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Coldwater Endemic Fishes of Northeastern Himalaya

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Message

The diverse endemic fish resources of Northeastern Himalaya have immense potential in generating income and providing food and nutritional security to the economically underprivileged population of the region. Unfortunately, these fishery resources are presently facing severe anthropogenic stress such as large-scale developmental activities coupled with increasing population as well as impact of climate change resulting in degradation of aquatic biodiversity. This has masqueraded a new challenge for conservation and management of aquatic resources which needs policy interventions to safeguard dwindling endemic fish species of the region.

I am happy to know that the ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, is organizing a two-day national workshop on '*Coldwater Endemic Fishes of Northeastern Himalaya: Avenues and Challenges*' during 5-6 November, 2015 at Gangtok, Sikkim.

I hope that the deliberations of the workshop will identify the challenges facing the management of resources and come up with recommendations and action plans for the conservation and sustainable utilization of endemic fish resources of NEH region.

I extend my best wishes for the success of workshop.

(M. V. Gupta)
World Food Laureate

Foreword

The Northeast region is bestowed with two important hotspots in the world in terms of biodiversity-the eastern Himalayas and the Indo-Burma region. These hotspots encompassing the hilly regimes of the Northeastern states viz., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura comprises of indigenous, exotic and endemic species in terms of ichthyofaunal diversity. Among the 422 fish species documented from the Northeastern region, several species are referred as 'endemic' to the region as these fishes are found to inhabit in a particular defined geographical location and not found elsewhere. The coming decades are expected to pose great concern for the endemic fishes which have significant values as food, ornamental and sports fisheries for sustainable management.

ICAR-Directorate of Coldwater Fisheries Research, Bhimtal has conducted and is associated with several developmental and promotional activities in the field of coldwater aquaculture practices, seed production of commercially important fish species, eco-tourism etc in the Northeastern region of India since inception. An attempt has been made further to elucidate the importance of endemic fishes of the region in terms of resource utilization, propagation, sustainable productivity and conservation. It is believed that the present document will prove to be an indispensable reference to the academicians, scientists, students and other stakeholders to understand and undertake the coldwater fisheries development programmes in the region.

(A.K. Singh)
Director, ICAR-DCFR

INTRODUCTION

Endemism is the ecological state of a species being unique to a defined geographic location, such as an island, nation, country or other defined zone, or habitat type; organisms that are indigenous to a place are not endemic to it if they are also found elsewhere. The fishes inhibiting in such a particular geographical location or in a defined place are referred as "Endemic fishes". These species proliferate or found in a certain zone, region or place and are common in that defined area.

Northeast region of India is very rich in the world in terms of biodiversity similarly also to fish biodiversity. This natural variation in life is also reflected in the demography of the land. Although the causes behind biodiversity and demographic diversity are different, the human population of the land has depended on the biodiversity in many ways for a long time. At the same time, today, the excessive human population of land is leading to a survival pressure on the biodiversity. Thus, it is important to know and appreciate the diversity in both human population, and flora and fauna particularly of ichthyofauna. Northeastern region is the convergence of two important biodiversity hotspots in the world, the Eastern Himalayas and the Indo-Burma region.

The Eastern Himalayas is the region encompassing Bhutan, Northeastern India, and southern, central, and eastern Nepal. The region is geologically young and shows high altitudinal variation. Together, the Himalayan mountain system is the world's highest, and home to the world's highest peaks. Some of the world's major river systems arise in the Himalayas and their combined drainage basin is home to some 3 billion people (almost half of Earth's population) in 18 countries.

The Indo-Burma region encompasses several countries. It is spread out from Eastern Bangladesh to Malaysia and includes Northeastern India south of Brahmaputra river, Myanmar, the southern part of China's Yunnan province, Lao People's Democratic Republic, Cambodia, Vietnam and Thailand. The Indo-Burma region is spread over 2 million sq. km of tropical Asia. Since this hotspot is spread over such a large area and across several major landforms, there is a wide diversity of climate and habitat patterns in this region. Much of this region is still a wilderness, but has been deteriorating rapidly in the past few decades. In recent times, many fish species have been discovered here.

The water ecosystems of the globe are broadly classified as warm and cold water based on their temperature regimes. The coldwater systems of India are generally restricted to Himalayan and sub-Himalayan regions in the states like J&K, Himachal Pradesh, Tamilnadu, Kerala, Uttarakhand and Northeastern states.

The coldwater fisheries has got vast and varied aquatic resources in terms of streams, rivers, reservoirs and lakes in the Northeastern Himalayan region. The Brahmaputra and Barak along with their tributaries form more than half of rivers in Northeast. The rivers Ranganadi, Subansiri, Siang, Dihang, Dibang, Lohit, Noadihing and Tirap cover an area of about 2000 km in Arunachal Pradesh. The Brahmaputra river system flows from east to west covering an area about 730 km receiving water from 47 tributaries originating from Himalaya such as Dibang,

Subansiri, Jia- Bhoroli, Pagladiya, Manas, Saalbhang, Sonkosh, Lohit, Disang, Dhansiri, Koplili, Kulsi, Jinjiram etc. In Manipur, two major rivers and their tributaries like Irang, Leimatak, Nakaror, Makru, Tuivai, Iril, Thoubal, Chakpi, Khuga, Namol, Nambol and others cover an area of about 2000 km. In Meghalaya, Umiam, Digaru, Khri, Dudhnoi, Krishnai, Jinjiram, Bala, Chanching and Samsung covering an area about 5600 km and harbours mainly chocolate mahseer. There are about 21 rivers in the hilly states of Mizoram covering an area about 1700 km. The tributaries of Brahmaputra river like Jhanzi, Dikhow, Diphu, Diyung and Dhansiri together flows in an area of 1600 km in Nagaland state. Longi, Juri, Deo, Manu, Dhalai, Khowai, Howrah, Gumti, Mahuri and Feni as well as their rivulets have a total length of 1200 km in Tripura state, where higher CPUE has been reported. The river Teesta and Rangeet contributes a significant fishery in terms of indigenous fish species in the state of Sikkim.

In addition to the rivers, the beels, lakes, swamps and reservoirs constitute an important fisheries resource in the Northeastern states. The floodplain wetlands (beels) known for their fisheries potential in Assam, Manipur, Arunachal Pradesh, Meghalaya and Tripura, are spread in an area of 1.0 lakh ha, 0.21 lakh ha, 0.025 ha, 0.084 ha and 0.045 ha respectively. The reservoirs area estimated about 0.92 lakh ha and 0.4 lakh ha in the form of ponds and mini barrages offers greater scope for coldwater aquaculture activities.

