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Aquaculture in North East Region: Realities, Opportunities and Challenges




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DEPARTMENT OF FISHERY SCIENCE
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Cover photographs:
Clockwise from top left:

Fishing by rural women in the fish pond at Umling of Ri-Bhoi district, Meghalaya

Fish harvesting from private pond at Mylliem of East Khasi hills district, Meghalaya

Fish pond at foothills of Mairang of West Khasi hills district, Meghalaya

Umiam reservoir at river Umiam in Ri-Bhoi district of Meghalaya

From the Editors

The total fish production, in India has increased to 6 folds from 0.75 million t in 1950-51 to 9.58 million t in 2013-14 and is continuing to increase. The contribution of inland sector has increased at a higher rate, from 0.218 million t during 1950-51 to 6.14 million t in 20013-14 with almost 2/3 of the current national consumption of food fish coming from inland aquaculture. Starting from a purely traditional activity, aquaculture at present have transformed to commercial enterprise in many states like Andhra Pradesh, Punjab, and Haryana. India's North East Region is endowed with huge untapped natural resources and is acknowledged as the eastern gateway for the country's 'Look East Policy'. The region comprises eight states- Assam Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Sikkim, Tripura and occupying 8% of total geographical area of the country. Aquaculture is an important economic activity in the rural areas of North East India. However, the country's north east has been experiencing a comparatively slower pace of growth in aquaculture sector. Though the region is blessed with abundant aquatic resources for fish production, its full potential has not, however, been realized to date. State and national policy is looking to address this and provide the framework for sustainable growth of aquaculture sector. However, the pattern of aquaculture growth has remained uneven across the regions. North East India is continued to be net importers of fish. Aquaculture production in North East India is basically carp based and widely-used aquaculture production facility is the earthen pond. It is now widely recognized that the rising demand for fish in the Northeast will have to be met by aquaculture. The future of aquaculture in this region will depend on how well it meets challenges with respect to adopting improved production technology, diversification of cultured fish species, quality seed production, low cost feed production, quality control in post-harvest period and proper marketing. This region can realize the export potential by opening up and expanding trade with the neighbouring countries such as Bangladesh, Myanmar and through Myanmar to South East Asia.

Two day long National seminar was organized from 25th August, 2015 to 26th August, 2015 by Department of Fishery Science, St. Anthony's College, and Shillong

on Aquaculture in North East Region: Realities, Opportunities and Challenges. The seminar was inaugurated by Shri P.B.O. Warjri, IAS, Chief Secretary, Government of Meghalaya and attended by Director Dr. A.K. Singh, DCFR, Bhimtal, Dr. P.C. Mahanta, Former Director, DCFR Bhimtal, Scientists, Academicians, Research Scholars, Entrepreneurs, fish farmers and Fishery officers from different parts of the country. The seminar was a grand success with more than thirty participants taking part in the deliberations. The papers presented in the seminar were divided in four different sessions and there were theme papers in each session presented by distinguished academicians and scientists. At the end of the deliberations in the technical sessions, there was a panel discussion and ten point recommendations were presented for reference in research and development of aquaculture in the N.E. Region of India.The valedictory function of the seminar was graced by Shri P. Kharkongor, IAS, Principal Secretary, Fisheries, and Government of Meghalaya as chief guest.

We take this opportunity to thank UGC-NERO, Guwahati, Meghalaya Apex Cooperative Bank Ltd, and State Fisheries Department, Government of Meghalaya for their sponsorship. We would like to thank Shri K. N .Kumar, IAS, Chief Executive, NFDB, Hyd erabad for his guidance and constant encouragement for organizing seminar successfully. We would also like to thank Mrs. I.R. Sangma, Director, Fisheries Department, Government of Meghalaya and Managing Director, MCAB Ltd, Shillong for their constant support to us for organizing seminar. We wish to place on record our gratitude to the Br. (Dr) A.L. Dkhar, Principal, St. Anthony's College, Shillong, Fr.(Dr). Joby Joseph ,Vice Principal, St. Anthony's College, Shillong and Fr. Saji Stephen Rector, St. Anthony's College, Shillong and the national advisory Committee as well as others who directly and in other ways helped to make the seminar a success.

We hope, the proceedings will help all concerned in the development of aquaculture and research in various fields, particularly from the North East India.

R. N. Bhuyan
D. Ghosh
S. M. Kharbuli
R. Nath

Contents

Upland Fishery Resources of North-Eastern Himalaya: Need based Strategies and Approaches for Sustainable Management

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Abstract
The present paper assesses the Himalayan water resources and also presents status of upland fisheries and aquaculture of north eastern states namely Sikkim, Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Tripura. These water resource harbours 258 fish species belonging to 21 families and 76 genera. Among these, some species are known for sports purpose, a few of them have potential ornamental value and majorities are considered as food fishes.

Introduction

Coldwater rivers and streams are known for their high velocity, waterfalls, rapids, cascades, deep pools and substratum comprising with bedrock-boulder-sand. These water resource harbours 258 fish species belonging to 21 families and 76 genera. Among these, some species are known for sports purpose, a few of them have potential ornamental value and majorities are considered as food fishes. In Indian Himalaya, the cultivation of fish contributes little to the overall freshwater fish production. Virtually every facility created for fish cultivation in the Indian Himalaya produces fish for stocking into the streams and lakes primarily to meet the requirements of sport fishing and livelihood security of the local people residing near to the lakes or streams. Commercial fishery is also dependent to some extent on the stocking of lakes and reservoirs with fry and fingerlings. While for a number of years fish hatcheries in the Himalaya have been raising eyed-eggs, fry and fingerlings of brown and rainbow trout, and fry and fingerlings of common carp for stocking, only recently have some hatcheries started producing seed for stocking the indigenous Mahseer and snow trout. To meet the ever-increasing demands of angling, subsistence and commercial fisheries, there has been a need for modernization of some hatcheries. The degradation of hatcheries took place especially where water quality deteriorated and the silt load in streams increased.

Himalayan Water Resources

The cold water fisheries resource of India has got vast and varied potential covering an area of 10000 km streams and rivers, natural lake 20,500 ha, reservoirs 50000 ha and brackish eater lakes 2,500 ha. The Himalaya, which cover 594 400 km2, run for about 2 500 km from West to East, between Nanga Parbat (8126 m) in the West and Namcha Barwa (7 756 m) in the East. This mountain system is bordered in the West by the Karakoram Mountains and in the North by the high plateau of Tibet. From South to North one can distinguish four parallel and longitudinal mountain belts of varying width, each having distinct physiographic features and its own geological history: the Siwaliks, the Lesser Himalaya, the Greater Himalaya and the Trans-Himalaya. The Himalaya are drained by 19 major rivers, of which the Indus and the Brahmaputra are the longest, each having a mountain catchment of about 1,60,000 km2. Of the remaining 17 rivers, five belong to the Indus system, of which the Beas and the Sutlej have a total catchment of 80 000 km2, nine (Ganga, Yamuna, Ram Ganga, Kali-Sharda, Karnali, Rapti, Gandak, Bhagmati, Kosi) belong to the Ganga system, draining nearly 150 000 km2. The Ganga has five source rivers (Bhagirathi, Mandakini, Alaknanda, Dhauliganga, Pindar). A number of rivers enter within India from Bhutan. The Brahmaputra (known as Yarlung Zangbo Jiang or Tsangpo, in China) has a catchment of about 110 000 km2. Most of these rivers flow in deep valleys until they exit the mountains.

Fisheries of Himalayan Rivers

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

Aquatic Resources and Fish Diversity in Sikkim

Sikkim, the small but beautiful kingdom is situated in the Eastern Himalaya. Sikkim is termed as the Switzerland of the East, a heavenly paradise on earth. The state has vast water resources in the form of lakes, snow-fed rivers and streams, some with marshy area. Sikkim has two major rivers, Teesta and Rangeet, with a total length of 900 km. These rivers originate from the glaciers of North and West Sikkim. Along with myriads of tributaries, the rivers harbor a diverse and rich fish fauna. The most important of these are the Snow Trout (Schizothorax sp.), Mahseer (Tor putitora). Cat fishes (*Glyptothorax spp., Bagarius sp., Pseudechencies sp.) and a number of Cyprinids e.g. Garra spp., Barilius spp*. etc. About 1500-2000 villagers living close to the river banks are engaged in part-time fishing. The cold-water species are highly esteemed by the local inhabitants. They fetch a good price. This shows that Sikkim's fishery wealth serves as a source of additional income to the poor villagers.

