changed every now and then. Egg- taking can be commenced at this stage.

The act of obtaining ripe eggs from female trout and sperms from the male is referred to as egg taking or stripping. Certain precautions need to be taken before performing this operation *viz.* a) brood fish are immediately available at the spot, b) less the handling time for brood fish *i.e.* the quicker operation, c) the egg-receptacle (tubs, buckets, mugs) and it's cover, bird's quills etc. are kept handy after washing with 5% potassium permanganate solution, d) ready 3% salt solution to

One-man method

A ripe female is grasped by the tail, dorsal side up with gloved hand and to gently held against the operator's body with other hand. The free hand is manipulated in such a manner that gentle pressure is exerted with fingertips on the belly of the fish to release eggs freely in to spawning pan. Oozing blood, if any, indicates injury of internal organs or extruding of unripe eggs by heavy pressure exerted during stripping operation which should be stopped immediately and fish should be released in the pond after dipping in 3% common salt solution. After viable eggs are stripped, the male fish is stripped of the milt by similar manipulation as was done for female brooder.

Two- men method

This method is simple especially for large fishes to avoid any physical injury. In this, one man holds the fish by gloved hands by caudal peduncle with one hand and by the pectoral fin with the other over the egg-taking pan. With the fish held tail-end down, the ripe eggs flow by gravity towards the vent. The other man or the egg taker, who sits opposite to the fish holder, gently presses out the free flowing eggs with the help of thumb and forefinger, beginning to apply gentle pressure, a little anterior to vent. Immediately after the female, the male is stripped of milt, which is spread over the eggs.

In both the egg-taking methods, brood stock before releasing in to the pond is dipped in a common salt solution for two minutes as prophylactic measure.

Fertilization

There is considerable difference of opinion on relative efficacy of dry and wet methods of egg- taking. In dry method, egg- pore (micropyle) remain open longer, so more time is available for collecting eggs from several hen fishes and also the milt from cock fish in the same pan. In most parts of the world it is

After taking the eggs and milt in the spawning pan, the sex products are mixed gently with a bird's quill. It has been observed that one-teaspoon full of milt is sufficient to fertilize eggs from two females (each av. 500 g in weight). The newly taken out eggs are pale yellow to deep orange coloured and slightly adhesive in nature till they are water hardened. After about 5 minutes, the eggs are washed off excess milt and any other foreign particle. For this, water is added to the pan and it's contents gently stirred. The water is then decanted off. This process is repeated a number of times. After washing thoroughly, eggs are water submerged in the pan which is covered and set aside in shade for about an hour to complete the "water hardening" process. At this stage, the eggs emit greenish tinge and hence termed as "green eggs" which are ready to be put in hatching boxes.

Estimation of egg fertilization rate and numbers

To estimate the rate of fertilization, a small sample of water-hardened eggs from each receptacle is taken and kept in 5% glacial acetic acid for 24 hrs. The viable eggs remain transparent while the dead eggs become opaque or translucent. By noting the number of either type of eggs in the sample, the percentage of fertilization is assessed.

It is customary to estimate egg numbers from each female brooder after they are water hardened. Since the trout eggs are sensitive to mechanical shocks at all stages, reasonable care must be exercised in handling them for estimating their number. In Indian hatcheries, two methods are prevalent: a) volumetric method and b) gravimetric method. In principal, both these methods comprises estimating the total volume/ weight of egg mass from each tray by measuring three small measured sub-samples, taking egg counts and then based on their average, computing for the total number of measured eggs. Generally, brown trout eggs ranges 8-11/ g by weight and 9-10/ ml by volume whereas in rainbow trout, their respective values are 9-11/g and 10-12/ml. Normally, fecundity of brown trout in Indian hatcheries is 1400-1500 eggs/kg body weight while 1850-1900/ kg body

Incubation and hatching

The incubation of trout eggs is mostly carried out in specially fabricated flow-through hatchery troughs. The troughs are made of R.C.C, galvanized iron sheet, aluminum or fiberglass of varied dimensions (2.0 x 0.33 x 0.10 - 4.0 x 0.90 x 0.60 m), which can accommodate 4-8 hatching trays (0.34 x 0.32 x 0.09 - 0.50 x 0.35 x 0.010 m). Trays are made of wood or fiberglass. The hatching trays are provided with synthetic mesh base with small windows on two sides fixed with synthetic mesh for in flow and out flow of water, however, in certain hatcheries, glass grills are used in hatching trays. In most of the hatcheries, the troughs are arranged in a series of four or more parallel rows. The water from supply tank flows into first or head trough, thence to the second, third, fourth and finally the tail trough in a series. In certain hatcheries, 'trout eggs incubator' is used. This basically consists of a number of shallow trays stacked one above the other vertically and spaced apart by guiding strips much as a drawer in a dresser. Each tray can be pulled up for inspection. This needs small amount of water, which permits its circulation, provides sufficient aeration and eggs are shielded from light.

Before making use of hatchery components, it is ensured that these are well washed with 5% potassium permanganate and other sanitation measures are adopted. The fertilized trout eggs are transferred in the hatching trays depending upon their capacity. The 'green' or fertilized eggs pass through three stages: i) eyed-eggs (ova), ii) alevin (sac fry) and iii) swim-up fry. The eggs become progressively more tender during first 48 hrs after water hardening until eyed. The normal period of stage- wise incubation and hatching of brown and rainbow trout based on the water temperature is :

Species/ Stage	Incubation period in days at different water temperatures (^{0}C)		
	3.0 - 7.0	7.0 - 11.0	11.0- 15.0
Brown trout			
i. Green egg to eyed ova	41-50	21-30	15-20
ii. Eyed-ova to alevin	31-40	15-23	11-15
iii. Alevin to swim-up fry	32-40	10-12	10-12
Total duration	104-130	46-65	36-47
Rainbow trout			
i. Green egg to eyed -ova	-	21-29	10-15
ii. Eyed-ova to alevin	-	20-27	8-12
iii. Alevin to swim-up fry	-	10-12	10-12
Total duration		51-71	28-39

Infections

Trout eggs and alevins during their incubation are prone to several infections which, if left uncared, often result in heavy mortalities. The most common maladies are :

a) **White spot :** White spot disease of trout eggs can be diagnosed by the presence of a white mark on the yolk which is caused due to physical injury.

b) **Soft egg :** The symptom of this disease of trout eggs is that they loose their turgidity and become soft and flaccid. Certain microorganisms make small openings in the egg membrane resulting water entering the egg making it flaccid and yolk comes out and get attached to the egg membrane. Disinfecting of hatchery components with potassium permanganate or lime is oftenly recommended as a treatment.

c) **Fungal infection :** Water mould infection - the greatest foe, caused by *Saprolegnia* affects the dead eggs in hatching trays and by contact, can contaminate healthy viable eggs. Affected trout eggs are completely covered by innumerable fine hair like projections. The troughs and trays holding trout should be flushed periodically with malachite green as prophylaxis @ 1: 2,00,000 for 30 minutes.

This disease of trout alevins often appears after few

Precautions during egg production and incubation

During incubation/hatching of trout, some main precautions to be taken care of are:

- Utmost sanitation conditions to be maintained in the hatchery and equipments
- Daily culling of dead eggs from each hatching tray with a tweezers, glass dropper or by siphoning without least disturbing the neighboring eggs
- Similarly the egg shells should be siphoned out
- Proper water supply should be monitored regularly and in case of oxygen depletion, provision need be made for water fountains in individual units
- Since the incubation of trout is fairly long, all possible measures are required to keep a vigilant regular watch on the developing stages
- At various growing stages, 'thinning operation' should be adopted *i.e.* lowering the density of stocks since they require naturally more space and oxygen in developing stages on one hand and there is size difference during the growth of different stages on the other

Transportation of trout eggs

'Eyed-eggs' is the best-suited stage for transportation even to long distances, but it is necessary that they must be kept cool and hatching prevented enroute. In India, transportation during winter is done either in "Pahari box" or specially designed thermocole containers.

Pahari box

This consists of an insulated wooden cabinet (0.51 x 0.25 x 0.40 m) with a lockable door. Top is provided a 11 cm high cupboard with a wire net base which is meant to keep moss with snow or ice. Beneath the cupboard, two trays with perforated zinc sheet base are provided with sufficient moss to hold water from the melting snow lying up in the cupboard. Below the zinc base trays, are arranged a series of 42 egg trays in two rows of 21 each. Barring the first zinc base trays at the top and the last two egg trays at the bottom, the ...

Thermocol container

These are specially designed insulated (thermocole) containers of varied sizes with a lid depending upon the quantity of eyed-eggs to be transported. The box contains 4-6 perforated trays of the same material with 4 equal compartments in each tray. The upper most tray is packed fully with crushed ice and in the down trays, eyed-ova are packed - could be in 3-5 layers even. The box lid can temporarily be sealed with a cello tape. The melting ice water from the upper tray tickles down the lower egg holding trays. However, periodically, it should be ascertained that the upper tray is fully filled with ice otherwise it could be refilled. This method of transportation is handy, easy and can withstand long distances and durations.

Swim- up fry and initial feeding

After the complete yolk sac absorption, the newly hatched fry is able to swim about and hence called 'swim-up fry'. It is at this stage that these are transferred to FRP start feeder tanks (1 m^2), which can accommodate 8,000-10,000 swim-up fry and the initial feeding is started with various formulated practical diets. The feeding is done every two hourly from sunrise to sun set ensuring that unutilized feed settling at the bottom is siphoned out properly to avoid pollution. After initial feeding for 15-20 days, the young fry are transferred to fry rearing tanks for further rearing.

FURTHER READINGS RECOMMENDED

- *Coldwater fisheries in India* By V.G. Jhingran & K. L. Sehgal. 1978. Inland Fisheries Society of India, Barrackpore (W.B)
- *Textbook on fish culture: Breeding and cultivation of fish* By Marcel Huet. Fishing News Books Ltd., Farnham, Surrey, England
- *Trout farming manual* By J.P. Stevenson. Fishing News Books Ltd., Farnham, Surrey, England
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NUTRITIONAL REQUIREMENTS OF COLDWATER FISHES

Madan Mohan

INTRODUCTION

Inland fish aquaculture has made tremendous progress world over particularly in Asian countries like China and India. The increase in yield has been manifold during last few decades. The success of this venture can be judged from the fact that a great number of people have accepted and taken up fish production as their main means of livelihood and source of additional income. New technologies have been developed for fish rearing in different agro-climatic conditions for various life stages of different fish species. In most condition, they are provided with man made diets to hasten their growth and in turn for quick production of fish biomass. These diets are prepared from the good quality materials yet cost are kept at minimum level as 60-70% of the total fish culture expenses are incurred of fish food. Hence, it becomes mendatory to know the nutritional requirement of these fishes particularly which are cultured in upland regions.

The main function of providing artificial diets is to promote growth in fishes, to provide source of energy, and finally prepare the fish stock for breeding in captivity. For these activities the food must contain essential amino acids, essential fatty acids, essential source of carbohydrates, critically required vitamins and minerals.