The ichthyofaunal diversity of upland water resources in India comprises of 258 species, belonging to 21 families and 76 genera. Out of these, the maximum of 255 coldwater fish species are recorded from Northeast Himalaya, 203 from the West and Central Himalaya and 91 from the Deccan plateau (Vass, 2005). The Northeastern states of India include eight states viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. The fishery resources in hilly regions of NE states includes populations of indigenous and exotic, cultivable and non-cultivable species in terms of species diversity. Among these, some of the endemic fishes have food, ornamental as well as significant values in sports fisheries. The NE regions of India share two of the 34 biodiversity hotspots listed by Conservation International such as the Himalayas and Indo-Burma as mentioned earlier (Roach, 2005). Biodiversity of the region mainly depends on hills, plateaus and valleys which are resulting in the occurrence of a variety of torrential hill streams, rivers, lakes and swamps. Total 422 fish species, belonging to 133 genera and 38 families from Northeast India has been documented including both warm water and coldwater fish species. Among the reported species, maximum 154 species has been reported from the family Cyprinidae where as the families like Anguillidae, Engraulidae, Chacidae, Aplocheilidae, Syngnathidae, Sciaenidae, Osphronemidae, Ophichthidae, Pristigastiridae and Tetraodontidae are represented by a single species each. Among these documented species, about 48 are listed as endangered, 69 as near threatened, 103 as vulnerable, 153 as least concerned and 23 as data deficient while the status of 26 species are not evaluated (Goswami *et al.*, 2012).

In the recent past with increasing anthropogenic pressure, the demand for fish has increased drastically. The coming decades are expected to pose newer and greater challenges to coldwater fishery sector both in the development of aquaculture and conservation practices in the hill regions of the country where there will be a great concern for the endemic fishes for sustainable management. An attempt has been made to prepare a check list of Endemic Fishes of Northeastern Himalayan region in this bulletin which needs further assessment depicting its

distribution and the economic significance in terms of food, ornamental and sports value. The list is illustrated as follows-

Table 1: Checklist of endemic fish species of Northeast India

Family	Species	Distribution	Economic significance
Clupeidae			
1	*Gudusia variegate* (Day, 1870)	Reported in river Irrawaddy and others in Manipur.	Food
2	*Psilorhynchoides arunachalensis* (Nebeshwar, Bagra & Das, 2007)	Reported in the Brahmaputra basin in Arunachal Pradesh.	Food
3	*Psilorhynchus microphthalmus* (Vishwanath & Manoj kumar, 1995)	Recorded in Chakpi stream in Manipur.	Food
Balitoridae			
4	*Aborichthys garoensis* (Hora, 1925)	Recorded in Garo Hills in Meghalaya.	Food
5	*Acanthocobitis zonalternans* (Blyth, 1860)	Recorded in Brahmaputra, Chindwin, Sitang and Salween basins.	Ornamental
6	*Balitora burmanica* (Hora, 1932)	Recorded in Irrawaddy, Salween and Tenasserim basins.	Ornamental/ Food
7	*Homaloptera modesta* (Vinciguerra, 1890)	Recorded in rivers of Manipur.	Ornamental
8	*Homaloptera rupicola* (Prashad & Mukerji, 1929)	Recorded in rivers of Manipur.	Ornamental
9	*Mesonoemacheilus reticulofasciatus* Kottelat et al. (2007)	Recorded in Barapani, Shillong, Meghalaya.	Ornamental
10	*Neonoemacheilus assamensis* (Menon, 1987)	Recorded in Brahmaputra river system.	Food/ Ornamental
11	*Neonoemacheilus labeosus* (Kottelat, 1982)	Recorded in rivers of Manipur.	Food/ Ornamental
12	*Neonoemacheilus morehensis* (Arunkumar, 2000)	Recorded in rivers of Manipur.	Food/ Ornamental
13	*Nemacheilus barapaniensis* (Menon, 1987)	Recorded in rivers of Meghalaya.*	Food/ Ornamental
14	*Nemacheilus pavonaceus* (McClelland, 1839)	Recorded from Brahmaputra basin in Assam.	Food/ Ornamental
15	*Nemacheilus tikaderi* (Barman, 1985)	Recorded from Namdapha Wildlife Sanctuary in Arunachal Pradesh.	Food/ Ornamental
16	*Physoschistura elongate* (Sen & Nalbant, 1982)	Recorded in rivers of Manipur.	Ornamental
17	*Schistura chindwinica* (Tilak & Husain, 1990)	Recorded in rivers of Manipur.	Ornamental

Family	Species	Distribution	Economic significance
18	*Schistura cincticauda* (Blyth, 1860)	Reported from tributaries of Manipur.	Ornamental
19	*Schistura devdevi* (Hora, 1935)	The fish is reported from eastern Himalaya; small streams below Sikkim.	Ornamental
20	*Schistura kangjupkhulensis* (Hora, 1921)	Reported from tributaries of state Manipur.	Ornamental
21	*Schistura khugae* (Vishwanath and Shanta 2004a)	Recorded from Khuga River in Manipur.	Ornamental
22	*Schistura manipurensis Chaudhuri* (1912)	Recorded from Manipur Valley and Nagaland.	Ornamental
23	*Schistura minutus* (Vishwanath and Shantakumar, 2006)	Recorded from Iyei River in Manipur.	Ornamental
24	*Schistura nagaensis* (Menon, 1987)	Recorded in Brahmaputra basin in Nagaland.	Ornamental
25	*Schistura papulifera* (Kottelet, 2007)	Found with certainty only from the Krem Synrang Pamiang system in Meghalaya.	Ornamental
26	*Schistura prashadi* (Hora, 1921)	Found in both Brahmaputra and Chindwin drainages.	Ornamental
27	*Schistura reticulate* (Vishwanath & Sharma, 2004)	Recorded in rivers of Manipur.	Ornamental
28	*Schistura sikmaiensis* (Hora, 1921)	This species is reported from the Chindwin-Irrawady basin of Manipur and other NE states comprising Assam, Meghalaya, Tripura and Nagaland.	Ornamental
29	*Schistura singhi* (Menon, 1987)	Recorded in Nagaland and Kiphire	Ornamental
30	*Schistura sijuensis* (Menon, 1987)	Reported from Siju Cave and Garo Hills in Meghalaya.	Ornamental
31	*Schistura tigrinum* (Vishwanath and Nebeshwar Sharma, 2005)	Recorded in Barak and Brahmaputra drainages.	Ornamental
32	*Schistura reticulofasciata* (Singh & Banarescu, 1982).	Recorded in Brahmaputra basin in Jaintia Hills, Meghalaya.	Ornamental
33	*Schistura vinciguerrae* (Hora, 1935)	Recorded in rivers of Manipur.	Ornamental
Amblycipitidae			
34	*Amblyceps apangi* (Nath and Dey, 1989)	This fish is reported from the Dikrong River in Arunachal Pradesh and Brahmaputra drainage.	Food
35	*Amblyceps arunachalensis* (Nath & Dey, 1989)	This fish is known only from the Dikrong and Subansiri rivers in Arunachal Pradesh	Food
36	*Amblyceps torrentis* (Linthoingambi & Vishwanath, 2008)	This fish is known from the Yu (Laniye) River headwaters in the Chindwin River drainage in Manipur.	Food