Glaciers

Glaciers are moving mountains of ice. There are many glaciers in Sikkim among which the most important ones are Zemu glacier, Rathong glacier and the Lonak Glacier in North Sikkim. The Zemu glacier is the largest and the most famous glacier of the Eastern Himalaya. It is 26 km in length and is situated in a large U-shaped valley at the base of the Khangchendzonga massif in Northwestern Sikkim. The Teesta river rises from the snout of this glacier. Many tributary glaciers feed the trunk glacier. The side valley which these glaciers lie open into the main Zemu valley from different directions. Icefalls and waterfalls have formed at the junction of the tributary glaciers with the Zemu glacier.

Lakes

Sikkim does have lakes though not very large in size on such a rugged terrain. These lakes are both spring fed as well as river fed. On the highway between Gangtok and Nathu La, 34 kms. from Gangtok lies the serene Tsomgo (Changu) lake at an altitude of about 12,000 feet. Khecheopalri lake is another well known lake that lies on a bifurcation of the route between Gyalshing and Yuksom. Menmecho lake, Green lake and Samiti lake are some other beautiful lakes.

Tsomgo (Changu) Lake

Tsomgo literally means "source of the lake" in Bhutia language. 'TSO' means lake and 'MGO' means head. About 40 kms away from Gangtok, this serene and holy lake is situated at an altitude of 12,000 ft on the Gangtok - Nathu La highway. It is about 1 km long, oval in shape, 15 meters deep. The lake remains frozen during the winter months up to mid-May.

Menmecho Lake

The lake lies between the mountains below the Jelep La Pass and is the source of river Rangpo-chu. It derives its water from melting snows around. The lake is famous for its Trout. Men Me Chu lake at an altitude of over 13 thousand feet, in East Sikkim near Indo-China border has been identified as the main breeding centre for exotic brown trout. The brooders collected from the lake and the streams are stripped artificially and reared in a regulated condition till it reaches the size of fingerling to be released in the lakes and streams.

Khecheopalri Lake

Khecheopalri lake is considered as one of the sacred lakes of this state both by the Buddhist and the Hindus. The lake remains hidden in the rich forest cover. It is believed that the birds do not permit even a single leaf to float on the lake surface. Karthok is also another important lakes in Sikkim.

Samiti Lake

The lake Samiti- A glacial lake in the Onglathang valley is situated near Gochala Pass.

Tso Lhamu Lake

Tso Lhamu is a lake which lies on the plateau that juts into Sikkim upto Tibet. From this moderately sized lake, the Teesta river takes birth as a trickle hardly a foot wide. The water in the lake flirts with ice before getting frozen in winter. A flock of birds, the cranes swim on the placid ice water of Cholha Mu.

Lakshmi Pokhari

It is a big natural lake cupped in deep crater. The rim of the crater is so hard above the lake level that it is easy to photograph the complete lake without using a wide angle lens.

Rivers

Flowing almost right across the length of Sikkim is the river Teesta. Teesta originates from the Cholamu lake where it is hardly a stream. Meeting Teesta at the border between Sikkim and West Bengal is its major tributary the river Rangeet which originates from the Rathong Glacier. During monsoon, the otherwise innocuous looking rivers of Sikkim become swollen, swift, muddy and dangerous. The rivers are narrow, serpentine and full of rocks and hence are not navigable. Because of swift currents hitting rocks, the rivers are very noisy and can be heard for miles together. The Teesta finally joins the Brahmaputra in Bangladesh. The rivers are fed by snow melting on the mountains as well as rain that accumulate in the catchment areas during the monsoons.

Mahseer Fishery

The lower belt of the Teesta and Rangeet river harbor one of the most popular game fish, Mahseer (*Tor putitora*) and chocolate Mahseer (*Neolissochilus hexagonolepis*). But it is very unfortunate to note that this precious game fish population has already dwindled and the species is considered as endangered. However, there is a hope of recovery with the construction of an experimental Mahseer breeding farm at Bagua by diversion of the course

of river Rangeet in South Sikkim at an elevation of 300 msl. The ICAR-DCFR also taken initiatives for releasing golden Mahseer fry in the Teesta river to increase its population in the river as well its rehabilitation.

Trout Fishery

Since the majority of the rivers and streams of Sikkim originate from glaciers and are snow fed, about two third of the river length along with a number of high altitude lakes fall above 6000 msl and are virgin due to the absence of indigenous fish fauna. The fisheries department in collaboration with DCFR, Bhimtal has already established a brown trout hatchery at Menmecho at an elevation of 12000 msl. in East Sikkim. The hatchery is operational since 1979 and is producing trout fry every year. Trout is the only cold-water species that can thrive well in these waters. The seeds produced at the hatchery are transported and stocked in all the high altitude lakes and streams so as to enrich the waters of the state with this exotic game fish for popularizing sport fishery.

Sikkim state has an inherent potential for rainbow trout culture due to conducive climate and availability of cool, clean and well oxygenated water. Of let, rain bow trout farming is a promising livelihood option in the state. So far with the technical support of ICAR-DCFR, trout farming was adopted by 199 farmers and technical support were rendered for their culture and breeding. Brood stock development and maintenance was also carried out. DCFR has given on farm training to the officials and farmers of the state. The state requires 4 lakh eyed ova for which brood stock of 800 kg need to be reared. The average production is 300-400kg/raceway. The production of rainbow trout in the state is 80t. Sikkim produced 1 lakh eyed ova during 2011, 2 lakh eyed ova in 2012 and 2.7 lakhs eyed ova during 2013 at the State Trout Farm Uttarey. The farmers have started trout breeding and maintaining good brood stock. At Nimachen area of East Sikkim, training & demonstration of trout breeding was given to the farmers.

Angling

Sikkim with its massive bio-diversity is a paradise for adventure and nature lover. With the vast river system, Sikkim is an angler's delight. For an ardent angler - Mahseer, Carp & Trout provide fond angling opportunities. The River Teesta & Rangit provide ample scope for Mahseer and Carp. During pre and post monsoon season angling can be done by laagering or spinning. Amongst the alpine region in North, East and West Sikkim, there is ample opportunity for trout angling by fly fishing or spinning. Ideal month for angling are March to May and August to October.

Aquatic Resources and Fish Diversity in Arunachal Pradesh

Arunachal Pradesh, the land of 'Dawn Lit Mountain' (26° 28´ to 29° 30´ North latitude and 90° 30´ to 97° 30´ East longitude) covering an area of 83,743 km2 situated in the extreme North Eastern part of India has huge potential with its enormous lotic and lentic water bodies. The state drained with network of many rivers and numbers of mountain lakes like PT Tso lake, Mechuka lake, Mehao lake and Ganga lake have formed potential resources for mountain fishery based eco-tourism. All these network of rivers are habituated by unique sport fishes like Mahseer, Indian trout, snow trout and carps. The lakes are enriched with introduced exotic trouts like brown and rainbow trouts. The diverse ecological habitats formed due to variations of climate and altitude with massive mountain picturesque along with natural biological diversity and cultural diversity of various mountain tribes make it one of the few states in India endowed with an array of such resources.

High Altitudinal Lake

The Tawang district of Arunachal Pradesh has got 12 numbers of lakes. The upper Siang district with 11 lakes placed in second. Besides, some other lakes have been reported from scattered region, like Mehao lake (10.6 ha area and 1640 msl altitude) and Sally lake (2.5 ha area and 435 msl altitude) in Lower Dibang Valley District (Laskar and Pujen, 2004 and 2005), Lake Mechuka in West Siang and Lake Geker Sinyi (Ganga Lake) in Papumpare district. Few lakes are located near the roadside and the many are located at some trekking distance. These types of lakes will give a multidimensional importance as angling, scenic beauty, hill trekking apartment from fisheries development etc. For angling, the fish resources have to be developed in the subjected lake. The suitable sport fishes are to be enriched in these lakes.

