Fish Diversity of Himalayan Region, India for sustainable development

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The coldwater fishery resource of India spread throughout 2500 km from Jammu & Kashmir in the west to Arunachal Pradesh in the east and 200-400 km from north to south comprise a mountainous area of 5,33,604 km^2 (FAO 2003). The geographical area of this region is about 16.2% and about 4% of total population of the country. The coldwater resources are distributed mainly in the form upland streams, rivers, high and low altitude lakes and reservoirs located in different hill states (Table 1). As the cold water resources are situated in difficult areas, it has not yet been exploited to its potential. Thus DCFR undertook exploration for the resource assessment of this sector both physical and faunal through different running projects.

Fish biodiversity

The water bodies of the Himalayan region inhabit diverse kind of fish fauna. Out of total fish fauna available in India 17% fishes were documented from the mountain ecosystem establishing the status of the area as a centre of origin and evolution of biotic forms (Ghosh, 1997). The vast mountain fishery resources of India inhabits around 258 fish species distributed in the Himalayan and peninsular region of the country of which indigenous mahseer, snow trout, exotic trout and common carp are commercially important (Singh *et al*, 2014). About 36 species of freshwater fishes (out of 1,300) are endemic to the Himalayan region (Ghosh, 1997). For the whole Himalayas, 218 species are listed (Menon, 1962).The distribution of fish species in the Himalayan streams depends on the flow rate, nature of substratum, water temperature and the availability of food. The species distribution in the upper reaches of the stream/river where water has a torrential flow is different from the mid and lower reaches of the stream where flow is moderate and water current is soft.

Hill states endowed with natural lakes and reservoirs could be utilized for the fish production under culture based capture fisheries programme. Introduction of composite fish farming using Chinese carps for mid-altitudes is a major success in increasing the fish production from the hilly regions. However, many endemic fish species of the Himalayan region can also be utilized for aquaculture and farming. Integrated fish farming for the hills could also be an important inexpensive aquaculture practice for the rural population residing in the mountain areas of the country as it is very popular in Arunachal Pradesh. The Directorate of Coldwater Fisheries Research has made significant contributions towards documentation of

Table 1: Fishery resources of Himalayan region, India

S.N	State Name	Lakes (ha)	Reservoirs (ha)	Rivers (km)	No of Fish Species recorded
1	Jammu & Kashmir	137275. 3	4087.3	10893.5	26
2	Himachal Pradesh	27.2	31320.2	10464.3	82
3	Uttarakhand	212	16864	10657.8	67
4	Sikkim	1004.5	--	3298.1	23
5	Arunachal Pradesh	2792.7	--	12351	167

Figure 1: Production of improved strain of *Hungarian mirror* carp in Hills

Figure 2: Rainbow trout *Oncorhynchus mykiss* farming in hills

Figure 3: Golden mahseer *Tor putitora* for culture propagation

Figure 4: Chocolate mahseer *Neolissocheilus hexagonolepis* of northeast Himalaya

Figure 5: Snow trout *Schizothorax richardsonii* for breeding in the DCFR farm

Figure 6: Minor carp *Labeo dyocheilus*, a candidate species for lower hills

fish fauna, breeding & culture practices of important fish species including technology dissemination.

The comprehensive initiatives of the ICAR-Directorate of Coldwater Fisheries Research aim to safeguard and improve the livelihood of the less privileged inhabitants of the access restricted geographic terrains, through technological interventions and knowledge transfer. Species diversification in upland aquaculture is necessary for enhancing fish production. We require more species for sustainable aquaculture. In order to meet the challenge, the DCFR has identified certain new candidate species and breeding protocol have been developed for *chagunius chaguni, Semiplotus*

nd ornamental fish; *barilius bendelisis*.

A. Aquaculture technologies

1. Carp farming

Owing to simpler farming techniques, low input requirements and possibilities of integration of available resources, culture of Chinese carps in small sized ponds (0.01 & 0.03 ha) is becoming popular in the region. Since existed common carp strains being old introductions did not perform well due to inbreeding and other reasons, Recently, DCFR introduced improved strains of Hungarian mirror (Figure 1) and scale carp which are performing well and its brood banks and seed banks are being established in different states. The composition of cultured species varies from monoculture of common carp to polyculture of grass, silver and common carp. The carp culture is more profitable by integration of fish culture if integrated with dairy, horticulture, agriculture and paddy. Grass carp emerged as a popular species for the low-cost hill aquaculture. In absence of aquatic weeds in the constructed ponds, the grass carp vigorously feeds on terrestrial soft plants and grass provided to the stock. DCFR, Bhimtal is trying to improvise the Chinese carp based composite fish culture along with endemic fish species e.g., Bangana devdevi, Labeo pangusia, L. dyocheilus in mid Himalayan regions (800-2000 msl).

2. Trout farming

Being a low volume high value commodity, rainbow trout has good potential for domestic consumptions as well as foreign export. However, there is ample scope for further enhancement of trout production in hill states through participatory approach. Trout farming has immense scope in the Himalayan and some peninsular regions, where sufficient quantity of quality water is available. Successful collaboration with European Economic Community (EEC) and Norwegian Government in last two decades has accelerated rainbow trout (Oncorhynchus mykiss) farming in the states of Jammu and Kashmir and Himachal Pradesh, respectively (Figure 2). Now, the trout farming is also developing in other hill states such as Uttarakhand, Sikkim and Arunachal Pradesh with concerted efforts of DCFR.