Family	Species	Distribution	Economic significance
37	*Amblyceps tuberculatum* (Linthoingambi & Vishwanath, 2008)	This fish is known from the Chindwin River drainage in Manipur (H.H. Ng *pers. comm.*).	Food
Akysidae			
38	*Akysis manipurensis* (Arunkumar, 2000)	This species is known only from the Chindwin River drainage (part of the Irrawaddy River drainage) in India (Manipur) and Myanmar.	Food
39	*Akysis prashadi* (Hora, 1936)	Known from the Lokchao area (Chindwin River system) in Manipur (Vishwanath *et al.* 2007).	Ornamental
Sisoridae			
40	*Exostoma barakensis* (Vishwanath and Joyshree, 2007)	This fish is known only from one locality in the Iyei River, a tributary of the Barak River in Manipur There have been no further studies to indicate a wider distribution.	Food
41	*Exostoma labiatum* (McClelland, 1842)	This species was described from the Mishmi Hills in Meghalaya. It is known from the Brahmaputra River drainage in Northeastern India (Arunachal Pradesh and Meghalaya: Vishwanath *et al.* 2007).	Food
42	*Exostoma vinciguerrae* (Regan, 1905)	A new Sisorid catfish reported from Manipur.	Food
43	*Glyptosternon maculatum* (Jayaram, 2007).	This fish is reported from the upper Brahmaputra River drainage and Arunachal Pradesh.	Food
44	*Glyptothorax sinensis* (Regan, 1908)	Recorded in Manipur.	Food
45	*Glyptothorax chindwinica* (Vishwanath & Linthoingambi, 2007)	This fish is known from the Chindwin River drainage in Manipur (in the Iril, Thoubal, Ithai and Lokchao Rivers and other locations in the Manipur Chindwin basin).	Food
46	*Glyptothorax granules* (Vishwanath & Linthoingambi, 2007)	Recorded from the Chindwin River drainage in Manipur (in the Iril, Thoubal, Ithai and Lokchao Rivers).	Food
47	*Glyptothorax manipurensis* (Menon, 1955)	This species is known from the Barak River drainage in Manipur.	Food
48	*Glyptothorax ngapang* (Vishwanath & Linthoingambi, 2007)	This fish is reported from the Iril River, a tributary of the Chindwin River in Manipur.	Food
49	*Glyptothorax striatus*	This species is known from the Meghna and Brahmaputra river drainages.	Food
50	*Glyptothorax ventrolineatus* (Vishwanath and Linthoingambi, 2005).	Reported from the Iril River, which forms part of the Chindwin River drainage in Manipur. It is a widespread species with recent collections from Lokchao River at Moreh (W. Vishwanath *pers. comm.*).	Food

Family	Species	Distribution	Economic significance
51	*Glyptothorax chimtuipuiensis* (Anganthoibi & Vishwanath, 2010)	The species is known only from the type locality on the Kaladan (Chimtuipui) River, Mizoram, India.	Food
52	*Myersglanis jayarami* (Vishwanath and Kosygin, 1999).	This fish is reported from the Laniye River at Jessami, Chindwin River drainage in Manipur.	Food
53	*Pareuchiloglanis kamengensis* (Jayaram, 1966)	This fish is only known from the upper Brahmaputra River drainage.	Food
54	*Pseudecheneis ukhrulensis* (Vishwanath & Darshan, 2007)	Reported from the Ukhrul District of Manipur, in the Chindwin River drainage (part of the Irrawaddy River drainage).	Food
55	*Pseudecheneis sirenica* (Vishwanath and Darshan, 2007)	This species is known from the Brahmaputra River drainage and Siren River of Upper Siang District of Arunachal Pradesh in Northeastern India.	Food
56	*Pseudecheneis koladynae* (Anganthoibi & Vishwanath, 2010)	Reported from Koladyne River in Mizoram.	Food
57	*Sisor barakensis* (Vishwanath & Darshan, 2005)	Reported from Barak river.	Food
58	*Sisor chennuah* (Ng & Lahkar, 2003)	Reported from the Brahmaputra River drainage in Assam.	Ornamental
Nandidae			
59	*Badis assamensis* (Ahl, 1937)	Reported from the upper reaches of the Brahmaputra River in India. Type locality is the Dibru river.	Ornamental/ Food
	Badis chittagongis (Kullander & Britz, 2002)	Hill streams in the states of Tripura and Mizoram.	Ornamental/ Food
60	*Badis ferrarisi* (Kullander & Britz, 2002)	This fish is reported in several Chindwin and Irrawaddy drainages in Manipur.	Food
61	*Badis kanabosi* (Kullander & Britz, 2002)	Reported from the middle reaches of the Brahmaputra river. There are also records from the Bhoroli, Janali, and Sukajan rivers and from Kokrajhar in Assam.	Food
62	*Badis tuivaiei* (Vishwanath & Shanta, 2004)	This fish is reported from Manipur from Tuivai and Irang rivers.	Food
Channidae			
63	*Channa aurantimaculata* (Musikasinthorn, 2000)	Endemic to the Brahmaputra River basin in the states of Assam and Arunachal Pradesh (Tezu in Lohit district).	Food/ Ornamental
64	*Channa bleheri* (Vierke, 1991)	Endemic to the Brahmaputra River basin, this fish has a type location at Dibrugarh, a city in the Northeastern part of Assam.	Ornamental
65	*Channa stewartii* (Playfair, 1867)	Recorded from Assam (Cachar), Nagaland, Meghalaya, Manipur, Tripura and Arunachal Pradesh in Northeastern India.	Food/ Ornamental

Family	Species	Distribution	Economic significance
Cyprinidae			
66	*Bangana devdevi* (Hora, 1936)	Recorded in Northeastern region.	Food
67	*Barilius chatricensis* (Selim & Vishwanath, 2002)	Recorded in the rivers of Manipur.	Food/ Ornamental
68	*Barilius dogarsinghi* (Hora, 1921)	Recorded in the rivers of Manipur.	Food/ Ornamental
69	*Barilius lairokensis* (Arunkumar & Singh, 2000)	Recorded in the rivers of Manipur.	Food
70	*Brachydanio albolineatus* (Blyth, 1860)	Reported from Irrawaddy, Salween, Mekong, Mae Khlong drainages.	Ornamental
71	*Brachydanio choprai* (Hora, 1928)	Recorded in Irrawaddy river system.	Ornamental
72	*Brachydanio nigrofasciatus* (Day, 1870)	Reported in Manipur.	Ornamental
73	*Brachydanio shanensis* (Hora, 1928)	Reported in Manipur.	Food
74	*Brachydanio sondhii* (Hora & Mukherji, 1934)	Reported in Manipur.	Ornamental
75	*Chagunius nicholsi* (Myers, 1924)	Reported in Manipur and Nagaland.	Food
76	*Chela khujairokensis* (Arunkumar, 2000)	Reported in Manipur.	Food
77	*Crossocheilus burmanicus* (Hora, 1936)	Reported in Manipur.	Food
78	*Cyprinion semiplotum* (Talwar and Jhingran, 1991)	Reported in Arunachal Pradesh and Assam.	Food/ Sports
79	*Danio jaintianensis* (Sen, 2007)	Known from the Rangriang Jowai, Jaintia Hills Districts of state Meghalaya.	Ornamental
80	*Devario acuticephala* (Hora, 1921)	Known from Ukjhang sang (most likely 'ukhongsang') road, one mile from Yairibok, in the state of Manipur. It is also reported from Dikhu River in Nagaland (Ao *et al.* 2008). It is endemic to this region restricted to less than 15,000 km2 in its distribution.	Ornamental
81	*Devario naganensis* (Chaudhuri, 1912)	This species is reported only in Chindwin basin in Manipur and Nagaland.	Ornamental
82	*Devario yuensis* (Arunkumar & Singh, 1998)	The species is reported to found in Lokchao River, Manipur in India.	Ornamental
83	*Garra abhoyai* (Hora, 1921)	Reported from Chindwin basin in Manipur.	Ornamental/ Food
84	*Garra rupecula* (McClelland, 1839)	This fish is known only from Arunachal Pradesh (Mishmi Hills) and Meghalaya (Khasi Hills).	Ornamental/ Food