River and Reservoir

Most of the rivers coming down from mountains and hills, criss-cross the region and have a combined length of approx 2000 km. Major perennial rivers of Arunachal Pradesh are the Kameng, Subansiri, Dikrong, Kamla (Ranganadi), Siang, Siyom and their tributaries.

A reservoir covering an area of 10-15 ha approximately has been constructed as a dam over the river Kamla (Ranganadi) of lower Subansiri district of Arunachal Pradesh. The reservoir mentioned above has recently been handed over to the state fishery department for initiating commercial fishery activities. There are many big tanks available in all the nine districts of Arunachal Pradesh. These tanks are basically reservoir tanks of mini-micro hydel project for generating electricity. The places are China Bridge, Keratang, Assam Hills, Lower Gompa of Tawang district, Rupa of West Kameng district, Tirbin of West Siang district and Mai and Tago of Lower Subansiri district.

Fish Diversity

Fish fauna of lower stretch of river Siang is comprised of 36 species belonging to 12 families. Ichthyofauna shows great affinities with fishes of Himalaya (Tor spp., Schizothorax richardsonii etc.), Assam (*Aorichthys aor, A. seengala, Mystus cavasius*) and other North-Eastern states (*Nemacheilus manipurensis, N. kangjupkhulensis, N. goroesis, N. kempi* etc.). Family Cyprinidae is largest, represented by 14 species while each of the families like Anguillidae, Synbranchidae, Belonidae, Psilorhynchidae and Clariidae, each represented by single species. *Labeo pangusia, L. gonius, Acrossocheilus hexagonolepis, Schizothorax richardsonii, Wallago attu, Aorichthys, seengala, Mystus cavasius* are abundant species of lower stretch of Siang. They inhabit mainstream while other species like Barilius spp., *Nemacheilus* spp. *Puntius spp*. and *Glyptothorax spp*. prefer to inhabit tributaries.

A total of 21 species were recorded from the Rana Ghat, proposed dam site in Siang river and near Along in Siyom river. Chagunius chagunio, Labeo pangusia, L. gonius, Acrossocheilus hexagonolepis, Puntius ticto, P. sarana, Monopterus chuchia, Xenetodon cancila, Psilorhynchus balitora were most common in lower stretch. Chagunius Chagunio accounted for 24% of total catch, followed by *Labeo pangusia*(13%), *Acrossocheilus hexagonolepis* (8%) and *L. gonius* (6%). In the upper ends of project areas, Schizothorax richardsonii, Labeo *gonius, Garra naganensis, G. tirapensis, Barilius shacra, B. tileo, Glyptosternum annandeli* accounted the major fish catch. *Schizothorax richardsonii* and *Labeo gonius* were predominant species of this zone accounting for 27% and 24%, respectively of total fish catch. The species like *Barilius shacra, B. tilieo, Semiplotus semiplotus* etc. inhabited the tributaries

Fishing and Angling in Arunachal Pradesh

Angling and fishing in Arunachal Pradesh offers lots of opportunities for anglers from all over the world. The abundance of water and the simplicity of the sport have helped the sport to grow in Arunachal Pradesh. Arunachal Pradesh offers numerous possibilities to catch fish especially trout and Mahseer. There is lot of places like Yingkiong, Bodak, Siom, etc. provide good spots for fishing and angling. The Mahseer being a favourite among anglers, getting a 20-30 kg over here is not uncommon. The colder water of the higher reaches of Arunachal have the golden and trout and anglers can easily enjoy the traditional but effective methods of fishing while trekking in the jungles of Arunachal. The state is bisected by the Lohit river and a number of smaller streams, all of which offer plenty of opportunity for reeling in some of the biggest fish catch. Trout fishing is possible at many locations viz. Bhalukpong and Tipi on the river Kameng, Pasighat on the river Siang, and Tezu on the river Lohit.

Trout farming

Arunachal Pradesh has got immense scope for rainbow trout farming particularly in the district of West Kameng and Tawang. The water and temperature is favorable for its culture and propagation. However, there has been a constraint of seed availability of rainbow trout in the state although a significant numbers of brown trout eyed ova was produced at Shergaon, Nuranang and Tawang trout farm. Keeping this in view, ICAR-DCFR made an effort to transport a consignment of rainbow trout from Jammu & Kashmir during the year 2009 and reared them in the raceways at Shergaon Govt. trout farm. The eyed ova developed into brooders during 2014-15 in the farm condition under technical support of DCFR. However, it was realized that seed production could be possible through the developed brooders at the farm. Therefore, DCFR supported technically and financially to install a ova house having hatching facility in the said trout farm in order to solve the problem of not getting fry and fingerling of trout. It is noteworthy to mention here that with all these efforts of DCFR with Department of Fisheries, Govt. of Arunachal Pradesh, 1 Lakh fry of trout has been produced during 2014-15 at Shergaon Govt. trout farm, Arunachal Pradesh for the first time. DCFR has taken further initiative to improve the seed production potential of trout providing balanced diet and other management techniques. At present 500 kg. of brooders of both rainbow trout and brown trout has been maintained in the farm creating further avenues of trout fry and fingerlings for the farmers of the region.

Aquatic Resources and Fish Diversity in Manipur

Fish is the main food item of the majority of the people in the state of manipur. The largest source of fish is the Loktak lake. About 15,000 ha of water areas have been brought under fish culture operation. It is well-known that both the Brahmaputra and Chindwin systems of rivers drain Manipur and its fauna included both Assamese and Burmese elements. The district of Ukhrul is a land of beautiful mountains interspersed by numerous tribal habitats echoing with rhythms of tribal culture and rich wild life. It lies between 94.0' and 94.45' East longitudes. The district is located at an elevation range between 388 and 2,740 meters msl. The district has got enormous potential of coldwater fish culture in terms of natural resources and aquaculture practices.

Upland Rivers

Maklang and Tuyeng are two important rivers for Kasom Khullen and Kamjong sub-division. Thoubal river starts from the district and run through the Ukhrul North and Ukhrul central sub-divisions. It is the longest and biggest river in the district. Chammu and Chingai rivers are running through Ukhrul North sub-division. These rivers are not useful for

transportation as the current of the rivers are very strong and wild during the rainy season and very thin during winter. They are useful for fishing and irrigation.

Coldwater Fish Diversity

Many fishes were recorded new to India from the state. They are-*Mystus microphthalmus Garra gravelyi, G. kempi, Neolissocheilus stracheyi, Exostoma stuartii, Salmostoma sladoni, Chagunius nicholsi, Homaloptera rupecula, H. modesta, Mystus pulcher.*

Minor carp culture

The state Manipur has got immense potential for culture and breeding of minor carp like Bangana devdevi and Pengba (O. Belangeri) which are endemic to the state. These are highly preferred by the local people and fetch a high market price. The fishes has been bred successfully, however there is an ample opportunity to expand its culture along with grass carp to increase the productivity of the pond as well as tanks which will ultimately benefit to the local people. ICAR-DCFR has been working to develop a package of practice of Bangana devdevi, Osteobroma belangeri along with grass carp for the state of Manipur.

Trout culture

Some parts of Ukhrul dist of Manipur has got potential to start trout farming, where the water temperature and water source is favourable for its culture. However, no such concrete attempt has been made for its farming. This area need to be strengthened which may play an important to improve the livelihood security of the region.

Fishery Resources and Diversity in Meghalaya

Meghalaya, the hilly state, is one of the eight states of North-Eastern Region of India is covering an area of 22,429 km2 and is located between 250 02/ north to 260 06/ north latitude and 890 48/ east to 920 52/ east longitudes. Meghalaya comprises a hilly upland plateau formed by the Khasi, Jaintia and Garo Hills with an elevation ranging from 150 to 1961 meters above sea level. The state has 25 major rivers and innumerable streams constitute 83% of total aquatic resources, flowing through high and steep hills of various elevation ranges which form an extensive drainage network in the state. The principal rivers of the state run either a northerly to Brahmaputra basin in Assam or southerly direction to Meghna/Barak basin in Bangladesh.