B. Breeding Technologies of Himalayan species

1. Flow-through hatchery for Mahseer

Golden mahseer *Tor putitora* is the most prized sport fish distributed in all the Himalayan waters. A flow through mahseer hatchery has been designed for seed production of this fish species (Figure 3). The system is simple and farmers friendly for breeding, egg incubation and larval rearing. Artificial mass seed production of this species would be helpful for the rehabilitation of this species through ranching in the uplands water bodies and also for enhancement of aquaculture production. Similarly seed production methodology for chocolote mahseer *Neolissocheilus hexagonolepis* has also been developed (Figure 4) and seed is regularly produced over the last five years. Technology is being disseminated to the different State Government and private agencies. Seed production and its ranching of both golden and chocolate mahseer in natural waters is the regular practice of the Institute.

2. Flow-through hatchery for rainbow trout

Seed availability is the main bottleneck in the rainbow trout culture in high altitudes areas. In order to achieve the goal of enhancing trout production, it is quite necessary to focus on seed production technology of this fish. DCFR has developed the flow through hatchery model for trout breeding. Flow through hatchery is comprised of an indoor structure having troughs, trays, nursery tanks and rearing tanks with continuous water flow. Technology has been transferred to the different State fisheries departments and private trout growers. DCFR is also technically associated with different state trout farms for the production of trout seed to meet out the state demand.

3. Seed production technique of Exotic carp in mid hills

Induced breeding of grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*) was standardized at DCFR. The maturation inducing hormones (MIH) like HCG and PG extract + Ovaprime at 18.0-26.0 °C were found

effective to reduce the maturation period. Technology developed for the breeding and larval rearing in climate of mid Himalayan region has a positive impact on the employment generation in these regions since the technology was taken as hot cake among the farmers in some areas of the hills. There is great scope for disseminating this promising technology in sub to mid Himalayan belt in order to upgrade the socio-economic conditions of the inhabitants.

4. Artificial spawning of Snow trout, Schizothorax richardsonii (Gray)

Snow trout is an important indigenous cold water fish species, endemic to the Himalayas and found in streams and lakes which receive snow melt water from the hills. Technology for artificial fecundation of pond raised brooders and rearing of young ones in controlled condition has been developed at DCFR (Figure 5). Previously seed was procured from the natural resources. This technique enables the production of pure and healthy seed in captive condition. This seed can be used for augmentation of natural stock and aquaculture of this species.

5. Induced Breeding of Indigenous minor carp

Indian minor carp, *Labeo dyocheilus*, widely distributed in streams and rivers of hill states and important species for culture practices in mid hills (Figure 6). Induced maturation and artificial breeding of this minor carp has been developed by DCFR, Bhimtal. Further, captive maturation and breeding technology for *Labeo pangusia* has also been developed.

Perspective Research programmes

There are several other important research programmes also undertaken at DCFR. Some of them are as follows:

- Genetic improvement programme have been taken up using genomics and transcriptome profiling. The institute is working on molecular genetic characterization of snow trout and mahseer from different geographical locations to identify the population with high genetic diversity which would be significant use in genetic improvement programme for improving strain to enhance growth and genetic management of the species.
- In changing climate scenario, there are opportunities to develop thermal tolerance strains that may thrive in wide range of water temperature. In order to comply the challenge the Directorate has initiated the work on exploring mechanism of thermal tolerance in major coldwater fishes. More emphasis is being given on intensifying the research in this direction using phenological responses and molecular modern tools.
- The Directorate has initiated breeding and rearing of local ornamental fishes at mid hills region that would be continued for livelihood security through small scale entrepreneurship.
- Eco-friendly carp based polyculture in low cost polylined tanks in mid hills would be out scaled for livelihood security and production enhancement. Directorate has initiated work on developing water conserving model for fish culture. In this context, plastics film lined ponds have been found very suitable for fish culture and overflow could be used for vegetable farming. The polylined act as a insulator which increases temperature of water resulted in enhanced fish production. The integrated model is very popular in mid hills and there is a need of upscaling the technology.
- GIS based resource mapping of the fishery resources in hill region has been taken up on priority for supporting planning.
- Development of location specific water conservation model for fish culture has been done. Further, research needs for developing location specific models for water conservation-cum- integrated fish culture and closed re-circulatory systems are being addressed.
- Maintenance of repository of important endemic fish has been initiated.
- Human resource development, technology transfer, knowledge sharing through networking
- Identification and introduction of new

candidate species and to develop their culture and breeding technology.

Conclusion

There is a vast scope and potential for enhancing fish production in hills by bringing natural Himalayan lakes located at different altitudes, newly created and existing upland reservoirs, under scientific management for fishery enhancement by bridging the gap between actual fish yield and production potentials utilising more endemic and local species. Research and development in coldwater fisheries and aquaculture has great potential for lateral as well as vertical expansion. In the hill regions, fish represents an essential, often irreplaceable source of high quality and inexpensive animal protein, crucial for the balanced diet of the marginally food secure communities. Keeping in view the global, national and ecological changes, the ICAR-DCFR is committed towards enhancing fish production in hills through intervention measures such as research, technological support, awareness programmes and frontline demonstration activities. In this milieu, the Directorate is continuously striving to document aquatic biodiversity in hill states and generate research information that helps in developing ecologically sustainable strategies for fish yield enhancement. It is also responsible for activities such as ranching in the deprived ecosystems and to develop model for sport and eco-tourism.

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