Family	Species	Distribution	Economic significance
85	*Garra compressus* (Kosygin & Vishwanath, 1998)	Reported from rivers of Manipur.	Ornamental/ Food
86	*Garra kalpangii* (Ng and Rainboth, 2001)	Known only from the Kalpangi River, a tributary within the Brahmaputra basin in the Himalayan foothills of Arunachal Pradesh.	Ornamental/ Food
87	*Garra lissorhynchus* (McClelland, 1842)	Recorded from rivers of Assam, Meghalaya and Nagaland.	Ornamental/ Food
88	*Garra litanensis* (Vishwanath, 1993)	*Garra litanensis* is known only from Litan Stream (Chindwin River basin) in Manipur.	Ornamental/ Food
89	*Garra manipurensis* (Vishwanath & Sarojnalini, 1988)	Reported from rivers of Manipur.	Ornamental/ Food
90	*Garra naganensis* (Hora, 1921)	Recorded from Nagaland and Arunachal Pradesh.	Ornamental/ Food
91	*Garra nambulica* (Vishwanath & Joyshree, 2005)	Reported from rivers of Manipur.	Ornamental/ Food
92	*Garra nasuta* (McClelland, 1838)	Endemic to Northeastern region of India comprising the states Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland.	Ornamental/ Food
93	*Garra paralissorhynchus* (Vishwanath & Devi, 2005)	Reported from rivers of Manipur.	Ornamental/ Food
94	*Labeo nandina* (Talwar and Jhingran, 1991)	Recorded in upper reaches of Brahmaputra river.	Food
95	*Labeo pangusia* (Hamilton, 1822)	Recorded from Assam, Arunachal Pradesh and Meghalaya.	Food
96	*Neolissochilus blythii* (Day, 1870)	Recorded from Manipur.	Sports/ Food
97	*Neolissochilus hexagonolepis* (McClelland, 1839)	Recorded from Northeastern Himalayas.	Sports/ Food
98	*Neolissochilus hexastichus* (McClelland, 1839)	Reported from Northeastern Himalayas.	Sports/ Food
99	*Neolissochilus paucisquamata* (Smith, 1945)	Recorded from Manipur.	Sports/ Food
100	*Neolissochilus stracheyi* (Day, 1871)	Recorded from Northeastern Himalayas.	Sports/ Food
101	*Osteobrama belangeri* (Valenciennes, 1844)	Recorded from Manipur.	Food
102	*Puntius ater* (Linthoingambi & Vishwanath, 2007)	Recorded from Manipur.	Food
103	*Puntius bizonatus* (Vishwanath & Laisram, 2004)	Recorded from Manipur.	Food

Family	Species	Distribution	Economic significance
104	*Puntius chelynoides* (McClelland, 1839)	Recorded from Assam.	Food
105	*Puntius yuensis* (Arunkumar & Singh, 2003)	This fish is known only from the Yu River system of Manipur at the lower zones of Maklang River and Lokchao River near Moreh, Manipur.	Ornamental
106	*Puntius jayarami* (Arunkumar & Singh, 1986)	Reported from Northeastern Himalayas.	Food
107	*Puntius khugae* (Linthoingambi & Vishwanath, 2007)	This species is reported only from the Khuga River (Chindwin basin) in Churachandpur district of Manipur.	Food
108	*Puntius manipurensis* (Menon, Devi & Vishwanath, 2000)	This fish is reported only from the Loktak Lake of Manipur, in northeastern India.	Food
109	*Puntius meingangbii* (Arunkumar & Singh, 2003)	This species is reported from Chindwin-Irrawaddy drainage of Manipur.	Food
110	*Puntius ornatus* (Vishwanath & Laisram, 2004)	The species is known from Lokchou River, Moreh, Manipur.	Ornamental
111	*Puntius shalynius* (Yazdani & Talukdar 1975)	This fish is known from Khasi and Jaintia hills in Meghalaya	Food/ Ornamental
112	*Puntius stoliczkanus* (Day, 1871)	This fish occurs in Chindwin basin in Manipur (Linthoingambi and Vishwanath 2007).	Ornamental
113	*Poropuntius burtoni* (Mukerji, 1933)	The species is found in almost all of the hill streams in Manipur, India, draining to the Chindwin River.	Food
114	*Raiamas guttatus* (Day, 1870)	The species is known from Northeastern India in Nagaland.	Food/Sports
115	*Rasbora ornatus* (Vishwanath & Laisram, 2005)	This fish is known from Chatrickong River and Lokchao River, both tributaries of the Yu River, Manipur.	Ornamental
116	*Salmophasia sladoni* (Day, 1870)	The species has been reported from Manipur near the Myanmar border (Selim and Vishwanath 1996).	Food
117	*Salmophasia phulo* (Hamilton, 1822)	Recorded from Manipur.	Food
118	*Semiplotus manipurensis* (Vishwanath & Kosygin, 2000)	This fish was described from the Challou river and Wanze stream in the Chindwin drainage of Manipur.	Food
119	*Semiplotus modestus* (Day, 1870)	The species is recorded from locations in Northeastern India in Koladyne River and its tributaries (Mat river) of Mizoram and rivers of Arunachal Pradesh and in the Brahmaputra drainage.	Food
120	*Semiplotus semiplotus* (McClelland, 1839)	Found in the Himalayan rivers of Assam and Arunachal Pradesh.	Food
121	*Tor progeneius* (McClelland, 1839)	Found in the Himalayan rivers of Assam.	Sports/Food