It has been observed that composition of fish fauna in upstream of river Umiam has changed drastically due to construction of dams. Mahseer species like *Tor putitora* (Khalad), *Neolissochilus hexagonolepis* (Khasaw) once an abundant game and food fish declined sharply. Mahseer are migratory form fish are suffering most due to construction of dam which prevent free flowing of water and migration of fish in the state. Mahseer species in Umiam river are replaced by uneconomical plain water and semi torrential form of species like *Chanda nama* (Khasnad), *Badis badis* (Khasnoing), *Channa punctatus* (Dothli), *Lepidocephalus guntea* (Sher Syngkai) and prawn (Macrobrachium hendersonii dayanum) species locally known as symprong. Introduction of exotic fish like common carp (*Cyprinus carpio var communis*) and Thiland magur (*Clarias gariepinus)* in Umiam reservoir is another threat to the native fish like mahseer. At present common carp is dominating all other fish species in the Umiam reservoir.

There are various scopes for fisheries sector in Meghalaya towards its overall development. Some of them are ornamental fisheries, introduction of new fast growing species, culture of minor carps, integrated fish farming, culture and brood bank development of mahseer, eco-tourism and sport fisheries, declaration of fish sanctuary etc. The various steps taken by Fisheries Division, ICAR Research Complex for NEH region in this direction has certainly benefited the state and improved the fish production status.

There is a very limited possibility for coldwater aquaculture in the state especially of rainbow trout farming because of the climatic condition. The water temperature of the state is

4

not conducive for rainbow trout farming; however, there may still some possibilities to harness a suitable place for its culture and breeding in some parts of the state.

Chocolate Mahseer conservation and aquaculture

The state Meghalaya harbors the endemic chocolate Mahseer (*Neolissochilus hexagonolepis*) in most of the rivers and streams of Khasi, Jaintia and Garo hills. Apart from the *N hexagonolepis*, the *Neolissochilus hexasticus* and *Neolissochilus stracheyi* are also dominant in the state water bodies. Although some researchers have reported the occurrence of Tor putitora and Tor tor from Meghalaya, however, their distribution is very rare. Recently few species of Tor putitora were caught from the rivers of Garo hills. There are few natural sanctuaries of mahseer have been established in Meghalaya especially in Garo and Jaintia hills. In Garo hills, the chocolate Mahseer sanctuaries on Simsang river at Romberge, on Silver gee river and Ganol river has been protected by the villagers in association with the fishery department as a means of conservation which is really encouraging. The most important step for conservation of Mahseer in Meghalaya is to establish Mahseer hatchery and produce seed in captivity. ICAR-DCFR has made an attempt to develop a chocolate masher hatchery in Garo hills on the bank of Simsang River. There is also a scope to include mahseer in aquaculture along with grass carp in the mid altitudinal region of the state. The sincere efforts from all concern working in this direction would definitely help to achieve the goal in the Himalayan state.

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Aquaculture Resource and Development Status in North Eastern Region of India

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Abstract

Freshwater aquaculture in India has a reachable history since its early research on breeding and culture of carp initiated by CIFRI in 1947, and followed by phased research of technology development, fish seed production etc, which are further supported by creation of infrastructure to utilize developed technology in all round fish production processes through culture systems. The North East region of India presently comprising of eight states represents one of the hot-spots of fish germplasm diversity. In spite of high fish diversity in the region and vast potential of aqua resources, the North East Region is still lagging far behind from other parts of India in aquaculture development. There are reasons to it, which are highlighted in the present paper. This theme paper deals with the high potential of water resources of NER India besides the strength, weakness, opportunity & threat associated with the issues of aquaculture development in the region. Of the eight states of the region only seven states (barring Sikkim) are considered in this paper for reviewing the aquaculture situation in NER states. The paper also highlights the variable habitat water resources of fish denizen comprising of suitable candidate species for conventional aquaculture as well as non-conventional species for diversification of the aquaculture system besides environmental variations of freshwater resources in the region. The state- wise suitable aquaculture opportunity of components, fish production-demand gap and bottle neck for aquaculture development in the region are also discussed.

Key word: Aquaculture resource, SWOT analysis, development status

Introduction:

The global scenario of fish production from aquaculture sector has projected 55.1 mmt against the total production of 145.1 mmt, of which 90.0 mmt from capture fisheries of both marine and inland water sectors. India contributes 4.02 mmt from capture fisheries and 4.27 mmt from aquaculture in 2010 (Working Group Report, XII th Plan, Planning Commission, 2011). The major constraint faced by the inland fisheries in the country as a whole is the slow rate of growth against high potential due to lack of sustainable development of capture fisheries and stagnation in multiple species culture and rate of yield in aquaculture, may be due to lack of satisfactory input of quality seed, feed, technology diversification and regional coordination. The situation of aquaculture development in NE states is far depressing because of various reasons. As a result consumptive pressure of fish denizens on rich capture water resources have been increasing enormously for last several decades. Before initiating any development programme for species diversification in aquaculture programme in the country, the pride of fish germplasm in North Eastern Region (NER) is taken into account, which is fading up due to declination of the diversity of coveted indigenous species from the natural resources. The North Eastern States constitute a vast fresh water resources with 1,43,740 ha wetlands and lakes, 19,150 km stretch of rivers, 23,792 ha reservoirs, 40,809 ha pond & Mini barrage and also 2,780 ha paddy field (Sugunan,2003) being deprived of the maritime environment . The new inclusion of Sikkim (which is not included here in this paper) puts in another cold water sector keeping

scope for cold water aquaculture development to the region. The whole region is dominated by varied and diversified aqua- habitats of lotic river (including streams & tributaries) network (19,150 km stretch) overlaid by 3,59,135 ha lentic habitat admixed in plain river valleys (Brahmaputra and Barak), upland flat land valley (Imphal), upland hilly mountainous region covering about 65% area in Arunachal Pradesh besides Meghalaya(48.4%), Mizoram(100%), Nagaland(100%) and Sikkim(100%). The latter five states are dominated by streams. Arunachal Pradesh, Meghalaya and Sikkim are dominated by cold water streams alluring opportunities for cold water aquaculture. The plain and upland flat valleys of the other states are mainly marked by a maze of rivers and warm water streams, floodplain wetlands and lakes, paddy fields, ponds more and mini barrage, which harbor about 300-350 riverine and hill stream fish species.

The rich fish diversity, which includes a host of precious ornamental fish species, coveted commercial food fish species and many other species of conservation interest, is the pride of the region. Assam and Tripura claim to venture more for fish production in plains, and Manipur in upland flat land valley. In spite of having very productive water condition, enormous rate of fish consumption and fishing tradition, aggregation of devoted scientist experts in the field of research and all universities besides institutes having fisheries curricula, aquaculture fails to grow in the region up to the National standard. This demands a full-fledged national aquaculture centre to be established in the region embracing both warm water and cold water systems. Despite high aquatic diversity and enormous demand of human consumable aqua products the growth of aquaculture in the region is felt to be stagnant for past several decades due to lack of relevant regional planning. However, it is the need of the hour to think that aquaculture development is inevitable to reduce the pressure on capture fisheries in the region and to provide an alternative for offering livelihood to the poor fishers and the beneficiaries. Continuous irrational exploitation of aquatic bio-resources from all corners of fish aqua-habitats establishes a self style trade among the dependent populace, which is encouraged by the consumers. Here aquaculture development in the region is felt to be a surrogate of natural fisheries in the coming decades.The grim scenario of wild fisheries indeed for losing density, biomass and diversity of piscine and non-piscine products in natural rivers and lakes/wetlands, their conservation through peoples' participation and species diversifications in aquaculture are two options for gaining conservation and production of fishes in the region. Rural based aquaculture including integration of fish culture with rice and live stock production is easily available option for fast development of aquaculture in the North Eastern states. The SWOT analysis referred by the author (Goswami, 2009) may be useful for identification of the bottlenecks and formulation of the aquaculture development programme in the region. The present paper highlights the water resource potential, status of aquaculture and promises for its development in the north eastern states of India.