BALANCED DIETS AND COMPONENT UTILIZATION

It is a well known fact that success in aquaculture depends on sound nutritional practices based on precise knowledge of nutrient requirements and the satisfaction of such needs through formulation of optimal diets, keeping in mind the health, well being and maximization of growth potentials of the respective fish species. Whether aquaculture strategy chosen is intensive or semi-intensive, this general principle remains valid with only changes in the modes of satisfaction of

NUTRITIONAL REQUIREMENTS OF COLDWATER FISHES

The nutritional requirements of fish mainly depend on their aquatic environment which generally has great impact on energy utilization. While formulating fish diets, protein is generally given first priority which is required for growth and maintenance and is more expensive than other energy producing components. The protein must be balanced for essential amino acids. The quantity of carbohydrate may differ from species to species which mainly depends on the ability of fish species to utilize its maximum quantity to their maximum advantage. Since lipid is the primary non-protein energy source for almost all the fish species, its type and amount to be used are decided to provide essential fatty acids. Vitamins and minerals are generally provided as premix as their availability in the feeds generally remains uncertain.

Protein

The studies on several fish species have revealed that feeding fry, fingerlings and subsequently adult ones require correct knowledge of their protein demand as its requirement is maximum during fry stage and it decreases with the increase in fish size. This higher demand of protein at fry stage can be attributed to rapid increase of majority of tissues in small fishes as growth shows positive allometry and even metabolic turnover is also higher. For example, as is known that rainbow trout in the wild feed on aquatic and terrestrial invertebrates provide quite high (37-66%) protein in their natural food. But during culture process, the amount of protein is reduced upto the level which will be sufficient for growth as quick fish production is the main target. But lipids and carbohydrates are provided as energy sources which compansate for less protein. It is important to include sufficient energy from non-protein sources in artificial diets.

Almost throughout the world, protein from animal and plant sources are extensively used. While fish meal is the main protein source of animal origin, soybean being from plant kingdom. Due to its high protein content and balanced essential amino acid profile, fish meal is widely accepted in fish farming. Fish meal is also ... digestible energy, minerals and vitamins.

can produce mineral imbalances. Other animal protein sources are by products such as meat and bone meal and poultry by-product meal, that contain about 45-55% crude protein but its quality is inferior to that of whole fish meal as the ash contents is usually high because a good amount of the material is derived from bone and non-muscle tissues. Flash or spray dried blood meal is rich in protein (80-86%) but low in methionine and unbalanced in branched chain amino acids.

Soybean meal is limiting in sulfur containing amino acids (Methionine, Lysine and Cystine) and contains many endogenous antinutrients including protease (tripsin) inhibitor, phytohaemagglutinin and anti-vitamins. Many of these factors can be destroyed or inactivated during thermal processing. It has been observed that the processing method of soybean meal has a significant effect on its nutritive value. It has been found that the germination and defattening of soybean meal reduced the activity of protease inhibitors. Heating soybean meal helps rupture the cellulose membrane surrounding the cell and release the cell contents making them more available . Heating also inactivates and destroys the antinutritional factors in soybean meal . It has been found that the quality of full fat soybean meal boiled at 100^0C for one hour was improved and tripsin inhibitor activity decreased in fish.

By several investigations conducted at National Research Centre on Coldwater Fisheries it has been observed that young ones of golden mahseer contains 58.27% of protein. In experimental conditions, these young ones evinced very good growth at 45-50% protein level. As mahseer grows, its protein requirements decreases in a gradual manner.

Carbohydrates

It is a well known fact that coldwater fishes do not utilize carbohydrates as energy sources so well as warm water species. The carbohydrate is the least expensive source in the diet, the maximum tolerable quantity can be used depending on the various fish species. Cereal grains serve as inexpensive sources of carbohydrates for warm water fish, but their use in coldwater fish feeds is limited. Starch is also important for the binding properties for pelleted feeds. Whole grains contain 62-72% starch, which is 60-70% digestible by warm water fish but markedly less digestible

Lipids

It is very essential to include lipids in the diets of the fishes as they form very important sources of energy and essential fatty acids required for normal growth and development. Dietary lipids contain both saturated and unsaturated fatty acids. The essential fatty acids function as components of phospholipids in all biomembranes and as precursers for eicosanoids that fulfill a variety of metabolic functions. Biomembranes must be in a fluid state to function properly at various temperatures. Membrane fluidity depends on the proper balance of saturated and unsaturated fatty acids as components of membrane phospholipids.

There is no definite percentage of dietary lipids required in fish diets without considering the type of lipid as well as the protein and energy content of the diet. Lipid concentrations upto 20 percent give optimum results with some species .It has been found that the protein content of rainbow trout diets could be reduced from 48 to 35 percent without any reduction in weight gain if the lipid concentration was increased from 15 to 20 percent. This indicates that all diets should be formulated not only to meet the optimum ratio of energy to protein for that species, but also to contain sufficient amount of lipid.

It is essential to add fat in enough quantity along with good source of protein for getting good growth in fishes. However, experiments conducted at National Research Centre on Coldwater Fisheries have indicated that about 15% fat addition is enough for mahseer.

Minerals

Mineral supplements are essentially required for achieving nutritionally balanced diets. They are absorbed by fishes not only from their diets but also from their outside aquatic environment. The main function of minerals are formation of skeletal structure, electron transfer, regulation of acid-base equilibrium and osmoregulation. Minerals are also important components of hormones and enzymes and they activate enzymes.

Calcium and Phosphorus

Calcium and phosphorus are two most required and well studied minerals. They are very important as they are directly involved in the development and maintenance of the skeletal system and participate in several physiological processes. Calcium also plays an important role in muscle contraction, blood clot formation, nerve impulse transmission, the maintenance of cell integrity and acid-base equilibrium and activation of several important enzymes. Generally fish absorb calcium directly from their environment . The uptake of calcium occures through gills, fins and oral epithelia, however gills are considered the most important site for calcium regulation in fresh water conditions. The calcium requirement is affected by water chemistry and species differences. A low concentration of calcium (0.34% or less) is required in the diet of carp for optimum growth . Calcium deficiency has not been detected in carp or cat fish in fresh water. Generally the natural diets supply sufficient calcium to meet the requirements of most fish species. For golden mahseer, 750 mg/kg of feed of calcium carbonate in a mineral premix has given good results .

It is known that phosphorus is an important constituent of nucleic acids and cell membranes, and is largely involved in all energy- producing cellular reactions. The role of phosphorus in carbohydrates, lipid and amino acid metabolism as well as in various metabolic processes involving buffers in body fluids, is also well established. Feed is the main source of phosphate for fish because the concentration of phosphate is low in natural waters. Rainbow trout and carp require 0.5 to 0.8 percent phosphorus. The dietary supply of phosphate is more critical than that of calcium because fish must effectively absorb, store, mobilize and conserve phosphate in both freshwater and seawater environments. In most fishes, the main phosphate deficiency sign include poor growth, feed efficiency and bone mineralisation. Other signs of deficiency in carp include increase in the activity of certain gluconeogenic enzymes in liver, increase in carcass fat with increase in carcass water content, reduced blood phosphate levels, deformed head and deformed vertebrae . Wide differences in the availability of phosphorus from various sources have been reported. The availability of phosphorus in fishmeal is significantly the enzyme phytase in the gastrointestinal tract. Phytic acid also forms insoluble salts with free calcium in the digestive tract. Therefore, the availability of phosphorus in most plant products is low; *e.g.* in soybean meal between 29 and 54 percent .

Magnesium

Magnesium is an essential co-factor in many enzymatic reactions in intermediary metabolism. These enzymes include phosphokinases, thiokinases, phosphatases and amino acylsynthetases. Magnesium plays an important role in the respiratory adaptation of freshwater fish. It is also required in skeletal tissue metabolism, osmoregulation and neuromuscular transmission. The quantitative dietary requirements of rainbow trout and carp have been estimated to range from 0.04 to 0.06 percent of the diet. The magnesium requirement of fish can be met either from the diet or water. It has been found that in fresh water, a concentration of 46 mg per litre was sufficient to meet the requirement of rainbow trout fed a magnesium free diet.The investigation on nutritional requirements of golden mahseer fry revealed that 30 mg/kg of magnesium feed is good enough .

Sodium, Potassium and Chlorine

The minerals like Sodium, Potassium and Chlorine are the most abundant electrolytes in the body. Sodium and chlorine are the principal cation and anion respectively in the extracellular fluid of the body, whereas potassium is the major monovalent intracellular cation. The deficiency sign of these elements are difficult to produce because fish really absorb these elements from the surrounding aquatic medium. Juvenile chinock salmon reared in fresh water required 0.8 percent potassium in their diet for maximum growth, and the whole body potassium saturation was reached at a potassium concentration between 0.6 and 1.2 percent of the diet . Supplements of 1 to 4 percent of sodium chloride in natural ingredient diets had no beneficial effect on the growth of rainbow trout . However, higher supplements of salt adversely affected growth and feed efficiency of rainbow trout. An amount of 750 mg/kg of Sodium chloride, and 2 mg/kg of feed of Potassium iodide added in the diet of fry of golden mahseer gave good results .

source of iron for fish because natural waters usually contain low amounts of soluble iron. Fish can absorb soluble iron from the water through the gills because the addition of ferrous sulphate to water enhanced growth and hemoglobin level in platyfish . Iron is absorbed from the peritoneal cavity in rainbow trout and stored in the liver, spleen and anterior kidney. Among salmonids, Atlantic salmon require 60 mg/kg of diet. In golden mahseer fry feed, 50 mg/kg of feed of ferrus sulphate gave good growth. Iron deficiency causes microcytic anemia in brook trout . The normal liver colour changed to yellowish white due to iron deficiency in carp. Dietary iron toxicity signs develop in rainbow trout when fed more than 1380 mg Fe/kg. The major effects of iron toxicity include reduced growth, increased mortality, diarrhea and histopathological damage to liver cells.

Copper

High concentration of copper is found in the heart, liver, brain and eyes. The dietary copper requirement of rainbow trout is 3 mg/kg . In golden mahseer diets, the addition of 6 mg/kg of feed of copper sulphate is enough. Carp fed diets containing high ash fishmeal without copper supplement showed reduced growth and cataract formation . Fish appears to be more tolerant of copper in the diet than of dissolved copper in the water. Concentration of 0.8 to 1.0 mg copper per litre as copper sulphate in water are toxic to many species of fish . There was no deleterious effects of feeding rainbow trout diets containing 150 mg copper/kg for 20 weeks.

Zinc

In rainbow trout, zinc defficiency caused growth suppression, mortality, lens cataract, erosion of fins and skin and short body dwarfism . When zinc supplement (40 mg/kg) were added to rainbow trout diets containing white fishmeal, dwarfism and cararact problems were alleviated .The zinc requirement of young rainbow trout and carp has been estimated from 15 to 30 mg/kg of diet and golden mahseer as zinc sulphate as 70 mg/kg of feed . The gills in rainbow trout play a major role in excretion of zinc . The bio -availability of zinc in fishmeal is inversely related to the tricalcium phosphate content. Rainbow trout and common

Iodine

The deficiency of iodine can cause thyroid hyperplasia in fishes. Thyroid hormone deficiency has been induced by glucosinolates in the diet. Relatively high concentrations of iodine and fluorine (4.5 mg/kg of diet of each) were essential to protect Atlantic salmon from bacterial kidney disease infections. The total uptake of iodine depends on the iodine content of the feed and water. It has been proved by experiments, that rainbow trout derive 80% of their iodide from water, 19% from diet, and less than 1% by recycling iodide from thyroid hormone degradation.