Family	Species	Distribution	Economic significance
Cobitidae			
122	*Acantopsis multistigmatus* (Vishwanath & Laisram, 2005)	Recorded in Lokchao river in Manipur.	Food/ Ornamental
123	*Acantopsis choirorhynchos* (Bleeker, 1854)	Recorded in Manipur.	Food/ Ornamental
124	*Lepidocephalichthys arunachalensis* (Dutta & Barman, 1984)	Reported in Arunachal Pradesh.	Food/ Ornamental
125	*Lepidocephalichthys berdmorei* (Blyth, 1860)	Recorded in Manipur.	Food/ Ornamental
126	*Lepidocephalichthys irrorata* (Hora, 1921)	This species is known in Meghalaya, Manipur and Assam.	Food
127	*Lepidocephalichthys manipurensis* (Arunkumar, 2000)	This fish occurs only in Manipur.	Food/ Ornamental
128	*Syncrossus berdmorei* (Blyth, 1860)	Recorded in state Manipur.	Ornamental
Bagridae			
129	*Hemibagrus microphthalmus* (Day, 1877)	Recorded from the Manipur.	Food
130	*Hemibagrus peguensis* (Boulenger, 1894)	This species is reported from the Chindwin drainage in Manipur.	Food
131	*Mystus falcarius* (Chakrabarty & Ng, 2005)	Recorded in Manipur.	Food
132	*Mystus rufescens* (Vinciguerra, 1890)	Recorded in Manipur.	Food
133	*Olyra longicaudata* (McClelland, 1842)	This fish is recorded from the Khasi Hills in Meghalaya and from the Brahmaputra River drainage.	Food
134	*Rama rama* (Bleeker, 1855)	Recorded from Brahmaputra river system in Assam	Food
135	*Sperata acicularis* (Ferraris & Runge, 1999)	Recorded in Manipur.	Food
Siluridae			
136	*Pterocryptis barakensis* (Vishwanath & Sharma, 2006)	This species is only reported from one location in the Barak River drainage in Manipur.	Food
137	*Pterocryptis berdmorei* (Blyth, 1860)	This fish is recorded in streams draining into the Yu River, a tributary of the Chindwin in Manipur.	Food
138	*Pterocryptis indicus* (Datta, Barman & Jayaram, 1987)	This fish is only known from the type locality in Namdapha River, Namdapha Wildlife Sanctuary, Arunachal Pradesh.	Food/ Ornamental

Family	Species	Distribution	Economic significance
Erethistidae			
139	*Conta pectinata* (Ng, 2005)	*Conta pectinata* was described from the Brahmaputra River drainage in Assam (Ng 2005), and is also present in Meghalaya.	Ornamental
140	*Erethistes serratus* (Vishwanath & Kosygin 2000)	Barak and Jiri rivers in Manipur and Brahmaputra drainage.	Food/ Ornamental
Synbranchidae			
141	*Monopterus hodgarti* (Chaudhuri, 1913)	Known only from Upper Rotung, Abor Hills, Arunachal Pradesh.	Food
Mastacembelidae			
142	*Macrognathus morehensis* (Arunkumar & Singh, 2000)	This fish is recorded from Maklang River, Chindwin drainage (Moreh Bazar, Chandel District) Manipur.	Food/ Ornamental
143	*Pillaia indica* (Yazdani, 1972)	Known from Northeastern India (Khasi and Jaintia hills of Meghalaya), and from Umsing river.	Ornamental
144	*Garo khajuriai* (Talwar et al. 1977)	This species occurs in the Garo Hills in Meghalaya, and in the Kaziranga Wildlife Sanctuary in the Barhmaputra basin in Assam.	Food
Belontidae			
145	*Trichogaster labiosus* (Day, 1877)	This fish is known from the Chindwin drainage, Manipur.	Ornamental
Ophichthidae			
146	*Pisodonophis boro* (Hamilton, 1822)	This fish has a distribution mainly in freshwater from Assam (including Brahmaputra and Barak drainages).	Food

Among the above listed endemic species in Northeastern region, many are known for their economic importance and are recognized as potential candidate species for coldwater fisheries and aquaculture. Species of mahseers, minor carps, barbs, loaches and catfishes play the important role in the economy of local fishermen in hilly region. Since, aquaculture is one of the fastest growing sectors in the world, many of these hill stream species can be considered as a candidate species for diversification in freshwater aquaculture particularly of hill aquaculture. Unless an effective management and conservation strategy is immediately taken, the prized species may be wiped out before long (Mahanta & Sarma, 2010). Farming of these important priced coldwater fishes will not only help in the propagation and generating livelihood for the people but also will help to conserve germ plasm from extinction.

Considering the anthropogenic interference and climate vagaries, there is growing concern over the resource assessment, breeding, production and management of the endemic species of the Northeast Himalayan region. At the same time, there is paucity of information on present status and proper documentation of the available species. Further, there are certain technical, social and environmental issues warranting immediate attention.

In this direction, ICAR-Directorate of Coldwater Fisheries Research, Bhimtal have been working on the following endemic candidate fish species of Northeastern Himalayan region for its propagation, culture and management practices-

1. *Bangana devdevi*
2. *Labeo pungusia*
3. *Neolissocheilus hexagonolepis*
4. *Osteobroma belangeri*
5. *Semiplotus semiplotus*

Bangana devdevi

The species inhabits in the freshwater river systems of tropical and subtropical regions. It shows full migration on seasonal basis may be for breeding or feeding. No information is available regarding the biology, maturity and breeding so far. The body is laterally compressed with oblong in shape and the dorsal fin is having 10-13 soft rays. Cycloid scales are present throughout the body except the head region. The mouth is ventral in position and a deep transverse groove present along the head region across the top of the snout. In the global context, it has restricted distribution to southern and eastern countries of Asia like Thailand, Myanmar and India. In India, it has been reported from the Irrawaddy river system of Manipur. It is bentho-pelagic in feeding habit so that feeds on the materials that are available in the whole water column. The maximum recorded length is 50.0 cm but there is lack of information regarding its annual growth rate.

ICAR-DCFR initiative on captive rearing of *Bangana devdevi*

This species has a good potential as food fish but however it is only restricted to the capture fisheries and no aquaculture information available till today. So whatever produce comes to the nearby market is from the riverine catch and consumed by the local people only. Hence, an initiative has been taken by ICAR-DCFR for the culture of *Bangana devdevi* along with Chinese carp in collaborative mode with Krishi Vigyan Kendra, Thoubal, Manipur in ten farmers pond for the livelihood upliftment of the fisher folk community. The composite culture of *Bangana devdevi* (locally known as Khabak in Manipur) along with *Osteobrama belangeri* (Pengba) at a

ratio 50:50 in the farmers' pond in Manipur show better result as observed from the experiment done by this Directorate along with KVK Thoubal.

Threats and conservation

As this species is migrant in nature, the construction of dams and other anthropogenic activities may destroy its habitats, which in turn may lead to the declining of its population. This species has been categorized as Least Concern (LC) by IUCN. A thorough survey work is needed in order to ascertain the present status of this species i.e. whether its population is really declining or going through natural population fluctuations or stock recruitment and recovery process has been started in the natural system.