Fishery- Resource Potential of North Eastern States

The NE region is represented by a host of diversified habitat of fishes, which includes two large River drainages (viz the River Brahmaputra and Barak) and their tributaries, meandering rivulets and cold & warm water hill streams. The floodplain wetlands (beels/swamps/lakes) and paddy fields, which contribute to the capture fisheries are potential wild fish habitat of the region while ponds, reservoirs and mini barrages are the home of fish productive denizens. Showing a wide range of altitudinal variations among the seven N-E states (900-7089 m from msl) it represents the zonal pockets of tropical, sub-tropical, temperate and alpine areas. Characterized by diverse agro-climatic situation, the states other than Assam plains, Tripura and southern Mizoram (humid tropical), the others like Meghalaya and high altitude tectonic valley of Nagaland(sub-tropical) besides typical temperate to alpine climate in upper and lower trans-Himalayan part of Arunachal Pradesh maintain a coldwater climate. The spectacular

thermal variations prevail between 9-100C in mean maximum temperature and 7- 80C in mean minimum temperature with sub-zero to above in hills of Arunachal to above 360C in valley of Assam, Manipur and Tripura during different parts of the year (Sinha,2011). The hill states are mostly dominated by rheophilic streams followed by slow moving potamogenic courses and stagnant lakes/wetlands, while the two valleys of Assam (Brahmaputra and Barak) are dominated by river and tributaries followed by flood plains (beels) and hill streams. The maximum water area is explored for fisheries in Tripura (88.35%) closely followed by Assam (87.39%) and the minimum in Nagaland (7.91%).

Table-1: Water Resource Potential of North Eastern Sates showing explored and unexplored ratio (Based on Sugunan, 2003 in NBFGR publication edited by Mahanta & Tiyagi, 2003) & Sinha,2011)

State	**Water Resorce Potential**		**Explored (%)**	**Unexplored(%)**
	Lentic(ha)	**Lotic(km/ha)**		
Aruanachal Prdesh	33869	2000/NA*	43.4	56.6
Assam	184900	4820/205000	87.39	12.61
Manipur	42568	3360/13889	45.36	54.64
Meghalaya	11488	3329/NA*	57.94	42.06
Mizoram	27653	1395/6000	57.48	42.52
Nagaland	34315	1600/NA*	7.91	92.09
Tripura	22408	1200 /4729	88.35	11.65
Total	**357201**	**19150/229618 *NA**	**7.91-87. 39**	**11.651-92.09**

Source: Goswami, 2009; Sinha, 2011)

Production-Demand gap

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

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

Assuming 5% increase in population in the last decade (2001-2010) in all N-E states and trend of increase in fish production in certain states like Assam(15%), Tripura(10%) and the rest (5%) during 2001-2010, it is relevant to mention that per capita availability of fish in the states like Meghalaya, Nagaland and Mizoram is highly deplorable while Tripura is found to be very close (10.75) to the target of national average (11.0). Assam and Manipur are yet suffering from significant deficit followed by Arunachal Pradesh in spite of steady increase putting the averrage for NE states at 5.55 kg with 49.54% deficit (Table-2).

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

States	**Projected population**	**Requirement of Fish (t/yr)**	**Production (t/yr)**	**Per capita availability (kg)**	**Deficit (%)**
Arunachal Pradesh	1145673	12602	5797	5.06	54.0
Assam	27970327	307674	215371	7.7	30.0
Manipur	2455566	27011	16281	7.6	30.9

Meghalaya	2421372	26635	4910	1.75	86.36
Mizoram	935611	10291	3034	3.43	68.82
Nagaland	2088086	22968	5250	2.05	81.36
Tripura	3350726	36858	32279	10.75	2.27
North East(Av.)	**40,36,7,343**	**44,039**	**2,49,935**	**5.55**	**49.54**

Coveted large growing food fish species of NE

The large growing carps, cat fishes, murrels, feather back, Indian shad, hill stream carps and a host of commercial intermediate food fishes cum huge number of warm water and cold water ornamental fish species of hill streams, rivers and other lentic water sources in the north eastern states carry unimaginable promise for development of fresh water aquaculture in the region(Table-3).

Prospect of Species diversification in aquaculture in NER

India is basically a carp producing country contributing about > 75% of production from carps alone. Species diversification in aquaculture is considered as a relative alternative to accelerate the production trend in recent scenario besides cultural conservation of many dwindling species in nature. A good many fish species (* & ** mark) in the hotspot zones of water resources in N-E states (Table-3) could be considered to bring into the fold of candidate species for culture by formulating culture and breeding protocols in true sense of commercialization. Some of the species(**mark) are already taken up by the nation for the purpose in institute/institutional level obtaining partial success for seed production and cultural manipulation, which need more efforts to reach farmers level particularly in northeastern states.

Status of aquaculture development

The present status of aquaculture development is in a budding state in northeastern states. Tripura is to some extent advance in the process followed by Assam. The state based aquaculture system with relevant components may yield better result. Table- 4 indicates the present status of aquaculture in the northeastern states.

Table-3. Status of aquaculture development in north eastern region

Sl.	Components	Present Status
1.	Scientific farm infra-structure	Not developed
2.	Aquaculture engineering in infra-structure development and fish breeding	Not yet applied
3.	Mico-lab facilities	Not available
4.	Infra-structure for brood bank and species specific breeding facilities	Not yet applied
5.	GIS mapping of fishery environment	Not yet started
6.	Species diversification in culture	Concept developed; but not seriously taken up
7.	Integrated fish farming with rice and live stock	Not properly materialized
8.	Fish feed mill	Major constraint and allocated in XII plan budget

9.	Cold storage facilities	Not available
10.	Aquaculture technology development/high tech aquaculture	Very poor/ not to imagine
11.	Fish seed production (carp)	Deficient
12.	Seed production of Magur, Singhi, Koi,Murrel, Pangas and Chital	Experimental stage; not adequate or available to farmer
13.	Introduction of improved variety of Exotic species	Unaware of
14.	Cold water aquaculture	Inadequately developed; proceed in trial & error method
15.	Composite culture/Carp aquaculture	Established
16.	Intensive & super intensive aquaculture	Yet to developed
17.	Cage, pen & race way culture	Not developed using modern technology support &not in farmers' level
18.	Innovative small scale aquaculture for non-piscine products	Scope denied
19.	Fish harvest / post-harvest technology	Not scientifically developed/ not developed
20.	Post-harvest management	Not followed
21.	Marketing network	Not developed
22.	Ornamental fish aquaculture	Remained in natural exploitation level for trade
23.	Rural based aquaculture practices	Not yet scientifically introduced
24.	Technical guidance and Training	In adequate

Table 4: Some important fish species of N-E states to enhance aquaculture development through species diversification (* Candidate species for diversification, ** Species already tried)

Group	Species
Indian Major Carp	*1. Labeo rohita, 2. Labeo calbasu, 3. Labeo gonius 4. Labeo nandina* 5. Catla catla, 6. Cirrhinus mrigala*
Important Catfishes	*1. Silonia silondia* 2. Wallago attu* 3.Sperata aor* 4.S. seenghala* 5.Hemibagus menoda* 6. H. peguensis* 7.H. microphthalmus* 6.Bagarius bagarius* 7.Pungasius pungasius*, 8. Preocryptis afghana*, 9.P. barakensis*, 10. P. gangelica*, 11. P. indicus**
Murrels:	1.*Channa marulius*, 2. C. striatus**, 3. C. aurantimaculata*, 4.C. barca*.* 5.*C.punctata**
Eel:	1.*Monopterus cuchia** 2.M. alba* 3. Anguilla bengalensis* 4.Mastacembellus armatus*.*
Indian Shad:	*1. Tenualosa ilisha**
Hill stream Carps	1. *Tor tor*, 2.T. putitopra* 3.T. progenies* 4.Labeo pangusia* 5. L.diocheilus* 6 .Neolissocheilus hexagonolepis*, 7.N. hexastichus* 8..Semiplotus semiplotus*, 9. S.modestus**