Vitamins

These organic compounds are very essential from an exogenous source for the normal growth, reproduction and health. They can be classified as water soluble and fat soluble. Eight of the water soluble vitamins are required in relatively small amounts, have primarily coenzyme functions and are known as the vitamin B complex. Three of the water soluble vitamins, choline, inositol and vitamin C are required in large quantities and have function other than coenzymes. Vitamin A, D, and K are the fat soluble vitamins that function independent of enzymes or in some cases such as vitamin K, may have coenzyme roles.

Fat soluble vitamins

They are absorbed in the intestine along with dietary fats and are stored by animals if dietary intake exceeds metabolic requirements. Fishes have the capacity to store enough fat soluble vitamins in their tissues to produce a toxic condition (hypervitaminosis) which has been observed in trout for vitamin A, D and E.

Vitamin A

This vitamin is essential for proper growth, reproduction, resistance to infection and the maintenance of differentiated epithelia and mucus secretions . Its defficiency in rainbow trout can cause anemia, twisted gill opercula and haemorrhages in the eyes and base of fins. Brook trout exhibited poor growth, high mortality, and eye vitamin is added in fish feeds as the acetate, palmitate or propionate ester in the form of free flowing beadlets in a multivitamin premix.

Vitamin D

This vitamin is required for facilitating mobilization, transport, absorption and use of calcium and phosphorus alongwith the actions of parathyroid hormone and calcitonin. Rainbow trout fed with a vitamin D-deficient diet exhibited poor growth, elevated liver lipid content, impaired calcium homeostasis manifested by tetany of white skeletal muscles. Vitamin D_3 is added in the fish feeds either in a beadlet with vitamin A or as a spray or drum-dried powder in a multivitamin premix.

Vitamin E

This vitamin functions as a very good antioxidant. Vitamin E and selenium function as part of a multicomponent antioxidant defense system which protects the cell against the adverse effects of reactive oxygen and other free radical initiators of the oxidation of polyunsaturated membrane phospholipids, essential proteins and sometimes both. Its deficiency has been studied in Atlantic salmon and rainbow trout whose signs include muscular dystrophy involving atrophy and necrosis of white muscle fibres, endema of heart, muscle and other tissues due to increased capillary permeability, impaired erythropoisis, depigmentation. The high concentration of dietary polysaturated fatty acids are involved in the feeds of common carp and rainbow trout , the requirement of vitamin E is increased. High dietary concentration of vitamin E (5000 mg /kg of diet) have shown to cause reduced concentration of erythrocytes in trout blood . This vitamin is added in fish feed as a dry powder.

Vitamin K

This vitamin is required for stimulation of prothrombin activity in plasma and synthesis of blood clotting factors VII, IX and X. It has been seen that many animals do not require vitamin K in the diet because of bacterial synthesis in the intestinal tract, but intestinal vitamin K synthesizing microflora have not been described in fish. High concentrati...

Water soluble vitamins

As these vitamins are not stored in fish body tissues, their constant supply is essential.

Thiamin

The deficiency of this vitamin can create neurological disorders such as hyperirritability in salmonids. It is available in coenzyme form as thiamin pyrophosphate which functions in the oxidative decarboxylation of a-keto acids, such as pyruvate and a-ketoglutarate. It is added in fish feed as thiamin mononitrate which is 91.9% thiamin.

Riboflavin

The sign of riboflavin deficiency appears in the eyes and include photophobia, cataracts, corneal vascularisation and hemorrhages in salmonids . Riboflavin deficient common carp exhibited hemorrhages in various part of body, nervousness and photophobia but no evidence of cataract development . It has been observed that the riboflavin requirement was not affected by temperature or by genetic differences in growth rate. Feeding quite high concentrations of riboflavin (upto 600 mg/kg diet) had no adverse impact on the growth of rainbow trout.This vitamin is generally added in fish feed as a dry powder in a multivitamin premix.

Vitamin B_6 (Pyridoxine)

The deficiency of this vitamin appears as anorexia and poor growth which appears in fish within 3 to 6 weeks after being fed with this vitamin deficent diets as well as creats histopathological changes in rainbow trout liver . This vitamin is added as pyridoxine hydrochloride in a dry form as part of a multivitamin premix in the fish feeds.

Niacin

This vitamin is essential for several oxidation - reduction reactions involving the transfer of hydrogen and electrons in carbohydrate, lipid and amino acid metabolism to 6 weeks. Its high dietary intake (10,000 mg/kg diet) can increase liver fat, decrease body fat and reduce growth rate in fingerlings of brook trout. This vitamin is added in fish diets as nicotinic acid or niacinamide.

Folic Acid

The deficiency of folic acid exhibits anorexia, reduced growth, poor feed conversion and megaloblastic anemia which can be seen as pale gills. The number of erythrocytes are found to decrease when rohu was fed folic acid deficient diet. Folic acid is added as dry powder in a multivitamin premix.

Vitamin B_{12}

This vitamin is required for normal maturation and development of erythrocytes, metabolism of fatty acids and the normal recycling of tetrahydrofolic acid. When salmon and trout are fed with low quantity of this vitamin, a high variability in numbers of fragmented erythrocytes and in hemoglobin value was seen. Whenever necessary, this vitamin is added as dry powder in multivitamin premix.

Choline

The deficiency of choline in rainbow trout diets may cause light coloured livers, protruded eyes, anemia and extended abdomen . In lake trout, when fish were fed with choline deficient diets for 12 weeks, a depressed growth rate and increase in liver fat content was observed. This is added in fish diets as a 70% choline chloride solution or a 25 to 60% dry powder.

Vitamin C

Ascorbic acid (Vit. C) allows the absorption of iron and prevents anemia. Ascorbic acid also fuctions with vitamin E and minimizes peroxidation of lipids in fish tissues. Its deficiency in salmon and trout can create body deformity such as scollosis, lordosis and abnormal support cartilage of the eye, gill, and fins and internal haemorrhage usually produced by nonspecific signs such as anorexia and lethargy. Deformities such as scollosis and lordosis due to this vitamin deficiency have been be higher for fingerlings or adults. Several coated forms of this vitamin *e.g.* fat coated are used to increase retention capacity of this vitamin in fish diets.

DIETS FOR MAHSEER

It has been observed that food and feeding of larvae and post larvae of himalayan mahseer (*Tor putitora*), finely emulsified chicken egg yolk followed by smashed goat's liver particles has revealed excellent results. Although this is not a complete diet, but can be used as primer feed for about a fortnight . Similarly, juvenile and adult specimens of golden mahseer may require well balanced diet. Though the wet feeds gave better results compared to dry artificial diets, but their cost (particularly goat liver) is very high and sometimes may not prove economically feasible for golden mahseer's aquaculture programme.

In the beginning, when diets with 21-50% protein levels were tested on mahseer juveniles, good growth could only be achieved with 45-50% protein levels . The main ingredients of these diets were soymeal, silkworm pupae, rice/wheat starch, casein, gelatin, cod liver oil fortified with vitamin mix and minerals. With different variations in these feed ingredients, about 6 diets were formulated for golden mahseer. On the basis of these investigations, it was observed that the early rearing stages of mahseer upto advance fry/ finferlings (45-55 mm) require about 45% of protein. The chemical composition of the best diet was estimated wherein protein was 45.38%, ether extract 14.12%, NFE 22.35%, crude fibre 3.93%, ash 5.98% and moisture 8.24%. This diet not only induced good growth but better conversion and feed efficiency as well. These diets have been taken up for further improvement for various stages of golden mahseer alongwith diets for snow-trout and good results are expected soon.

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FEED FORMULATIONS FOR COLDWATER FISHES

Madan Mohan

INTRODUCTION

The main objective of feed formulation in fish culture is to make available a nutritionally balanced feed which must support the growth, maintenance of good health and finally reproduction of the fish. The mixture of the ingredients must be able to facilitate the feed manufacturing process to produce the feed of the desired physical qualities as well as in good quantity.

While preparing artificial feeds, the ingredients containing different sources of proteins, amino acids, energy, essential fatty acids, vitamins etc. have to be identified and arranged.

Quality of feed ingredients

Quality control in the selection of diet ingredients is very essential in the preparation of artificial diets because a final product of artificial diet can never be better than quality of its ingredients. Selection must be based on maximum-minimum limits in which a particular item can be incorporated. For example, fish meal is sometimes added in minimum quantities to balance the amino acid composition of plant protein sources. Similarly, wheat flour, rice powder and other starch product such as potato meal are added in feed in minimum quantities to improve the durability and water stability as well as to provide energy in the feed.

Feed Processing

The artificial diets must be prepared as water stable, in particulate forms *i.e.* granules or pellets so that cultured fish is able to comsume it more efficiently and it will minimize fouling of the aquatic medium. When feed is prepared on a mass scale, it

Compression method

This method involve steam pelleting through compression and produces a dense pellet that can sink in water more rapidly. Here the process involves use of moisture, heat, and pressure to agglomerate feed ingredients into compact and bigger particle. Steam is added to the ground feed mixture during pelleting which helps in partially gelatinizing starch and in binding of the ingredients. This is done to add about 5 to 6 percent moisture and temperature is increased between 70 and 90°C. After few minutes, pellets are cooled and dried by forcing air over the surface of the steamed pellets. Steam pelleted feed must be firmly bonded to prevent rapid disintegration in water which will reduce diet efficiency and water quality.

It is very essential that the ingredient mixture must be finely grounded to a particle size of few microns prior to pelleting. Starch and gluten are very good binders while fibre and fat are antagonitic to firm binding. Hence it must be kept in mind that supplementary fats should not be added to the feed until after pelleting. Similarly, high fibrous feed ingredients must not be used in large quantities.

Extrusion method

In this method, the feed mixture in the form of a dough is forced through a small orifice at high pressure and temperature. This method allows entrapment of water vapour by the feed particles which on drying shall float on water. This method needs specialized and expensive equipments and also more inputs of moisture, heat and pressure than pelleting. In this method, the mixture of finely ground ingredients is conditioned with steam into a mash that may or may not be precooked before putting into extruder. This mash or dough which has about 25% of moisture, is compacted and heated between 100 to 150°C under pressure in the barrel of the extruder. Since this dough is pressed or squeezed through die-holes at the end of the barrel, the external pressure is decreased and part of the water in the already overheated dough get vaporized immediately and creates expansion of the feed particles. These extruded particles of the feed contain more water than steam pelleted particles and require external heat for drying. In this manner, after the extruded feed is that pellets are firmly bound due to gelatinization of the starch and denaturation of the protein which helps them in long water stability. For salmonids production, the extruded feeds are preferred particularly for larger ponds because they allow good observation of the feeding process including its consumption by the fishes.

Granule preparation

The granule diets are generally formulated for small sized fishes and prepared by pelleting the ingredients mixture and by reducing the size of the pellets by crumbling. These particles from crumbled pellets are separated into different sizes by screening. Fat is generally sprayed on the surface of these crumbled particles. In this process, considerable loss of water soluble nutrients may occure due to leaching with small particle dites because of the large amount of their numbers. Therefore, additional quantities of water soluble vitamins must be added.