Labeo pangusia

The *Labeo pungusia* is an important endemic fish of Northeast India distributed in hill streams of this region. However, the population of the fish is drastically declining in nature due to various natural and anthropogenic factors and considered as threatened species as per IUCN red list status. The body of *Labeo pungusia* is elongated and dorsal profile is more convex than ventral. Over hanging small mouth with distinct lateral lobes could be seen. Eyes are small, lips are thick and non-fringed. One short maxillary barbells, concealed in labial fold. Dorsal fin inserted to snout tip, pectoral fins do not extend up to pelvic fins and fin deeply forked. Lateral line complete with 40 to 43 moderate scales. Fish body colour varies with water colour. In river, fish exhibits brownish colour above, yellowish and white at sides and below (Vishwanath *et al,* 2011).

L. pangusia exhibits seasonal feeding intensity with bimodal peaks: one in March - April and other in September - October (Biswas, 1982). The fish lay eggs in the mid of April to end of July when the water temperature are between 24-28°C in Northeastern region. The species attains maturity in the 2nd year of its life span (Biswas, 1982). It is a highly fecund fish and the fecundity ranges from 7, 50, 000 to 8, 00,000 of eggs. The maximum length recorded is 90 cm (Menon, 1999). *Labeo pangusia* is a slow growing species. Although males grow faster than females, the female attains a larger size than the male. Both male and female attain maturity at 25-30 cm length group. Spawning occurs coinciding with monsoon rain and fingerlings usually encountered in August-September when the floodwater recedes. *Labeo pangusia* can breed in natural environment.

ICAR-DCFR initiative on captive rearing and breeding of *Labeo pungusia*

To conserve and rehabilitate this important fish of Northeast India, ICAR-DCFR, Bhimtal has made an effort to rear the fish in captivity at the hatchery premises of Eco-Camp, ABACA, Nameri, Assam in PPP mode for a period of three years since 2012. The fry of the fish (20 nos.) were collected from Jia-Bharali river of Assam and were reared in a cement cistern (21 m x12 m x1.5 m). Male and female fish are found to attain sexual maturity at the age of three. Induced breeding is attempted by selection of suitable brooders. Female brooders in size range of 210-250 gms bred successfully and a total of 3.75-4.0 lakh eggs has been produced resulting 1.9 lakh spawn. The protocol developed for seed production of this important hill stream fish by ICAR-DCFR, Bhimtal in collaboration with ABACA, Nameri, Assam through captive breeding is the first record of its kind in Northeast and is an important breakthrough for hill aquaculture and conservation.

As per the IUCN status the fish is considered as near threatened category (IUCN, 2014). Therefore, an attempt has been made for captive rearing and breeding of *Labeo pangusia* at Nameri Eco Camp, ABACA, Nameri National Park in Assam, India. The breeding trial was commenced on 11th July, 2015 with the selection of male and female brooders of *Labeo pangusia*. The brood fishes of 3^{+} year age groups which were reared in cemented tank of size 0.02 ha that attained fully gonadal maturity in pond condition were selected. The length of the brooders were ranging from 35-50 cm and weighing between 1.0-2.0kg. The brooders were administered with inducing agent Ovatide @ 0.5ml-1ml/kg body-weight in both male and female brooders (2:1 ratio). The fishes were kept in breeding hapas overnight for their courtship and mating. The fishes spawn after 6-8 hrs of hormonal injection having 70% fertilization success. The fertilized eggs of *Labeo pungusia* were transparent white and round in shape. A total of 7,50,000-8,00,000 fertilized eggs of Labeo pungusia were achieved during the breeding trial.

Fig. 1 Female brooders

Fig. 2 Male brooders

Fig. 3 Stripping of eggs

Fig. 4 Fertilization of eggs with milt

Fig. 5 Fertilised eggs

Fig. 6 Incubation of eggs and larvae

Table 2: Water quality parameters during the captive breeding programme

Water quality parameters	Optimum Range
Temperature	28 -30°C
pH	7.5-8.5
Dissolved oxygen	6-7ppm
Total Hardness	250-300 ppm
Total Alkalinity	200 -250 ppm

Table 3: Weight of injected brooders during the breeding trial

Weight of male brooders	1.5± 0.01 Kg
Weight of female brooders	2.0± 0.06 Kg
Ovatide	0.5-1.0 ml/kg body wt.

Fig. 7 Water quality analysis

Significance of *Labeo pangusia* as a potential species for diversification in hill aquaculture

Labeo pangusia is a priced species having high consumer preference due to its good taste. If the culture protocol of the species is perfected and seed availability in a large scale is assured, it has the potential to fetch higher market demand in the domestic markets of entire Himalayan states. The cost of fresh fish may increase up to Rs. 500-600 during the festive seasons in Northeastern part of India. The price of the species is reported to be two times higher than the Indian Major Carps, which may generate more profit to the famers. The highly coiled intestine and the nature of the gut contents indicate that the species browses in the river bed for periphyton and detritus and therefore, the species is a detritophagus in feeding habit. Since the fish is bottom feeder in nature, it can be considered as an alternative to other bottom feeding fishes in composite fish farming, without compromising the yield and profit. Also, in order to save the germ plasm of *Labeo pangusia* from extinction in nature, it is important to culture them in pond condition and propagate their seed in a large scale for releasing into the rivers and streams to increase their population as well as rehabilitation of the fish in the natural eco-systems.

***Neolissochilus hexagonolepis* (Chocolate Mahseer)**

ICAR-DCFR initiative on culture and breeding in chocolate mahseer in Mid-Himalaya

Out of seven important mahseer species, chocolate mahseer is only available in uplands of Northeastern region. It is an economically important game as well as food fish which recognized as a cultural icon in the water bodies of Eastern Himalayan region (Sarma, 2007, 2009).The fecundity of chocolate mahseer is 6000-8000 eggs/kg body weight. Breeding period last from August to September. Average fertilization of 95% and hatching of 80% has been achieved. Incubation period is 38-40 hrs. Colour of the egg is light yellow to lemon yellow. Male attain the sexual maturity having size ranging from 450-500 gm and female brooder weighing of 600 gm and above. During the experiment conducted at ICAR-DCFR the growth of chocolate mahseer were recorded and observed approx. 120 to 150 gm increment in every year. The growth rate was maximum during second and third year of its life span. The growth of female is faster than the male. During the captive rearing period the fishes are regularly fed with feed having different ingredients consist of 35% protein @ 3-5% body weight twice daily. Incorporation of spirulina was also studied as a feed additive for the fishes and found to be significant improvement in growth, survival, and feed utilization. This ingredient has high percentages of all the essential vitamins, minerals, trace