Some other economic food species:	1.*Clarias magur*** 2.*Heteropneustes fossilis***, 3.*Labeo bata***, 4.*Chagunius chagunio**, 5.*Osteobrama belengari***, 6.*Puntius sarana***, 7.*Ailia coila**, 8.*Eutrochpichthys vacha**, 9.*E. murius**, 10.*Mystus cavasius**, 11.*M. bleekari**, 12. *M. vittatus**, 13.*M. tangara** 14. *Ompok bimaculatus***, 15.*O. pabo**, 16.*O. pabda**, 17. *Gudusis chapra**, 18.. *G. varieyata**, 19. *Anabus testudineus***
All exotic carps, cichlid & catfishes	Already introduced in India
Other ornamental fish species	Include all species reported so far having identified characters of ornamental fish species following the guide line

Development strategy

The development strategy may be aimed with the following objectives.

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

A SWOT ANALYSIS

Sl	SWOT	Parameters
1	**STRENGTH**	**1.** Healthy fish habitat potential. **2.** Coveted species of cultivable fish germplasm **3.** Institutional guidance and skilled human resource **4.** 90-95% fish eating population and high market demand of fish **5.** Abundance of fast growing fish species
2.	**WEAKNESS**	1. Technology backwardness 2. No proper utilization of unemployed youth 3. Poor and slow development of aquaculture infrastructure 4. Unorganized planning and lack of united efforts for aquaculture development among the states 5. Negligence in integrated aquaculture 6. Inadequate utilization of non-piscine product mix in aquaculture 7. Poor management strategies 8. Non availability of nutritional fish feed ingredients in the region and non availability of fish feed preparation industries 9. Lack of follow up action of the worked out plan offered by various central organizations, local researchers and planners 10. Absence of grass root level research in the region on culture and breeding programmes of aquaculture

		11. Poor understanding for linkages among the researchers of institution, institutes, Govt, departments, NGO's etc.
3.	**OPPORTUNITY**	1. Institutional and institute guidance and help 2. Opportunity to receive Central Government and International fund 3. Project allocation from various agencies 4. Presence of vast cultivable water area 5. High diversity of ornamental fish species 6. Presence of fish breeding infra structure **7.** Research on fish culture & breeding and fishery economy and aquaculture environment
4.	**THREAT**	1. Decline of fish population/increasing number of threatened and vulnerable fish species 2. Shrinkage of fish habitat 3. Ignorance of values of avenues of aquaculture by local population 4. Infrastructure bottlenecks **5.** Failure of confidence building among the people of NER by the Central Government

Table 5. State wise opportunity of aquaculture

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

Source: Goswami, 2009.

Delineation:

The fisheries sector in the N-E region (Sikkim not included here) is dominated by capture practices as a traditional avenue followed by sluggish development of aquaculture practices. In the total land area of 2,55,000 km2 covering about 7.7% of the country except two states (Arunachal 32.8% and Assam 30.8%) the rest of the five states are smaller in land area(4.1-8.8%) and Tripura being the smallest (4.1%). This land locked zone remains isolated from the rest of the country since independence. In spite of having about 3,57,201 ha lentic and about > 2,29,618 ha lotic water resources (being deprived of marine and brackish water) and convincingly high fish diversity ie. about 35.2 % of 806 freshwater fish species of India (Talwar and Jhingran,1991), high diversity of productive fish habitats and high emergence of large growing carp & cat fishes and small ornamental fishes mostly found in Asia, this region is far lagging behind in aquaculture development from the rest of the country. Remoteness and disadvantage of surface communications (Sinha, 2011) may be the identified reason for such distress. A complied list of 284 fish species state wise occurring in the region (Sinha, 2011) based on the records of Sinha (1994), Nath and Dey (1997), Sen (2000), Vishwanath (2000), Ao et al. (2008) establishes the strength of fish diversity of the region. Also from the subsequent publications the diversity is recorded to be higher (296) known from the record of Vishwanath et al.(2007). Besides that from Manipur itself more than 35 new species have been reported in the couple of recent decades by Vishwanath and his associates (Singh,2014). Considering the strength of food fish diversity, for the use of diversification of species in aquaculture development of N-E states, about 50 species have been identified in the present report (Table -3). The state of affair of ornamental fish diversity in N-E states is a boon for the region (Biswas et al.,2007) considering about 91% fishes of the region exhibit ornamental values (Singh, 2014).

Of the seven states (Sikkim not included), Tripura has shown considerable development may be due to honesty and respect to the programme of aquaculture. Being the smallest land area and with meager available capture fishery resources, the fresh water aquaculture remains the main stray of fish production in Tripura (Sinha,2011). The available capture resources and utilization status of aquaculture, Tripura is in the first leading state closely followed by Assam (Table-1). It is interesting to note that Tripura created about 5978 ha new water areas in 2004-05 to 2008-09, of which available aquaculture resources added up to 19,258 ha in 2008-09 consisting of ponds/tanks and mini-barrage (7,340 ha) followed by creation of more new area to reach 20,521 ha during 2009-10. (Sinha,2011). As a result, Tripura is able to minimize the production - demand gap up to 2.27% below the national per capita consumption of 11kg (Table-2). From the point of view in progress of aquaculture development, Tripura claims to have the first state in NE- region.

The culture based fisheries potential over capture fisheries can be increased in many folds to achieve a ratio of 4:1 in terms of production sharing 80:20 to reduce pressure on capture fisheries (Goswami, 2009). In the present scenario all states are still dependent on fish production potential of capture water resources and in that, Assam registers the highest (from rivers and beels etc) followed by Manipur. Again, considering the habitat diversity of fish in 19,150 km of streams and rivers, 23,792 ha reservoirs (besides 68,760 ha for expansion), 1,79,696 ha beels and swamps, 40,809 ha aquaculture ponds/minni barrage (besides 12,286 ha for expansion) and 11,544 ha paddy cum fish culture (besides 48,910 ha for expansion) – (Table-1), there has been enough scope to organize suitable aquaculture packages among all N-E states (Goswami, 2009). It is also reported that compared to the capture fisheries habitat (excluding 19150 km stretch of rivers) the existing aquaculture area so far available in the region is extremely meager (5.27%), ie. in a ratio of 95 : 5. and it is far below (about 1.0%) when river fishery is taken into consideration (Goswami, 2009). By taking into account the status (Table-4), development strategy, SWOT analysis, need of aquaculture components in

N-E states, and state wise opportunity (Table-5); the development of aquaculture and application of state based aquaculture technologies in north eastern states will definitely help to increase production and to reduce the gap.