Microencapsulation

This process involve coating of a small particle of artificial feed with a thin layer of a compound that will reduce disintegration, leaching as well as bacterial degradation till the particles are consumed by the fish or removed from culture medium. For these particles, the coating material must be water insoluble but digestible by enzymes in the digestive tract of the fish. Some of the coating material used include cross linked proteins, calcium alginate and oil which can be used for encapsulation.

FEEDING LEVELS

It is generally observed that with the increase in the weight of the fish, the relative calorific nutritional requirement *i.e.* requirement per unit fish weight decreases. The amount of the feed to be given to the fish mainly depends not only on the food requirement but also on the availability of the natural food and the they may consume 10-15% of their fish body weight per day. But this percentage decreases in juveniles and finally in adults, it may range 3-5% of their body weight.

FEEDING FREQUENCY

Depending on the life stages of the fish, artificial feed can be given as single or multiple meal or even continuously. Fishes must be fed three to four times during fry to fingerling stage and twice for adults. The morning and evening hours are considered appropriate. Though feed is generally broadcasted by hand at majority of fish farms throughout the world, feed on floating trays or demand feeder/other feed dispenser can save lot of feed from wastage and labour required.

FEED UTILIZATION AND FEED CONVERSION RATIO

Both these processes are inter-related and express the efficiency of conversion of feed to body weight gain. The feed conversion ratio (FCR) expresses the amount of feed required to obtain a weight unit of body weight. FCR indicate the efficiency of supplementary feed in fish production as it gives a simple formula for estimating how much feed is required to produce a unit weight of fish and whether the use of the amount of feed is economically viable. The FCR generally decreases with increase in feeding level until it reaches its lowest value.

ANTINUTRIONAL FACTORS IN FISH FEED

Some of the plant derived feed items are known to contain a wide variety of antinutritional substances . These can be divided as follows :

1. Factors affecting protein utilization and digestion, *i.e.* protease inhibitors tannins, lectins
2. Factors affecting minerals utilization which includes phytates, oxalates, glucosinolates

Antinutrients also can be classified :

1. Which can withstand thermal processing.
2. Which can be decreased by thermal treatment

GLUCOSINOLATES

Glucosinolates are commonly found in plants belonging to family Cruciferae. Glucosinolates are the main antinutrient present in rape seed (*Brassica* species) and mustard oil cake. The ingestion of very low amounts of glucosinolates lead to decrease of both growth and feed efficiency. Heat treatment is effective in reducing the glucosinolate content of fish feed employing wet pressure cooking.

Phytates

Phytate is common in plant seeds. Since phytates can not be broken down by non ruminants like fish, their occurrence in feed reduces the availability of phosphorus. Soybean meal contains 10-15 g, rape seed meal contains 50-75 g and sesame meal contains 24 g phytate per kg. High dietary phytic acid (25.8g/kg) depressed growth rate in chinock salmon. The abnormalities in thyroid, kidney, alimentary tract and morphology of fish were observed. Milling to remove the outer layers of seeds reduces the phytate content. Heat treatment (autoclaving) can reduce phytic acid in seasame meal upto 74%. Salmonids can tolerate dietary levels of phytate @ 5-6g/kg. It is advised to maintain the level of phytate below 5g/kg in fish feeds.

Protease inhibitors

Protease inhibitors are widespread antinutrients in many plants derived nutritional ingredients. Commercial soybean products contain 2-6 mg/g tripsin inhibitors. Rainbow trout has been found to be highly sensitive to soybean protease inhibitors. Below the 5mg/g level, most fish species are able to compensate tripsin inhibitors by increasing tripsin production. Moist heat treatment (Autoclaving for 15 to 30

Saponins

Saponins are steroids found in legumes (ranging 18 to 41 mg per kg). When added to water, saponins are highly toxic to fish. Saponins reduces the protein digestivity of soybean chymotrypsin perhaps by the formation of digestible saponin-protein complexes. Levels of saponins below 1 g per kg shall not effect growth performance in fish.

CONCLUSIONS

The feed prepared from different kind of ingredients derived either from animal or plant origin must have balanced protein, fatty acids, carbohydrates, vitamins and no growth inhibitors. The limits depend upon the kind and objectives of fish culture. Similarly the quality or quantity of the feed to be given depend on fish species, temperature and finally the cost involved in terms of profitability.

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FISH CULTURE IN HIMALYAN STATE OF UTTRANCHAL - AN EXAMPLE TO ADOPT IN HILL REGIONS OF NORTH EAST STATES OF INDIA

B. C. Tyagi

INTRODUCTION

Mountain and hill regions are important and supposed to contribute substantially to the economic development of India. Uttaranchal (28^0 47'-31^0 20' N; 77^0 35'-80^0 55' E) is a small (53204 km^2) and beautiful hill (198-7816 m asl) state bordered with China, Nepal and Indian states of Himachal and Uttar Pradesh. Of the total, 37% area is in the form of peaks and glaciers, 41% covered with forest and 7.4% land falls in tropical zone. Rest is hill area where in inhabitants derive their livelihood from agriculture and allied activities. Among 85-lakh population, 41.6 lakh are women and majority of them (86.4%) live in rural areas. A sizable population (61.9%) is below poverty line and 18 % belong to SC/ST group. Inspite of average rainfall of 1593 mm / year, 89.2% area has no irrigation facilities. The land holdings are small (av. 0.6 ha / family), fragmentary besides resource crunch. As a result, the farm productivity is extremely low.

Fish is cold-blooded aquatic animal, which need water for all activities but hardly consume 10-15% volume of it for survival and growing. The water, a scared commodity for survival of all living beings, in hills can be harvested from rains or by diverting from stream / rivulet into ponds and later can be used for crop / vegetable growing, cattle needs, fish rearing at a time. Carp fishes are efficient utilizers of insects, worms available in the ponds, can convert wastes fom cattle yard, agricultural, kitchen into fish flesh of high nutritive value ready for consumption. Harvesting and conservation of water will not only improve the sub-soil water availability but also will enhance the farm productivity and upgradation indigenous and alien origin in hills (800-1740 m asl) and developed a composite carp farming system for the mid-Himalayan region. Three species namely grass carp (feeding on all type of aquatic & terrestrial weeds), silver carp (feeding on natural microscopic insects-plankton) and common carp (feeding on faecal matter of grass carp, worms on bottom and unutilized feed) are stocked @ 2.8-4 fishes/ m^2 in April when water temperature is above 17°C with the provisions of supplementary feed and fertilizers. Further, the trials conducted during 1998-2004 in farmer's ponds located at 800-1740 m asl in the district of Nainital, Almora Bageswar, Champawat of Uttaranchal State gave encouraging results.

Reviewing the present status of physical and human resources in hill region of Uttaranchal state, only integrated farming system based on fish culture seems to be most relevant, economical and viable programme which can easily be applicated in the hill regions of north eastern states of Arunachal Pradesh, Meghalaya, Manipur, Nagaland, Mizoram and Assam.

CARP FARMING SYSTEM

Based on the survey conducted and data generated on bioecological status of ponds, socio-economic level of clients, 39 ponds located at 800-1740 m asl in the district of Nainital, Almora Bageswar, Champawat of Uttaranchal State were selected to demonstrate composite carp farming system developed for hills. The selected ponds were renovated to hold harvested water. Pre - stocking management *i.e.* filling ponds, liming, seed transport and stocking @ 2.8 -4 fish/ m^2 having grass carp 35-50 %, silver carp 25-30 % and common carp 30-35 % of 20-40 mm size; stocking management *i.e.* feeding fish daily @ 3-4 % of their body weight on supplementary feed prepared from kitchen wastes/ local cheap food items and terrestrial weeds in relation to water temperature and production of natural food by fertilizing water from cattle wastes as per requirement were carried out. The performance of each fish species in terms of growth, survival, contribution to total biomass, FCR, pond conversion ratio and the economic viability based on expenditure

The fish production is a complex process. The yield depends on growth rate and retrieval of the stocked species at harvest. The growth and survival of fishes are found directly correlated with water temperature, quality and quantity of supplementary feed provided, natural food available in ponds and *modus operandi* of the operator in both tropical and temperate waters. The coldwaters located in the hills at different altitudes are no exception. The temperature tolerance studies inferred that our Indian major carps can not survive and grow if water temperature is below 17.0^{0}C where as grass carp, common carp and silver carp were found growing above this temperature and surviving at 6.3^{0}C. The growth of coldwater fishes like Himalayan mahseer and snow trout was recorded 6.6-12.9 and 3.3-4.9 g / month at 800-1200 m asl (Table 2).

The stocking density was found regulating individual fish growth irrespective of other treatments. It is observed that more biomass can be obtained by stocking fish seed @ 6 but growth reduced to15-20 g/ month against the average growth of 33.4 - 77.1 g/ month @ when stocked 2-4 fish/ m^2. The growth of grass carp was found related to the quality and quantity of the grass fed. It grew equally well in hills on *dub grass*. In a span of 7-8 months @ 45-50 % of stocking density it has attained the maximum weight of 1060 g. The importance of supplementary feed in carp polyculture or other fish culture system is well recognized and lots of investigations have been carried out. In hills, irrespective of altitude, the quantity and quality of supplimentary feed played very important role. Higher doses of feed @ 3-4 % of body weight of fishes produced an average production of 4235-5610 kg/ha/yr during 1998-2004. On reducing the feed to @ 2% of the body weight, production recorded low to 2371-3246 kg/ha/yr in the corresponding period. Those farmers applied feed occasionally (2-3 days/ week) got an average production of 1183-2736 kg/ha/yr (Table 3). Based on the trials (148) results, 9000 kg feed / ha for the rearing period of 8 months is enough at 17.6 - 26.5^{0}C to produce the fish @ 5610 kg/ha. The quantity can be reduced if temperature is low and also can safely applied @ 10000-12000 kg/ ha /yr at higher temperature of 27-28 ^{0}C to fish feed in culture systems is a single input and share 45% of total expenditure (Fig. 1). The use of local feed items or recycling of cattle yard/ kitchen wastes appeared to be one way to reduce the cost of fish production. Admixture of backery/ kitchen wastes to the extent of 50% @ 3% of body weight of fish helped to get production @ 3379 kg/ha/yr. Further trials on recycling cattle/ kitchen wastes in different ponds revealed impressive growth of fishes and production @ 3421-4106 kg/ha/yr indicating utility of integrated farming based on fish culture (Table 3).

The fertilizers of organic nature like raw cattle dung, oilcake together in prescribed doses at 8-10 days interval are important to produce natural food in ponds. Such fertilization procedure play vital role in getting higher survival and growth of fish. The use of inorganic fertilizers in hill ponds is not required at all as in tropical aquaculture. There are much more scope to replace the fertilizers by recycling the cattle yard washings or wastes.