Fig. 8 Chocolate mahseer fingerling

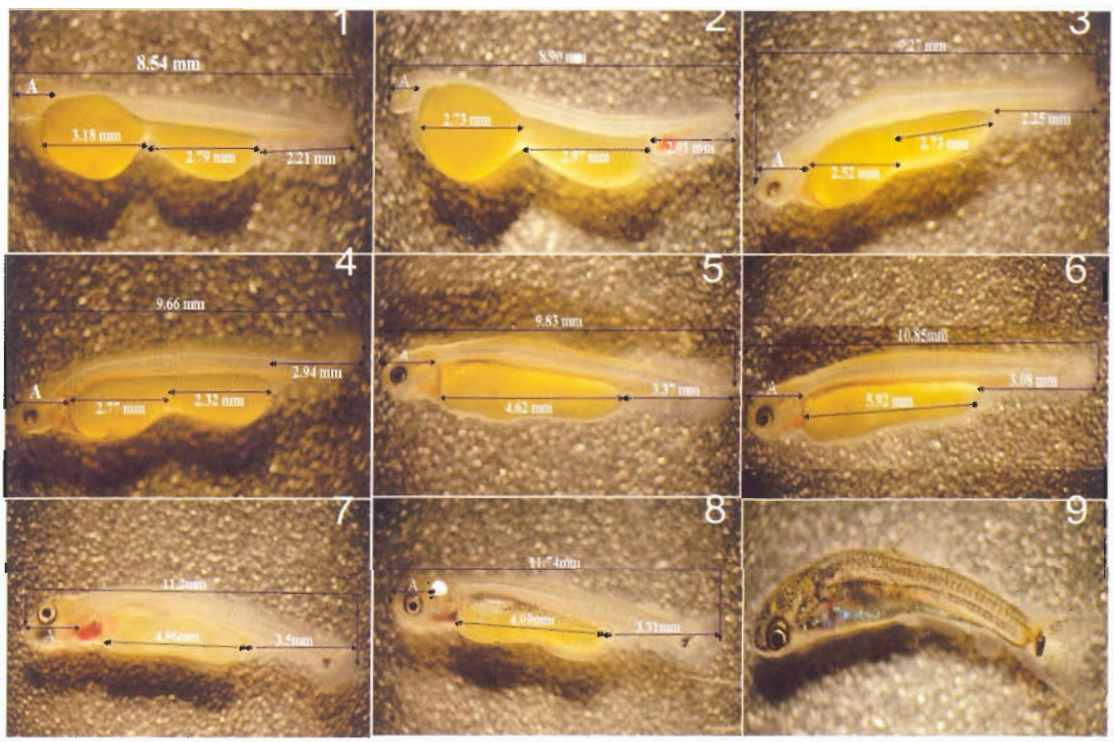

Fig. 9 Larval development of chocolate mahseer

Fig. 10 Captive rearing of chocolate masheer

Fig. 11 Haul of chocolate mahseer

Fig. 12 Stripping of eggs

Fig. 13 Fertilization of eggs with milt

elements and carotenoids that are responsible for proper growth, pigmentation and enhances nutrient profile if taken in appropriate quantity.

The breeding and larval rearing of chocolate mahseer has been standardized and this technology may be replicated in the different parts of NE states for effective management and conservation of this fish. An initiate is also being taken by ICAR-DCFR to establish a chocolate mahseer hatchery at Romberge Fish Sanctuary, Tura, Garo Hills, Meghalaya for production of seed of chocolate mahseer for the entire Northeastern states.

Jhora Fishery Management

The Jhora Fishery in Kalimpong dist., GTAD, West Bengal is a special type of organic farming where water is taken from the stream and organic feed is fed to the fishes for its growth and development to minimize the cost of production and good quality fish muscle. ICAR-DCFR has made an attempt to revive the culture of chocolate mahseer with grass carp in Jhora fish pond. Average size of the pond is 40 to 50 sqm. 80-100 nos. of chocolate mahseer and 80-100 nos. of grass carp fingerling were stocked in each pond It has been observed that after culture duration of 12 months the final weight gain of chocolate mahseer was 150 gm and grass carp was 400 gm. The cost of chocolate mahseer in the market is Rs. 300-400/kg which gives a good income generation for the local fish farmers of the region. This farming practices is farmers friendly and they may adopt it with ease. Training was also given on the subject and almost 33 farmers are interested to adopt these practices in this region.

Culture of *Osteobrama belangeri* along with Chinese carps: ICAR-DCFR developed protocol at Manipur

Osteobrama belangeri locally known as Pengba, is the state fish of Manipur and this species can be included in composite fish culture. Experiment was conducted in 10 farmers pond in Manipur by ICAR-Directorate of Coldwater Fisheries Research, Bhimtal in collaboration with Krishi Vigyan Kendra, Thoubal in five different combinations of Pengba, Grass carp and Silver carp in two replicates viz. a portion of 20%, 30%, 40%, 50% and 60% Pengba and the remaining portions contributed equally by Grass carp and Silver carp. The present study aims to determine the optimum growth of fish, yield and benefit cost ratio in different combinations.

Fig. 14 Experimental pond

The water parameters of pond were temperature (24±3°C), pH (7.5±0.5). Manuring was done by raw cow dung @ 15000kg/ha/yr. Liming was done using quick lime @ 300kg/ha/yr. Since the natural fish food production remains limited, energy requirement for somatic growth after fulfilling the sustenance demand can be met by providing food from outside. Hence, supplementary feed (Rice bran + Mustard oil cake in the ratio of 1:1 + Vitamins and minerals) was fed @ 3% of body weight of fish per day. Macro vegetation and micro vegetation (*Lemna* sp.) were also fed for Grass carp and Pengba.

Harvesting of fish was done after a culture period of 11 months. Growth of Pengba was highest in the combination of 50% Pengba and the growth of Grass carp and Silver carp were highest in the combination of 60% Pengba. The maximum total lengths of Pengba, Grass carp and Silver carp recorded during the study period were 187mm, 480mm and 415 mm respectively. The maximum weights of Pengba, Grass carp and Silver carp recorded during the study period were 115g, 1220g and 1010g respectively. The harvested fishes were sold at the rate of Rs. 600/kg for Pengba, Rs. 180/kg for Grass carp and Rs. 120/kg for Silver carp. However, the gross and net incomes were maximum in the combination of 40:30:30 (Pengba: Grass carp: Silver carp). The gross and net incomes from this combination were Rs. 7,68,150 and Rs. 6,26,800 respectively. Total fish production and benefit cost ratio for different combinations of stocking density were shown in Table 1.

Table 4: Total fish production and benefit cost ratio for different combinations of stocking density

Different combinations of stocking density	Total fish production (kg/ha/yr)	B:C
20:40:40 (Pengba: Grass carp: Silver carp)	3459.2	4.5
30:35:35 (Pengba: Grass carp: Silver carp)	3124	4.3
40:30:30 (Pengba: Grass carp: Silver carp)	4294.2	5.4
50:25:25 (Pengba: Grass carp: Silver carp)	2640	3.5
60:20:20 (Pengba: Grass carp: Silver carp)	2405.4	4.2

From the above table it is clear that the total fish production and B:C were highest when the Pengba is 40 % of the total stocking density. However, the highest growth of Pengba is observed when the Pengba is 50% of the total stocking density, the growth of Grass carp and Silver carp were highest when they contribute 20% each of the total stocking density. The demand of Pengba in the state is very high leading to high price per kilogram of fish and increase in benefit cost ratio. Species diversification in culture system is a major frontier for increasing fish production for providing food for increasing human population. Hence, scientist and extension functionaries should encourage the culture of *Osteobrama belangeri* along with Chinese carp in the ratio of 40:30:30 (Pengba: Grass carp: Silver carp).