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Potential and Challenges for the Development of Aquarium Fisheries in N.E. India

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Abstract

Species composition and species diversity vary widely in the riparian ecotone of the Brahmaputra basin. Being in high rainfall areas, various types of seasonal water bodies, derelict ponds, paddy fields, and road side canals are found in the plains of the region. The floodplain lakes (FPL) in riparian zones were often found richer in species composition than the adjacent/connecting river itself. The 3500 odd FPL, (locally known as beels) scattered throughout the Indian side of the Brahmaputra River are the main storehouse of aquatic biodiversity of the region. Trophic structure is typically present in the FPL from surface dwelling to typical substrate dwelling species like Glossogobius giuris to mud-dwellers like Monopterus cuchia or burrower like Channa barca. The beels constitute a major inland fisheries resource for the region providing livelihood support to thousands of riparian fisher folks for centuries. Besides harbouring a large number of highly threatened and endemic species, the beels are also very vital for conserving finfish and shellfish germplasm essential for sustained development of aquaculture. Traditionally, seasonal water bodies serve important fishery resources in rural areas. Among all the available water resources, the beel (wetlands) offers greatest scope for the expansion of culture based fishery. Assam alone has the potential to produce an additional 1 lakh ton of fish/yr even if 10% of the available wetland area is covered under aquaculture programme. However, lack of management and zero investment, fish yield per unit area from this type of aquatic system is moderate and often very erratic. Further, a number of natural and anthropogenic threats like siltation and shrinkage of beels and other seasonal water bodies, over exploitation and destructive methods of fishing have been identified as prime causes for the depletion of natural stock of Botia, Badis, Chanda, Channa, Chaca, Macrognathus, Mastacembelus, Nandus, Leiodon and Trichogaster from the beels. There is an inherent danger of certain species disappearance from this region if the present mode of exploitation continues unabated. Emphasis need to be given to utilize seasonal water bodies like wetlands, swampy areas, paddy fields and nallas for mass rearing of ornamental fishes. Practically seasonal water bodies act as nursery ground for all these species. Another major issue is the standardization of breeding protocol suitable to the climate condition of the region. But the major impediment in artificial propagation of indigenous ornamental fish is the limited knowledge of their biology. Information on the biology, particularly feeding habit and maturity cycle are essential along with the knowledge about habitat ecology of the target species for successful propagation and rearing in controlled environment. All these issues need to be addressed properly before taking any developmental programme on ornamental fish culture.

Key words: Ornamental fish, seasonal water bodies, captive breeding, north-east India

Introduction

The north-eastern region of India is blessed with a number of river- formed and tectonic beels, out of which about 84% belongs to Assam. However, with burgeoning growth of population, fishing pressure continues to increase particularly in the inland waters. Many fish species are in decline and some have become endangered due to a combination of overexploitation, aquatic pollution and habitat modification. Most of the fish species available in NE region are captured from their wild habitat. A good number of them have

been collected from the wild waters and made available to the domestic and overseas market for trade (Das & Biswas. 2008). Considering its vast potentiality, mass culture of indigenous ornamental fishes for the global market could be one of the most viable alternative sources of livelihood for the rural masses of the region. However, feeding habit, reproductive strategy or technique for captive breeding is unknown for most of wild fish species of the region. Biological information of prioritized species and standardization of their breeding protocol should get top priority to achieve the goal.

Biswas et al., (2007) identified 93 species of fish from north-eastern region suitable as potential aquarium rearing and amongst them; a good number of species are larvivorous in feeding habit. The indigenous fishes of the genus Puntius, Amblypharyngodon, Trichogaster (Colisa) etc. use mosquito larvae as a part of their diet, requiring no additional effort for culture (Bambaradeniya et al., 2004; Chandra et al., 2008). Thus, the indigenous larvivorous fish can be a potential candidate for biological control of mosquitoes in rice fields. Further, in most of the larger mosquito larval habitats, the feeding efficacy of the indigenous larvivorous fishes are better than insect predators (Aditya & Saha, 2006; Chandra et al., 2008). Similarly, *Channa gachua*, a common murrel found in derelict water bodies can be used for the biological control of the mosquito larvae (Phukon & Biswas, 2013).Despite the importance of these wild fish species, no serious attempt has been to rear and breed these so called 'trash fish' in captivity. Further, there is an inherent danger of certain species disappearance from this region if the present mode of exploitation continues unabated. Fortunately, a few attempts have been made to breed indigenous ornamental and food fish species from Assam in recent years (Purkayastha et al., 2012; Hazarika et al. 2014; Bailung & Biswas, 2014). The present paper therefore, mainly focused on feeding and spawning habit as well as rearing and captive breeding of certain ornamental fish species which have been carried out in the Dibrugarh University since 2007.

Materials & Methods

The fish species selected for the present report are two species each of barbs (Esomus danricus and P. daniconius), loaches (Botia dario and Lepidocephalichthys guntea) and gourami (Trichogaster fasciata and T. sota) Different aspects of feeding (RLG, feeding intensity or GSI, food preference) and spawning (sexual dimorphism, maturity cycle, maturity index or GSR, fecundity) habit of selected species were studied following Biswas (1993).

Rearing experiment:

For rearing feasibility, live specimens of selected species were collected from their natural habitats (various wetlands of upper Assam). The collected specimens were treated with 2 to 3 drops of KMnO4 solution mixed with 10 l of water and kept for 2-3 days. The rearing of different species has been done in separate aquaria with a varying water depth of 18-30cm for acclimatization. Each aquarium was having few floating weeds and provided with constant aerator, aquarium thermometer and bottom were covered with fine sand mixed with small sized stones (Fig.1). During winter season, the temperature was found to be below tolerance level so to maintain water temperature around 240C, a heater was installed. Rearing was done by maintaining standard water quality and providing artificial formulated feeds along with supplementary feed was provided to both the fishes. Fishes were also supplied with insect larvae, mosquito larvae and chopped snails mixed with flour dough and given to the aquarium fish in pellets form. Plankton was collected from their natural habitats. A conc. of 0.2-0.3ml/l plankton was given every week. Further, growth performance of each individual species was recorded by taking their length and weight randomly. Growth rate and survival rate of the fishes was calculated following (Francis, 1995; Pillai & Lakra, 2000).

Experimental design for captive breeding:

A total of 8 no of glass tank size of (120 x 45 x 45) cm and (60x 30 x 30) cm were selected for breeding of the selected species. Each aquarium was provided with a mixture of river sand and small gravel with smooth surface and the thickness of bottom bed was 1.5-2.5 cm, containing some submerged/floating weeds were kept to create a spawning habitat for the test fish species. This was followed by filling up of 3/4th of each aquarium with good quality water. The water was allowed to settle for the next 5 days. In the corner, filter with feeble aeration is provided in the tank. Selection of brooders was done from March- April onwards when the GSR values of both males and females steadily increases. Brooders were segregated as soon as 'pair formation' was noticed (Fig.2). Since the gouramis are bubble nest builders, a set of 2 male and 1 female was released in the aquarium a couple of days prior to hormonal injection and allowed them for acclimatization and for formation of bubble nest. After formation of bubble nest, both male and female of T. fasciata and T. sota were injected with ovaprim hormone 0.3- 1.0 ml/ kg body wt between the dorsal fin and slightly above the lateral line with a 6 ml hypodermic syringe and were released in the respective aquarium (Fig.1). Similarly, to start with captive breeding of loaches dosage of ovaprim was administered @ 0.3-0.5ml/kg body wt of the fish (Fig.4). If the brooder did not respond, the dosage was increased. As a whole, this was a trial and error method for standardization of hormonal dose.

Results & Discussion

For each T. fasciata and T. sota, 7 breeding trials were conducted during the second year. Observation was made on the courtship behaviour after 6-8 hours ovaprim treatment. Each breeding set consisted of two male and one female. In natural breeding the ripe male creates 'bubble nest" (Fig.5). After completion of courtship the female releases the eggs at late night and completed the spawning activity in the morning. The mating took place below the nest. The released eggs were scatter and fall inside the bottom. The numbers of egg varied from 190 to 429, in T. fasciata and 111 to 236 in T. sota depending on the size of the females and dose of ovaprim injected. After spawning parents collects the falling eggs in their mouth and spit them beneath the nest. The latency period varied from 9 to 15 hrs. The rate of fertilization was varied from 44 to 74% in T. fasciata and 46 to 57% in T. sota. The eggs remained attached to the underside of the nest. The male guards the eggs and hatching occurs in 48-72 hours. The percentage of hatchlings was 44 to 64 in T. fasciata and 48 to 60 in T. sota. After 96 hours, the fry were free swimming and they were fed with egg albumen. Fine flake foods were given to the fry once they are approximately one month old. Water was changed every two to three days. As the fry grew larger (Fig.6) they were distributed between several tanks to reduce lethal build-up of wastes. L. guntea is a hardy fish and thrived well in captive condition, while B. dario being sensitive to the confined condition, recovered 65% survivability during the study period. The results revealed that they can grow well in aquarium condition provided temperature and aeration kept at a reasonable range. Water quality parameters of aquarium were maintained within the permissible range of BIS (1982). Their feeding efficiency revealed that they were nocturnal bottom foragers. No aggressive behaviour was noticed. However, if frightened they quickly hide under sand/aquatic plants. The loaches are high fecund species. The 50% maturity revealed that both the loaches mature at 10-15 cm (males) and 15-20 cm (females). Based on the K value, GSR and ova diameter studies, it may be concluded that the peak breeding season for B. dario is June-July while L. guntea have a relatively prolonged breeding season (April- July). The breeding attempt with ovaprim @0.5ml/kg body wt was not successful and the breeding experiment would be repeated next season under a different set of conditions. Both the species are suitable for

aquarium rearing and such standardization of captive breeding technique has been recommended as future programme of work.