From the studies conducted by us and other researchers, it is inferred that water temperature is inversely correlated to altitude and is single vital factor to control the growth, survival and production of fish. Each species has its own thermal regime but adverse impact can be neutralized in lower and upper range of it by adopting scientific management practice. Higher production and growth was recorded at 1740 m asl as compare to 800-1200 m asl irrespective of the altitudinal location of the ponds and temperature ranges. The management practices adopted by the farmers were found directly correlated to production level (Table 3). Under extensive culture system the production was recorded 1183-2736 kg/ha/yr during 1998-2004 (n= 108) ; semi – intensive practices resulted in higher production of 2371-3246 kg/ha/yr; intensive programme led to the highest fish production of 4232-5610 kg/ha/yr during the corresponding period. It is quite comparable to the production rates achieved in tropical aquaculture. The production figures indicate that culture of Chinese carps under the technique named **Composite carp farming System** developed by the NRC on coldwater fisheries is easy to operate, economical,

Economical evaluation of fish culture under the TOT programme in Uttranchal during 1998-2004 indicated higher profitability from integrated farming system based on fish culture. The average expenditure on fish unit has been enlisted in Table 4 and Fig. 2. The net profit is reported to Rs. 47/- / kg against the cost of production of Rs. 23/- /kg. Scope for further improvement still exists.

Based on the present studies, the operational calendar of composite carp farming system has been developed as model according to scientific requirements and needs of the hill people (Table 4). The variants of the technology for different altitudinal regions have been evolved and found economical and operative (Table 5).

The knowledge and aptitude of the prospective clients, financial constraints in constructing fish ponds, non-availability of quality fish seed of candidate species at right time and non persuasive approach of the concerned agencies are some factors which restrict the adoption of composite carp farming system in hill areas. Imparting training to the clients through demonstration programme in fish culture, providing technical and financial assistance initially can pave the way to adopt the integrated farming based on fish culture in Himalayan uplands which in turn can help the people to improve their socio-economic status and availability of high protein food especially for the people of North East region who relish fish most.

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Table 1. Temperature tolerance of cultivable carps under farm conditions

Species	Optimum water temperature (°C)	Average water temperature (°C)	Adverse water temperature (°C)
Common Carp	28.0	20.0 - 26.0	6.3 - 9.1
Silver Carp	28.0	20.0 - 27.0	6.3 - 10.0
Grass Carp	27.0	20.0 - 29.0	6.3 - 17.0
Mahseer	22.0	20.0 - 27.0	9.2 - 10.0
Mrigal	-	22.0 - 28.9	9.1 - 17.0

Table 2. Performance of different fish species under farm conditions in hills

S. No.	Species	Density (no/m^2)	Growth (g/month)	Contributed production (%)	Rank
1.	Common carp***	1.0 - 2.0	12.0-27.1	23.3-46.3	2
2.	Silver carp***	0.6-2.0	14.7-26.8	11.1-32.4	3
3.	Grass carp**	0.4-2.9	30.2-62.8	24.2-66.8	1
4.	Mahseer***	0.1-1.2	6.6-12.9	4.0-18.0	5
5.	Snow trout***	0.1-0.3	3.3-4.9	0.1-0.6	6
6.	Rohu*	0.3-0.5	7.1-8.2	5.0-6.6	4
7.	Mrigal**	0.3-	5.0	NIL	7

* At 1400 m asl **At 1620 m asl *** At 800 - 1740 m asl

Table 3. Fish production in relation to altitude, density and husbandary practices adopted in hill ponds

Particulars	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04
Total No. of ponds	8	15	24	39	31	31
No. of ponds harvested	6	14	14	24	23	30
Location (m asl)	800-1740	800-1740	800-1740	800-1740	800-1740	800-1740
No. of fish species	3-4	3-4	3-4	3-4	3	3
Density (no/m^2)	1.6-5	2.3-5	3-4	3-4	3-4	3
Average production (kg/ha/yr)	3289	3404	3590	3698	3508	4972
Highest production (kg/ha/yr)	4345	5041	5987	5981	6942	9860
Lowest production (kg/ha/yr)	2028	1183	1330	1335	1200	2736
Production (kg/ha/yr) under intensive culture	4956	5041	4235	4902	4271	5610

Table 4. Fish farming technology and its operational calendar

Area of application	Sub - Himalayan area (800 - 1740 m asl)
Pond Size	Minimum 100 - 150 m^2
Depth of the ponds	Minimum 1.8 - 2.0 m
Type of the ponds	Earthern / RCC having soil at bottom
Water	Harvested rain water or from stream
Period of operation	April - October/Early November
Fish Species	Grass carp, Silver carp, Common carp, (Mahseer & Rohu below 1200 m asl)
Fish density	2.8 - 4 fish/m^2
Fish species combination	Grass carp 35 - 50%, Silver carp 20 - 30% Common carp 30 - 35%
Size of fish stock	30 - 40 mm
Fertilization	RCD 15000 kg + Urea 50 kg/ha at every 10th day
Liming	@ 200 - 350 kg/ha/yr every 10th day
Feeding	Soaked in dough form made from OC 30% + WB 40% + RP 20% + Soybeans 10% @ 9-11000 kg/ha/yr Daily in two frequency in trays Vegetable waste/terrestrial grass for grass carp daily on platform
Monitoring growth/ water quality	As and when required. At least once in 1 months
Harvest time	Early November
Expected harvest	90.00 kg or 0.596 kg/m^2
Estimated expenditure	Rs. 23.00 / kg
Expected income	Rs. 6300/- per unit
Expected net profit	Rs. 47/- kg.

Table 5. Composite carp farming technology and it's variants suitable for west or east hills himalayan region.

Particulars	CFCV - 1	CFCV - 2	CFCV - 3	T-1
Area of application (m asl)	260 - 800	800 - 1300	1300 - 1800	>1800
Operational period	March-November	March-October	April-October	Round the year
Temp range (°c)	15.0-31.0	9.1-29.5	4.5-27.6	3.0-18.0
Nature of pond	Earthen	Earthen/RCC	Earthen/RCC	RCC/GRP
Size (m^2) & shape	1000 rectangular	400-1000 rectangular	150 - 400 any shape	150 - 200 rectangular
Pond depth (m)	1.8-2.5	1.8-2.0	1.5-2.0	1.0-1.5
Source of water	Rains, canal, tube well	Rains/stream	Rains/stream	Stream/ Springs
Fish species**	C, R, M, Gc, Sc.Cc	R, Gc, Sc.Cc, Ma/katli	Gc, Sc.Cc,	Rainbow trout
No./(m^2)	0.6-1.0	2.0-3.0	3.0-4.0	10-15
Percent of species	10,10,10,25,25,20	10,35,20,25,10	50,20,30	100
Size of fish seed (mm)	25-30	25-30	30-40	40-50
Feed				
i.) % of body weight	1.5-3.0	2-3	2-3	5-8
ii.) @ kg in 1000/ha	14-19	12-15	9-11	As per requirements
iii.) Frequency	Daily	Daily	Daily	Daily
iv.) Items***	OC+RB+WB+FM	OC+RB+WB+FM	OC+RB+WB+sbM	Formulated
v.) Grass	Daily 15% of wt. or as required	Daily 10% of wt. or as required	Daily 10% of wt. or as required	Nil
Fertilizer : every 10th day in mixture of (kg/ha/yr)				
i.) Raw cattledung	15000	8000	5000	Nil
ii.) Urea	250	50	-	
iii.) S. phosphate	300	100	-	
iv.) Oil cake	100	50	50	
Liming every 10th day (Kg/ha/yr)	250	300	300	Nil
Monitoring, growth, health, water quality	Every month	Every month	Every month	Every 10th Day
Harvest	Early December	Mid November	Early November	On marketable size
Expected harvest (kg/m2)	1.0-1.2	0.6-0.8	0.4-0.6	-
Range of fish wt. (kg)	0.8-2.1	0.5-1.0	0.4-0.9	0.6-0.8
Expected net profit Rs./kf	23.00	30.00	47.00	-

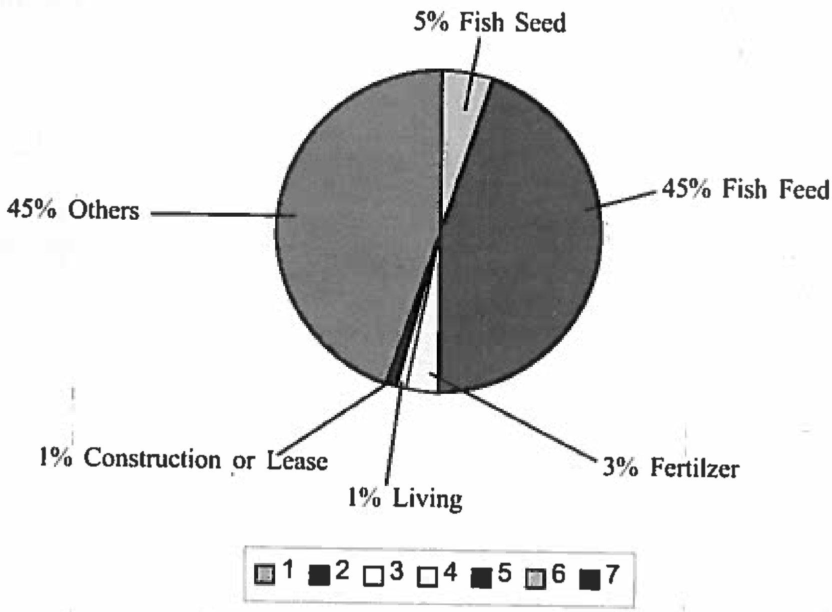
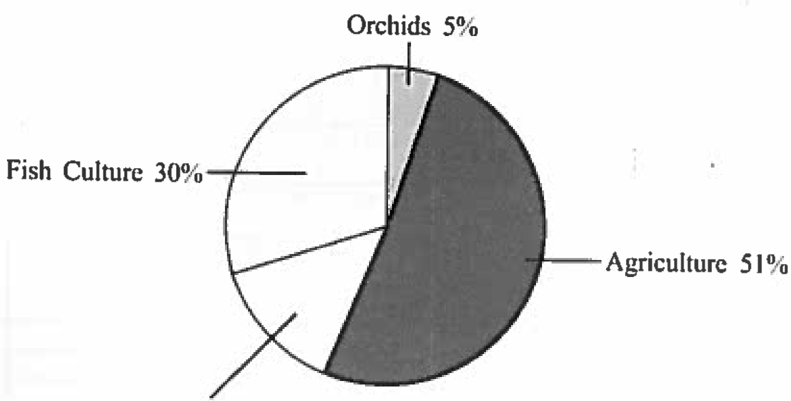


Fig. 1. Expenditure on different inputs in fish culture



GEOGRAPHICAL INFORMATION SYSTEM (GIS) APPLICATION IN FISHERIES MANAGEMENT

Ashok K. Nayak

INTRODUCTION

Geographical Information System (GIS) may be defined as the integration of computer hardware and software with spatially referenced digital data so that storage, retrieval, analysis, manipulation, report of the data is possible in order to produce new spatially related output. GIS is a computerized information system like any other database, but with an important difference is all information in GIS must be linked to a geographical (spatial) reference (latitude and longitude or other spatial coordinates).

GIS is a tool to produce various kind of data pertain to natural resource including aquatic one important from fisheries point of view. The fishery resources in the North East Hill States exhibit diversity in their physiography, magnitude, bioecology and have not been assessed property from fisheries development point of view.