Fig. 15 Photographs of culture of Pengba with Chinese carps

***Semiplotus semiplotus* (The Assamese King Fish)**

ICAR-DCFR initiative on captive rearing

Semiplotus semiplotus is an endemic and highly preferred food fish species available in the lotic systems of Arunachal Pradesh and foothills zones of Northeastern states. The population structure has reached at alarming status in most of the river system of Arunachal Pradesh and other NE states because of anthropogenic activities, over exploitation from open water bodies and developmental activities. Therefore, it is time to propagate in captivity for its rehabilitation. All total 1050 live specimens of *Semiplotus semiplotus* were collected from Dikrong river and Sinki river of Papumpare district, Arunachal Pradesh. Fish samples were collected during October, 2014 to March, 2015. The catch frequencies of different size groups were not so satisfactory because of various anthropogenic impacts. Particularly adult fishes were very rarely found. Fishes were caught by cast net and drag net as well as by nylon happa. The samples were transported to the laboratory either by using oxygenated plastic bags or using buckets fitted with battery operated aerator. Then collected live fish specimens were acclimatized in cement cisterns and after 3-5 days collected natural seeds are sorted according to their size group and

segregated in to different cisterns for future stocking in various farms or in running water deep cisterns of Rajiv Gandhi University (RGU). Generally smaller seeds are kept in RGU cistern system and larger groups are transported to various farms. The size of the advance fry are ranging from 2.5-4.5 cm, fingerling 4.5-5.5. cm and advance fingerling 5.5- 8.5 cm.

The fishes of advanced size groups viz; fingerling and advanced fingerling were transported from RGU after initial acclimatization to Pavoi fish farms. Besides all the fry collected during the seasons are maintained in flowing water cistern system of RGU after initial acclimatization at COB cistern for 3-5 days. In all the farms and cisterns, water qualities were regularly monitored, supplementary feed is being applied at the rate of 5% of the body weight either the formulated feed in addition to weekly application of lithophyton in cisterns and other natural algal fish food in farm ponds. To take prophylactic measure against diseases potassium permanganate, Rid-all, Methylele blue, and Melacite green are applied periodically with recommended doses. The entire rearing program is progressing satisfactorily. A consignment of *Semiplotus semiplotus* are also being transported to Bhimtal and experimental captive rearing practices are going on monitoring the growth rate and environmental parameters. To obtain sufficient seeds of Semiplotus, the river courses of Dikrong, Pachin and Poma in Papumpare district were extensively visited for locating the spawning grounds of the fish, foraging sites of spawn, fry and fingerlings of the species. The physical observation along the periphery of the River Dikrong and R. Pachin was done through pilot survey method and as and when any confluence of tributaries found irrespective of size of the channel/stream were also taken into consideration for locating the sites. The seeds of the species are very easily identifiable by the longer base of dorsal fin and blunt terminal mouth; besides, the species is well known for the deeper body depth which is distinguishable in the early life stages. Nevertheless, the plain extreme silvery body colour without any bars, lines or spots neither on the fins nor anywhere on the body makes it different from the seeds of other species. The collections of seed were carried out from the selected sites where the collection procedure was ease of operation. The most suitable site was flag marked after every trial operation of collection. The method of collection was also assessed for the ease of operation and reliability.

Fig. 16 Male fish

Fig. 17 Female fish

Fig. 18 Rearing of *Semiplotus semiplotus* in captivity at RGU, Itanagar

Nutrient quality of few endemic fish of Northeastern region

Table 5: Proximate composition (Sarma *et. al.*, 2014)

Fish species	Moisture	Crude fat	Crude protein	Ash
Neolissochilus hexagonolepis	76±2.2	3.3±0.3	18±0.4	1.2±0.1
Labeo pungusia	76±1.4	6.7±0.8	16±1.8	3.5±0.3
Semiplotus semiplotus	71±2.1	7.7±0.4	18±0.6	1.2±0.2

*Values are expressed as mean±SE

Table 6: Minerals (Sarma *et. al.*, 2014)

Fish species	Macro-minerals (mg/100 g)			Micro-minerals (mg/100g)			
	Sodium	Calcium	Potassium	Iron	Manganese	Zinc	Selenium
Neolissochilus hexagonolepis	105±13	1175±23	810±17	1.9±0.4	0.10±0.01	1.6±0.04	1.9±0.02
Labeo pangusia	123±5.4	2021±53	1118±58	1.9±0.3	0.02±0.03	0.26±0.12	50±2.22
Semiplotus semiplotus	133±7	467±21	701±24	4.0±0.7	0.21±0.03	1.7±0.26	1.2±0.04

*Values are expressed as mean±SE

Table 7: Amino acid composition (g/100 g muscle) of *N. hexagonolepis* (Sarma *et. al.*, 2013)

Amino acid	Mean±SE	Amino acid	Mean±SE
Aspartic acid	3.220±0.083	Leucine	0.956±0.033
Threonine	0.476±0.099	Tyrosine	0.445±0.055
Serine	2.206±0.009	Phenylalanine	0.348±0.042
Glutamic acid	2.085±0.084	Histidine	0.481±0.071
Proline	0.448±0.053	Lysine	1.009±0.114
Glycine	0.908±0.112	Arginine	1.062±0.135
Alanine	1.989±0.183	Tryptophan	0.309±0.114
Cystine	0.135±0.048	Aspergine	0.054±0.013
Valine	0.831±0.108	Cysteine	0.033±0.013
Methionine	0.638±0.132	Ornithine	0.747±0.086
Isoleucine	0.382±0.101		

Table 8: Fatty acid composition (% of total fatty acids) *N.hexagonolepsis* (Sarma *et. al.*, 2013)

Fatty acids		Mean±SE
Saturated fatty acids	C12:0	2.473±0.041
	C13:0	0.070±0.023
	C14:0	4.670±0.021
	C15:0	0.413±0.043
	C16:0	29.780±0.040
	C17:0	0.590±0.040
	C18:0	5.873±0.035
	C19:0	0.100±0.006
	C20:0	0.323±0.038
TOTAL	**C22:0**	**ND**
Mono unsaturated fatty acids	ΣSFA	44.29±0.20
	C16:1n9	10.897±0.029
	C16:1n7	0.167±0.023
	C17:1n7	ND
	C18:1n9	9.540±0.026
	C18:1n7	1.383±0.038
	C18:1n5	ND
	C20:1n9	1.567±0.027
	C22:1n9	0.397±0.035
TOTAL	**ΣMUFA**	**23.95±0.032**
Poly-unsaturated fatty acids	C18:3n3	7.727±0.035
	C18:4n3	ND
	C20:3n3	0.527±0.035
	C20:4n3	0.620±0.055
	C20:5n3	7.430±0.064
	C22:5n3	0.003±0.003
	C22:6n3	5.173±0.043
	C18:2n6	7.653±0.061
	C18:3n6	ND
	C20:2n6	0.003±0.003
	C20:3n6	ND
	C20:4n6	2.063±0.032
	C22:4n6	ND
TOTAL	**ΣPUFA**	**31.2±0.1**

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