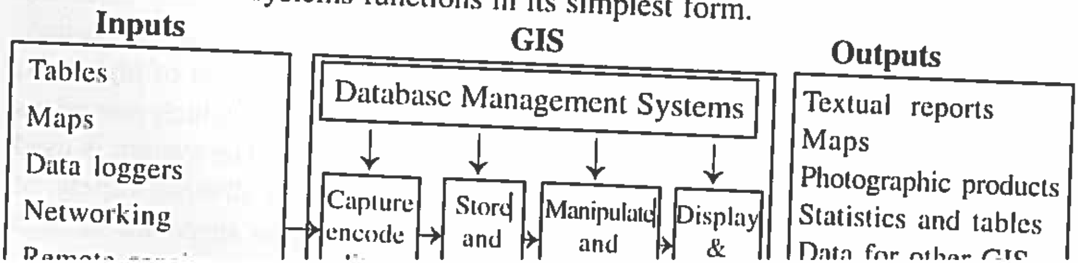
The fisheries resources in general and in Northeastern States in particular are in crisis with a wide range of problems like pollution, overexploitation and habitat destruction, which directly affect not only socio-economic status of the fishermen but also to the biodiversity. These problems are aggravated due to poor planning in absence of non-availability of the scientific database. The supply of anticipated fish production could only be compensated by aquaculture and allied activities. Management of the resources requires enormous data, based on reality since the planning is done after their interpretation. Handling and analysing of vast information, is not practicable manually due to chances of biasness, involvement of high cost, manpower and time required. It is wise to prefer to use of GIS, which comprises of a collection of integrated computer hardware and software. The system is used for input, storing, manipulating, analysing and presenting a diverse variety of geographical data. The advancement of computers in its higher speed and storage

Any spatial management system needs data. Within certain limitations the maxim would apply that the more data leads to the better result. Certainly any management system falling under the overall heading of "Fisheries" or "Fisheries Resources" could not possibly function without having access to, not only large amounts of data, but also to data from a wide variety of sources in a potentially huge array of formats. Given these growing data requirements, the spatial management operations can really only function with the aid of information technology systems. There are now a wide variety of relevant computer based IT systems, some of which are general in their use, e.g. database management systems, spreadsheets, graphics packages and some which have been developed specifically for fisheries and related purposes.

COMPONENTS OF GIS

The GIS have three important components, mainly computer hardware, set of application software modules and a proper organization setup. These three components need to be in balance if the system is to function satisfactorily. GIS run on the whole spectrum of computer systems starting from personal computer to multi-user super computers and are programmed in a wide variety of software packages. The hardware component is particularly the high performance computer systems, input devices like scanners, digitizer and others as CD, Graphic Monitor, Global Positioning System and Plotters. The software component requires input modules, editing, analysis and modelling for spatial and non-spatial data. This also requires skilled personnel to perform this job.

It is useful to view GIS in terms of inputs, processes and outputs. The figure below shows the overall systems functions in its simplest form.



GIS software provides the functions and tools needed to store, analyze and display geographic information. The key software components are

- Tools for the input and manipulation of geographic information
- A database management system (DBMS)
- Tools that support geographic query, analysis and visualization
- A graphical user interface (GUI) for easy access to tools

HISTORY OF GIS IN FISHERIES

Use of GIS for fisheries management started during mid 1990's. Potentiality of GIS is realised in the recent past and now it has become popular among many users for variety of applications. In India the major developments happened during last decade with significant contribution coming from Department of Space, emphasising applications of GIS for Natural Resources Management mainly by Natural Resource Information System, Integrated Mission for Sustainable Development etc. Indian Institute of Remote Sensing is also playing major role in GIS through education and training programmes at the National and International level. Recently the commercial organisations in India have realised the importance of GIS for many applications like natural resource management, infrastructure development, facility management, business/market applications etc. and many GIS based projects are taken up according to the requirement of user organisation.

Over the past three decades there has gradually evolved a branch of IT which is specifically dedicated to mapping and spatial analysis. This emerging technology is usually referred to as Geographical Information Systems (GIS), though it has also been called "geo-data systems", "spatial information systems", "digital mapping systems" and "land information systems". This latter term is clearly a response to the fact that many GIS software houses are looking to promote GIS as part of an essential suite of tools which will collectively make management decisions easier. Also the term "geomatics" may be encountered, i.e. as encompassing the complete geographical information technologies. Exact definitions of GIS are made difficult

APPLICATION OF GIS IN FISHERIES DEVELOPMENT

Bio-resource mapping with remote sensing and GIS applications naturally points at fisheries studies. Fisheries management has become wedded to biomass as the principal measure of resource status and the key to sustainability is to maintain the geographic distributions of each species. Applications of GIS in fisheries is so diverse that relevant data can be collected, co-located and displayed in a way as to enhance understanding beyond that which existed before the exercise. Some existing use of GIS in fisheries management is discussed hereunder.

Aquaculture Site Selection and Resource Inventory

Aquaculture is an important occupation which provides flexible employment to a sizeable population and fetch remarkable amount of foreign currency. The success of an aquaculture farm is dependent on the site that has suitable qualities of soil and water. Prejudiced policy of manually selecting sites for aquaculture may not be scientific mainly due to the low levels of interpretations of the field realities. Geoinformatics provides various ways of data handling, analysis, interpretation and decision making process. Space Application Centre proposed the suitable site for aquaculture by using IRS LISS II data of land use map on 1:50,000 scale. Engineering, biological, meteorological, socio-economic and infrastructural aspects were considered as criteria for suitable sites. More weightage was given to conveyance, water supply and seed availability. Geo-informatics in selecting suitable site for aquaculture obviously will minimise the loss incurred to the aquaculture industry due to ignorance of many legal, social and environmental aspects during pre-establishment of aquaculture farm. The entrepreneurs could be advised in identifying the most suitable areas for aquaculture thus conserving the delicate ecosystem. The undue intrusions to other places and habitats can be avoided focusing to conserving our natural wealth; the nation's treasure.

Resource inventory is one of the significant applications of GIS in fisheries management. Mapping of catch or fishing effort distributions and in the matching

Location of Potential Fishing Zones and Fishery Forecasting

The probability of occurrence of fish at a location depends on many complex factors. The physical feature of the land along the water bodies, fluctuations in water temperature, the influence of wind and water flows, variations in the water quality parameters like pH, dissolved oxygen, CO_2, presence of nutrients, phytoplankton, zooplankton etc. in the water bodies. A number of water quality parameter influencing a periodic and seasonal occurrence and migration of fish, their spawning, recruitment, survival and growth. Thus, the fluctuations in the environmental conditions of the water bodies have a significant bearing on the lives and habits of fishes. Of practical importance for the fishes is the knowledge of the behavior of the fish in respect of those environmental factors, which are easily observable. An attempt to utilize remote sensing approach for this purpose and techniques to be developed for water color sensing and sea surface temperature retrievals using data from various sensors. Water colors in general and phytoplankton present, which gives an indication about the standing stock of green biomass. Temperature on the other hand indicates whether favorable environmental conditions exist or not. Satellites with their potential to cover vast areas of the land and the data are also economical in comparison with other sources of data.

The Potential Fishing Zone maps are generated after analyzing the features such as thermal boundaries, fronts, water flows in different regions for 3 to 4 days. The potential fishing zone maps possess such details as the longitude and latitude, bathymetry, bearing in degrees, distance in km and the validity period. These maps are analyzed accordingly to find out the suitable locations for fishing point of view. The feedbacks received are subsequently transferred to the selected points on to the respective georeference map. It is important to determine the extent and shape of these features, as they are associated with the occurrence/abundance of fish.

CONCLUSION

Fisheries management is a multidisciplinary approach, therefore an applications of GIS do not only comprise of local, national and international fishery authorities and levels of production are established, the remotely sensed data could be utilised for studying migratory characters of the fishes, preparation of spatial distribution of fish, fishery forecasting and eco-system modelling. Progress in applying GIS to fisheries management has been rapid, diverse and imaginative. NRC on coldwater fisheries Bhimtal has initiated a project to the fisheries resources of North East State using geographical information systems (GIS)

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TECHNIQUES TO ASSESS GENETIC VARIABILITY IN FISHES WITH SPECIAL REFERENCE TO RANDOMLY AMPLIFIED POLYMORPHIC DNA (RAPD)

Rajeev Kapila

INTRODUCTION

Genetics and biotechnology have played a pivotal role in enhancing agricultural and animal production. It is only recently that genetics has acquired an important status in fishery science. Genetic improvement is the process of replacing a given population of genotypes with another that subtends superior phenotypic performance. Selection, by imposing differential reproductive opportunities for individuals of the population provides directional impetus to genetic change. Animal breeders define their design in terms of desired phenotype and their building materials are genetic variability at molecular level, distributed among the genomes of individuals in the population, which quantitatively or qualitatively condition expression of their phenotypes. There are number of techniques, which can indirectly or directly, depict variation in genes. An overview of various such techniques is given below as these are the basics of any selective breeding and stock improvement programme.

A. INDIRECT VISUALIZATION OF GENETIC VARIABILITY

1. Morphological and morhometric characters

The analysis of morphological characters which include the multivariate analysis of external anatomical characteristics as well as the study of scales and otoliths, have been used as a means of stock identification for many years. Other markers used for stock identification included parasites, elemental composition of various body parts and artificial tags.

None of the above approaches to stock identification are directly related to primary property of stocks independent reproduction. In contrast, natural genetic marks

2. Non-specific staining of proteins

Gene structure determines protein structure. Genetic variation at protein coding loci results in changes in the amino acid sequences of proteins. At the protein level, electrophoresis, is one technique which can be utilized to detect such differences. Numerous early electrophoretic studies of fish stock employed the analysis of variation of general proteins in muscles as revealed by nonspecific protein stains such as amido black or commassie blue.

3. Specific staining of proteins and enzymes

Nowadays staining of specific enzymes on the gels are preferred over general proteins as genetic markers of fish stocks due to several reasons. First, the often complex patterns resulting from large number of bands revealed by nonspecific staining can make the interpretation of gels extremely difficult. Secondly, there is little or no supportive information available for interpreting any variation in banding patterns that may be observed. That is, important information such as inheritance data from other species, data concerning the subunit structures of the proteins involved and number of loci encoding them, and knowledge about the influence of environmental variables and differing physiological states on the expression of the characters is almost always lacking for general proteins. Third, the action of any number of nongenetic factors that can affect protein banding patterns is difficult to detect and document because of complexity and largely unknown genetic and physiological bases of general protein patterns. These lacunae can be overcome by specific enzyme staining.

B. DIRECT VISUALIZATION OF GENETIC VARIABILITY

DNA based markers • Mitochondrial DNA (mt-DNA) • Genomic DNA

1. Mitochondrial DNA (mt-DNA)

Mitochondria are cytoplasmic organelles in eukaryotic cells where respiration takes place. Mitochondria have their own DNA, which contains numerous genes vital for mt DNA is clonally inherited. All of these factors combine to reduce the effective population size for mt DNA to one-fourth of that for nuclear gene of the same organisms. In many organisms, the mtDNA also seems to accumulate mutations more rapidly than do single-copy nuclear genes. In other words, it provides markers with greater variability and sensitivity to drift, and is therefore more likely to show differences between population/species; this makes mitochondiral genome more attractive for both systematic and population genetic studies. Initial investigations relied on purified mtDNA laboriously produced by ultra-centrifugation, meaning that sample sizes were small and that statistical tests lacked power. This rate-limiting step can now be circumvented by visualizing mtDNA fragments through Southern blotting, and more recently PCR methods have further speeded up analysis of mtDNA by RFLP . Sample sizes can now approach those used in allozyme studies, although the time required is still appreciably greater.

Because different regions of the mitochondiral genome evolve at different rates, certain regions of the mt DNA have been targetted for certain types of studies. The cytochrome b and ND (NADH dehydrogenase) genes have been examined in number of species as they are reported to exhibit variability on the population level. The D-loop has been targeted for population studies because it is highly variable in mammals, but this is not necessarily the case with fish. The mitochondiral ribosomal genes evolve more slowly and have been used for species or even family-level studies . It should be noted, that the mitochondrial genome although contains over thirty genes, it is treated as a single locus in population genetic analyses because of the absence of recombination in the mtDNA molecule.

2. Restriction Fragment Length Polymophism (RFLP)

RFLPs, as indicated by name, are defined by two main factors. Firstly, restriction enzymes (RE), a special class of bacterial enzymes which recognize and cut the DNA at specific sites and secondly, a properly labeled specific probe. Upon incubation of DNA with RE, the latter scans the sequences and cleaves the DNA at the specific target sites yielding a series of fragments. The size distribution of the resultant DNA fragment depends on the relative location of of adjacent restiction in the genomic DNA create, eliminate or translocate the RE sites and thereby affect the length of the resultant restriction fragments. A point mutation , deletion or insertion can create or abolish the recognition site for particular RE, whereas inversion, as on the other hand, changes the distance between a pair of RE sites bracketting the probe homologous sequence. Thus the changes in DNA sequence associated with an allelic change at the locus will be visualized as shift in location of the hybridization band. Individuals carrying different allelic variation of genes will show different band distribution patterns.These difference in band numbers and locations that result from changes in fragment size are termed as restriction fragment length polymorphism (RFLP).

3. Minisatellites

Direct examination of nDNA variability remains at present a relatively less developed field as far as fisheries is concerned due to non availability of suitable probes. However, one source of nDNA markers that is being increasingly studied concerns the analysis of repeated sequences (VNTR loci-variable number of tandem repeats). The repeat unit may be anywhere from one to a few hundred nucleotides long, have shown so much variations that they can be used as 'fingerprints' in some organisms . In some animals, certain satellite DNAs may occur as millions of copies of the repeat sequence per cell. Minisatellites contain repeat units from ten to a hundred nucleotides long which are often GC rich and are highly polymorphic for repeat number, heterozygosities approach 100% and mutation rate exceeds 2% per generation . This fingerprinting approach reveals large numbers of loci simultaneously, producing highly variable and complex patterns in which individual locus genotypes cannot be distinguished. This variability is strength in some applications, notably in studies of parentage and breeding systems, but a severe limitation when individual locus genotyping is required.

4. Microsatellites

Microsatellites comprise VNTRs of short (one to four nucleotide) repeats that are generally less than 300 bp in total, but can be much larger . As in minisatellites, mutation rates are high, estimated at around 0.05% to 0.2% ...

amplification and description of individual alleles, or by cloning the entire VNTR or one or both domains of unique flanking nDNA and using this to probe Southern blots. Unfortunately, such single locus probes or primers currently have to be developed new for each species, or groups of clearly related species, and the development phase may take several months of skilled and expensive labour.

5. LINEs/SINEs

Interspersed repeated DNA (long and short interspersed repetitive elements, LINEs and SINEs respectively) also occurs multiple times (sometime hundreds of thousands of times) throughout the genome, but constitutes a smaller part of the genome than satellite DNA. Unlike satellite DNA, the repeated copies are scattered around the genome, not tandemly repeated. Some evidence exists that points to retroviral origins of certain SINEs. Because insertions of these elements are assumed to be random, the insertion of an element in a specific site could be viewed as a rare event. Based on this premise, SINEs have been used as characters in phylogenetic analysis. Scientists visualized and characterized eight loci of SINEs in the genome of salmonids, which are known as members of the *Hpa* I family. These have been inserted in species-specific manner in the genome of *Oncorhynchus masou* (cherry salmon). All of these SINEs were fixed in each of the local populations examined. These observations suggested that a SINE insertion event must have occurred in the genome of the single ancestral species of all the subspecies of *O. masou* and that the SINEs must have spread throughout the various populations before the divergence of subspecies, thus provided an evidence of *O. masou* as monophylatic.

6. Amplified fragment length polymophism (AFLP)

Amplified fragment length polymorphism is a recently developed technique that combines the strengths of RFLP and RAPD. In this procedure, genomic DNA is digested with two restriction enzymes, *EcoRI* and *Mse I*, and suitable adaptors are legated to the fragments. Because sequences of the artificially ligated adaptors are known, they provide sequences for PCR primers used to selectively amplify a subset of fragments based on the additional terminal selective bases in the primers.

capable of producing large numbers of polymorphic bands in a single analysis, significantly reducing the cost of analysis per marker.

7. Randomly Amplified Polymorphic DNA Fingerprinting (RAPD)

The PCR-based RAPD analysis is conceptually very simple . A very small amount (in Nanogram) of genomic DNA is subjected to PCR using short synthetic oligonucleotides of random sequence. Unlike in standard two primer mediated PCR amplification, in RAPD-PCR only a single random oligonucleotide is employed and no prior knowledge of the genome subjected to analysis is required. It is based on the principal that, when the primer is short (e.g. 8 to 10 mer), there is a high probability that the genome contains several priming sites close to one other (i.e within amplifiable distance) that are in an inverted orientation. The technique essentially scans a genome for these small inverted repeats and amplifies inverting DNA segments of variable length. The amplification products are then resolved on agarose gel by electrophoresis resulting in DNA fingerprinting type-banding pattern. The profile of amplification products depends on the template –primer combination and is reproducible for any given conditions. Since in this technique primers of arbitrary nucleotide sequence are used to access random segments of the genomic DNA to reveal polymorphism, these markers are named as Randomly Amplified Polymorphic DNA. The polymorphisms obtained may result from point mutations, insertions, deletions, and inversions. RAPDs are usually dominant markers and are inherited in simple Mendelian fashion. In comparision with RFLP, the procedure is less expensive, faster, requires a smaller amount of DNA (0.5 to 50 ng DNA), does not involve the use of radioisotopes and requires less skill to operate. RAPD has been successfully used for genome mapping, gene targeting, and taxonomy.

7.1 Experimental strategies

7.1.1 Isolation of DNA

The isolation of DNA from fish tissues is now not a limiting factor for successful implementation of molecular biology secondary metabolites etc.) should be isolated to obtain reproducible results. The quality of DNA may be checked by horizontal gel electrophoresis, the best DNA preparation has sharp high molecular band instead of smear due to sheared DNA. While isolating the DNA, detergents like SDS, Sarcosyl or CTAB are generally used in lysis buffer to solublize the plasma membrane of cell and nucleus. Proteinase K in lysis buffer solublizes various proteins and RNase to remove RNA from preparation. Proper quantification of isolated DNA with spectrophotometer is also important to check non reproducibility in results.

7.1.2. Reaction conditions

PCR programme generally used in RAPD has low stringency at primer annealing than usual PCR reactions with specific primers. This is due to the relatively short and arbitrary sequences of primers used. Optimization of the PCR program involves a search for the best combination of step lengths and cycle numbers, with a view to minimizing total amplification time without losing any information. This effectively means empirical optimization of denaturating time, annealing time, and extension time. In addition, number of cycles also needs to be determined. Denaturation time as little as possible, because Taq has a limited lifespan at higher temperatures. Also important are the genome size, complexity and purity of DNA. Annealing time depends upon the GC content of the primer. Extension time has correspondence with the maximum size of fragment amplified.

7.1.3. Reaction composition

Reproducibility of the results depends upon the optimization of the cocktail. Generally, the concentrations of tempelate DNA, Mg++ ions, primer, enzyme, and dNTPs need to be optimized. Commercial and biological source and quantity of thermostable DNA polymerase, length and base composition of the primers also influence the results tremendously. A review of RAPD studies clearly indicates that at the beginning of a study with RAPD procedure, it is essential to test a variety of reaction conditions to determine those that are best suited for the popular species under study.

purpose. For best resolution of bands quality of agarose and polyacrylamide, electrophoresis buffer are also important as the apparatus itself. Proper system to store and document the gels is also needed to avoid loss of data generated and improving the reaction conditions while checking the reproducibility of results.

7.1.5. Statistical analysis of data

Amplicons are scored as discrete variables, using 1 to indicate presence and 0 for absence . Alternative condition in even a single accession is classified the band as polymorphic. A pairwise similarity matrix is generated using Jaccard's similarity coefficient (JSC). $JSC=(n_{xy})/(n-n\propto)$, where n_{xy} is the number of bands common to accessions x and y; n is the total number of bands; $n\propto$ is the number of bands absent in both x and y but present in other accessions. UPGMA cluster analysis is performed to develop a dendrogram. These computations can be performed using the any specific program such as NTSYS-pc (Numerical Taxonomy and Multivariate Analysis System Programme).

7.2 Precautions

- Avoid contamination of template DNA
- Autoclave all the plastic and glassware used
- Always vortex $MgCl_2$ prior to use
- Keep dNTPs in frozen aliquots
- Ethidium bromide (EtBr) is a mutagen. Always handle EtBr stained gels with gloved hands
- Wear a full face UV protector while viewing gels

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STATUS PAPER ON FISHERIES OF ARUNACHAL PRADESH

Tage Moda

INTRODUCTION

The State of Arunachal Pradesh, occupying the North-Eastern proximity of the country is characterized by the hilly terrain and criss-crossed by a number of rivers/rivulets with good number of beels and lakes adding to the scenic beauty of its topography. The fisheries programme was first initiated in the year 1958-59 on a very modest scale. However, with the passage of time and expansion of the activities, pisciculture has taken a firm root and the people are presently looking forward as a means of additional income. This is attributed to the fact that the people are basically rural farmers and no "FISHERMAN" exists by caste. So long The people had to depend on nature for fish protein but now the scientific method of fish culture in confinement has taught the people to reap the harvest from their doorsteps.

PRESENT STATUS

Arunachal has abundant water bodies. It comprises stagnant water (about 7000 ha.) and 2000 km running water suitable for the development of fisheries. The drainage of the State is affected by rivers *viz.* Siang, Subansiri, Lohit, Noa-Dehing, Dibang, Kameng and Tirap. The estimated potential of different type of resources available for pisciculture, their respectie utilization/exploitation are indicated in Table 1.

Table 1 : Fisheries resources of Arunachal Pradesh

Types of Resources	Estimated	Utilization till (1.4.2004)	Utilization (%)
Ponds & Tanks	2200 ha	1042 ha	47

The fisheries resources have been estimated based on primary information which need re-assessment. Further, Ranganadi Reservoir at Yazali in Lower Subansiri District with estimated 160 ha water area is ready for fisheries development.

The state exhibit fish biodiversity with more than 167 species comprising 20% cold water and about 80% admixture of cold and warm water species. Five new fish species have been reported from Namdapha National Park, Miao, Changland District by the Zoological Survey of India (Table 2).

Table 2. New records from Namdapha National Park, Miao Changlang District, Arunachal Pradesh

Name of Species	Family	Author
Noemacheilus arunachalensis	Cobiditae	Dutta & Barman, 1984
Aborichythys tikaderi	Balitoridae	Barman, 1984
Danio (Brachydanio) horai	Cyprinidae	Barman, 1983
Garra tirapensis	Cyprinidae	Dutta & Barman, 1984
Barilius jayarami	Cyprinidae	Barman, 1985

Demand - Supply Scenario

Fish and Fish seed demand - supply scenario of the State is as under :

a) Fish (In tons)

i)	Estimated demand (as per 2001 census)	13093
ii)	Estimated demand by 2020	22000
iii)	Present production	2600

b) Fish seed (In number)

i)	Estimated demand	42
ii)	Estimated demand for stocking by 2020	80
iii)	Present production	25

ORGANISATIONAL STRUCTURE

At present, the fisheries department is headed by the Secretary as the administrative head, Director of Fisheries, a technical head, is supported by three Deputy Directors, five Assistant Directors, one Farm Manager and thirteen District Fisheries Officer.

ALLOCATION OF FUNDS

The trend of allocation during various plans for the development of fisheries sector is furnished in Table 3.

Table 3. Financial Allocation in fisheries sector in Arunachal Pradesh

Period	State Plan Outlay (Rs. in lakhs)	Outlay in Fisheries (Rs. in lakhs)	Percentage of Allocation
2nd Plan	509.00	1.00	0.20
3rd Plan	715.00	1.70	0.24
Annual Plan (1966-69)	874.15	2.90	0.34
4th Plan	1799.00	12.00	0.67
5th Plan	633.00	38.30	0.61
Annual Plan (1978-80)	4681.00	10.00	0.21
6th Plan	22290.00	114.20	0.51
7th Plan	55561.00	252.45	0.45
Annual Plan (1990-92)	38656.00	172.00	0.44
8th Plan	179153.00	734.00	0.41
9th Plan (1997-2002)	356989.00	904.17	0.25
10th Plan (2002-07)	388832.00	2394.00/703.21	0.62/29.37

FISHERIES PROGRAMME

There are seven schemes in operation under State Sector - (i) Rural aquaculture, Borbeel Fishery Project for capture-cum-culture fishery in the foot hills, iii) Pilot project for running water fish culture, iv) Culture of warm water species and, v) Cold Water Fishery Project are in progress. The culture and production of trout and local indigenous species like snow trouts also have been initiated.

Hill Fisheries

Trout Farming

In view of the scope for cold water fisheries in the areas at high altitude trout farming had come up from the year 1967-68. The favourable water temperature ranging from below freezing point to as high as 20^{0}C led to the eatablishment of a trout hatchery along the stream of Nuranang at an altitude of 3900 ft in Tawang District with the brown trout seed imported from Jammu & Kashmir. The encouraging results of trout farming could be further disseminated by way of establishment of another trout hatchery at Sheragaon, West Kameng District located at an elevation of about 3000 m. For culture, both brown and rainbow trout the stock has been imported from Himachal Pradesh during 1974-75. To commercialise the production of trout, another Project on coldwater hatchery complex has been sanctioned by the NEC which is functioning now. The trout hatchery at Nuranang produces 15000 - 20000 eyed ova and the incubation period ranges between 70 - 80 days. The breeding season is October to January. The swim-up fry have been stocked in almost all the available fishery resources of Tawang District including the high altitude lakes, whereas the Sheragaon trout hatchery has the capacity to produce 40-50 thousands eyed ova with water temperature ranging from 4^{0}C to as high 18^{0}C. Raceways and circular pools are being utilized for raising table size trout fish.

Trout farming in Arunachal Pradesh has also drawn the attention of other neighbouring hill states like Nagaland and Meghalaya and imported trout seed repeatedly from this State. To popularise the sport fisheries two consecutive "International

Mahseer Fishery

The medium altitude zone represents majority of the hill areas of the State. This climatic zone offers much higher average annual temperature and biogenic capacity than the high altitude zone. The commonly available game fishes in these waters can be grouped as follows : (a) golden mahseer *(Tor putitora)* (b) deep bodied mahseer *(Tor tor)* and (c) chocolate mahseer *(Neolissocheilus hexagonolepis).* Bhalukpong in West Kameng District, Daporijo in Upper Subansiri District, Namsai in Lohit District and Roint in Dibang Valley District are some of the important centres for collection of mahseer seed. It may be mentioned that mahseer seed are being supplied to the fisheries division, ICAR complex, Umiam, Meghalaya and demands from other adjoining states have been met.

Paddy cum fish culture

The programme has gained popularity in the Apatani Palteau of Lower Subansiri District beyond 1500 m asl. Similarly, in the middle belts as well as in some high altitude areas like Upper Subansiri, Upper Siang, East Siang, West Siang, Tawang and West Kameng District. This activity is slowly taking pace by providing dual crops *viz.* paddy and table fish, the later within a period of nearly 3 months. The programme was traditionally practiced by the Apatanis in a very humble way and the department launched this activity on scientific lines from the year 1974 onwards and presently 1121 ha. of paddy fields is under integration of fish culture. The production is ranging between 150-200 kg/ha with no provisions of fertilizers and fish feed.

CONSTRAINTS CONFRONTING FISHERY ACTIVITIES

From the above write up it reveals that the fisheries in Arunachal Pradesh is at the growing stage and progressing at a very modest scale probably for which the following constraints are :

- High magnitude of predation by otters
- Multiple ownership of resources and conflicts in their use
- Lack of fishery legislation for conservation and exploitation
- Lack of experience of the people in fish farming and problems in management
- Lack of reserach and technological support for fish culture in hill region
- Lack of authority with the department for registration of fisheries co-operative society (Registration vested with Department of Co-operation)
- Frequent natural calamities- flood/excessive rains resulting in damage of ponds/ loss of crops etc.

CONCLUSION

Pisciculture is not only having social relevance, but also is an economic activity in the State. The ever growing population, besides unemployment scenario, there is a need to strengthen fishery activities with special thrust to the high altitude areas which are strategically very sensitive. Trout culture needs privatization. Fish culture technologies to suit the middle and higher altitude are urgently to be developed and adopted. The solution to such burning problem rests with the research institutions dealing with the subject and they should come forward to redress the issues for fisheries development in the state.

STATUS AND PROSPECTS OF FISHERIES DEVELOPMENT IN MANIPUR STATE OF NORTH EAST

Birmani Singh

INTRODUCTION

Manipur, an erstwhile princely state is one of the smallest of the seven states, which constitute the NE Indian mosaic. Situated in an extreme corner of India it is bordered by Mayamar. The entire state has an area of 22,357 km^2 of which the valley has only 1920 km^2 and rest belongs to the hills. The valley area is about 10% of the total but inhabited by 65% population. The total population of the state was 23,88,634 in 2001. There are about 26 tribes. Majority of the population are non-vegetarian and prefer fish. Because of different geographical entity, the aquatic resources in the state exhibit diverse characteristics and fish biodiversity. The biggest wetland of Asia, the Ramsar site, the Loktak Lake is located in the state and offer good fish and fisheries.

FISHERIES RESOURCES

The state is endowed with vast inland fishery resources covering about 56,459 ha in the diversed forms like natural lakes, swampy beels, ponds/tanks, rivers,small reservoirs, irrigation canals, submerged cropped lands, low lying paddy fields, which are suitable for the development of fisheries. The details of fisheries resources in the state are enlisted in table 1 :

Table 1. Fisheries Resources of Manipur (Area in ha)

1.	Ponds and Tanks	9,939
2.	Lakes	2500
3.	Reservoir / canals	782
4.	Marshy swampy lakes/beels	20132
5.	Submerged cropped lands	3480

FISH BIODIVERSITY

About 156 fish species belonging to 21 families have been reported from state waters. Indian major carps, Chinese carps, Mahseers, Catfishes and Minor carps are important from commercial point of view. Some of the important fish species from food, sport and ornamental value are *Bagarius bagarius, Glyptothorax cavia, G. manipurensis, C. batrachus, H. fossilis, M. armatus, Badis badis, Nandus nandus, Oreochromis mossambica, Glossogobius giuris, Anabas testudienus, Colisa fasciatus, C. softa, Channa marulius, C. punctatus, C. striatus, Ompok bimaculatus, Wallago attu, Aorichthys aor, M. cavasius, Nemacheilus assamiensis, N. peguensis, Rasbora rasbora, Barilius barila, B. bendelisis, Aspidoparia morar, Cyprinus carpio var. nudus, Cyprinus carpio var. specularis, Cyprinus carpio var. communis, P. sarana, C. cotio, L. calbasu, L. gonius, L. pangusia, L. rohita, L. fimbriatus, L. bata, Neolissocheilus hexagonolepis, N. stracheyi, Tor tor, T. putitora, Cirrhinus mrigala, C. reba, Catla catla, C. idella, H. molitrix, A. nobilis, Garra compressus, G. gotyla gotyla, Garra manipurensis* etc. and snow trouts in hills.

FISH PRODUCTION

The present level of annual fish production in the state is 17,600 MT against the total requirement of about 23000 MT. As a measure, to increase the fish production in the state and to abridge the gap between demand and supply of fish, the department has started stocking of fish seeds of commercially imporatant and high yielding varieties like Rohu, Catla, Mrigal, Silver carp and Grass carp in the open waters. Both the phenotypes of common carp *i.e. C. carpio communis* and *C. Carpio specularis* have established in the rivers, lakes and beels of Manipur and contribute a major share in the total fish catch from the state.

The state, at present, has also a number of trained private fish farmers under the guidance of the Fisheries Department, Manipur who are well expert in production of fish seeds by adopting hypophysation techniques. About 117 million fish seed is being produced annually. The state has become self sufficient in production of private fish farmers for culture in their ponds in addition to the stocking in lake Loktak.

FRESH WATER PRAWN CULTURE

Further, culture of giant fresh water prawn has been taken up in the four valley districts of Manipur *viz.* Imphal west, Impha east, Thoubal and Bishupur in collaboration with CIFE under TOT programme. A consignment of 32000 prawn seeds was made available to the department for distribution among the selected fish farmers. Prawn feed is also being supplied by CIFE to the farmers for the total grow-out period. A second consignment of prawn seeds has also been taken from Tripura for taking up further experimental culture of the prawn in the farms of some other selected farmers. Growth rate have been found to be quite encouraging though the survival rate is a bit low. Polyculture of Indian Major carps with fresh water cat fish (*Pangasius santhii*) is also under trial at the Research Center, Imphal. Culture and induced breeding of magur (*C. batrachus*) is also in practice on trial basis in indoor hatchery in collaboration with CIFA, Bhubaneshwar.

COLDWATER FISHERIES

Efforts are also being made by the Department to establish fish seed farm in some of the hill districts of the state. The cold-water fish farm that was established at Siroi Village of Ukhrul district with the sole purpose of rearing trout has not been successful due to problems arising out of the supply of running water to the farms. Necessary steps are being taken up to improve the water supply to the farm after which it will be used for culture of cold water fish species like rainbow and brown trout. Mahseers like *T. tor, T. putitora* and *N. hexagonalepsis* have great potentials as sport and food fishes but their improvised breeding and culture technologies are needed.

Eight Fish Farmer Development Agencies in 8 districts out of total 9 are actively