The breeding season of barbs starts from April and lasts till August. During the experiment both the species thrived well at a pH between 7.2 and 7.8. Both the species were found comfortable and preferably to alkaline water. Water temperature was recorded over the experimental period was 26.5–310 C. The DO ranged between 4.8 and 5.6 ppm. FCO2 in the breeding container was 3.5 ppm.

In the first attempt, administration of ovaprim @ 0.5-0.8ml/kg body wt did not give satisfactory result. In the next trial, both the sexes of E. danricus and P. daniconius were injected with a dose of 1ml /kg body wt. Stripping helps the female to released eggs in the roots of the aquatic plants. The no. of eggs released was between 220 and 300 and out of which 30–60 eggs were hatched. 26 number of Esomus danricus survived (47% survival) for 24 days. However the overall survival rate was further decreased as only 16 individuals survived till adulthood (170 – 200 days). Hence, final percentage of survival rate is estimated as 35%. But when both male and female of E. danricus and P. daniconius were injected @ 1-1.5 ml/ kg body wt, the brooders were found very active, chasing each other after 12 hrs -14 hrs of hormonal administration, and female released their eggs in the roots of the Pistia and at some stone chips floor of the aquarium. As soon as the female release their eggs, the males also release the spermatozoa and fertilize the eggs. During the period, the absolute growth attained by E. danricus was between 0.81 to 1.02 gm and 3.7 to 4.2cm. In case of P. doniconius, females released about 200-350 numbers of eggs, out of which 50 to 80 eggs were hatched. Altogether 42 individuals survived till 3 months with a survival rate of 60 % of which 27 survived till it grows upto adult stage (180 – 220 days). Hence, final percentage of survival of P. daniconius was 41%. During this period the species attained body weight of 2.24 - 2.85 gm and a length of 4.8 - 6.5 cm (Fig.3). Both the species were removed from the aquarium to avoid predation on eggs.

It has been noticed that when the fry were kept in aquarium for more than two weeks and fed with synthetic fish meal, they lost their body colouration. It is suggested that the fry should be kept in earthen pond where they would get the natural planktonic food, necessary for the development of body pigmentation. If cemented tank is used for rearing, the bottom of the tank should have a thick ‘mud’ layer and a fair amount of floating and submerged aquatic macrophytes are to be provided for the shade/shelter of fry as well as for attracting aquatic insects which form the food of the growing fry.

Conclusion:

Traditionally, seasonal water bodies serve important fishery resources in rural areas. Among all the available water resources, the beel (wetlands) offers greatest scope for the expansion of culture based fishery (Biswas & Choudhury, 2008). Assam alone has the potential to produce an additional 1 lakh ton of fish/yr even if 10% of the available wetland area is covered under aquaculture programme. However, lack of management and zero investment, fish yield per unit area from this type of aquatic system is moderate and often very erratic. Further, a number of natural and anthropogenic threats like siltation and shrinkage of beels and other seasonal water bodies, over exploitation and destructive methods of fishing have been identified (Biswas et al., 2001) as prime causes for the depletion of natural stock of Botia, Badis, Chanda, Channa, Chaca, Macrognathus, Mastacembelus, Nandus, Leiodon and Trichogaster from the beels. Considering its vast potentiality, mass culture of indigenous ornamental fishes for the global market could be one of the most viable alternative sources of livelihood for the rural masses of the region. Further, unsustainable mode of resource exploitation coupled with human induced habitat alteration threatened the natural fish population including the ornamental one of the region. The market demand for ornamental fish and as all the collections are hitherto been made from wild

population, there is an inherent danger of certain species disappearance from this region if the present mode of exploitation continues unabated. So, development of breeding technique is necessary to avoid such wild collections and for their long term conservation.

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A Study on Present Scenario and Development of Fisheries in Assam

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Abstract

Assam is the second largest state of North East India covering 78,523sq.km endowed with varied aquatic resources are in the form of beel, rivers, ponds and tanks, derelict water bodies etc. The state harbours altogether 216 economically important species. Besides offering a potential source of income generation, fish provides an excellent source of protein for human health and fishery sector contributes 2.42% towards GDP of state. During the last six years fish production in the state has increased steadily and reached a level of 2.82 lakh MT in 2014-15 as compared to production of 2.18 lakh MT in 2009-10. Simultaneously the fish imported to the state is also gradually declining from 18.87 thousand metric ton in the year 2009-10 to 12.00 thousand metric ton in 2014-15. With a view to address some of the constraints attributed to inadequate fish production in the state, Department of Fisheries has taken several measures with holistic approach .One of the important measures is enactment of Assam Fish Seed Act, 2005, first of its kind in the country is to improve the quality fish seed. The need in this juncture is the holistic development through need based planning, mobilization and sustainable utilization of resource and efficiency enhancement.

.Key words: Fishery sector, aquatic resources, GDP, Department of Fisheries

Introduction:

Assam is the gateway to the North Eastern part of India. It is the most populous and second largest state in North-East India with the total area of about 78,438 sq. K.M. The land locked state is situated in eastern Himalayan region between 24.10N to 27.90N latitude and 89.80E to 96.10E longitude. The state is bounded by Bhutan and Arunachal Pradesh in the north; towards east and south of it lie Arunachal Pradesh, Nagaland, Manipur, Mizoram, and Meghalaya. Its western boundary touches West Bengal, Bangladesh and Tripura. Bangladesh touches twice at Dhubri and Cachar districts. Geographically the state is divided into four distinct regions viz. Brahmaputra valley, , Barak valley and the Hill Zone consists of two hilly districts namely KarbiAnglong and Dima Hasao. The climate of Assam is cool but humid. The heavy monsoon rain begins from mid June and continues up to early October with occasional dry spells. The total average annual rainfall varies from place to place from 100-300 cm. Average maximum temperature is 35-38oC and minimum is 6-80C. As per census 2011, the population of the state is 3, 11, 69, .272 and population density in Assam is about 397 per sq. km; sex ratio is 954 females in per 1000 males and literary rate is 73.18 % (Males 78.81% and females 67.27% (Statistical handbook of Assam, 2013). Fish is an important food item in almost every household in Assam, plays an important role in the economy of sizeable section of population of Assam. It also occupies a significant position in the socio-cultural scenario of the State. Above & beyond, offering a potential source of income generation, fish provides an excellent source of protein for human health (Mishra and Das, 2014). Fish is an integral part of cuisine and culture of people of Assam. Most of the Assamese people prefer fresh fish almost in every meal and thus fishing is traditionally interwoven in their everyday life. Nearly 95% of them are fish eaters. The present per capita consumption of fish in Assam is 8.3 kg/annum against national figure of 8.5 kg/annum. Assam is also rich in water resources with two major river systems- the mighty Brahmaputra and the Barak besides wetlands, low-lying and derelict water bodies which are most potential for fish production. However, with an abundance of about 4.9 lakh ha of freshwater

resources, the State has still not been able to tap the potential area for inland fish production. This sector can largely contribute towards uplift of rural livelihood, nutritionals security and economic prosperity, provided fisheries management and fish cultivation is done on a scientific basis.The state is also considered as a biodiversity hotspot including diversified aquatic flora and fauna (Kottelnat and Whitten, 1996). So far 216 fish species has been recorded in the State out of which more than 50 species are having ornamental value with global demand (Bhattacharjya et al, 2004). Among the fish farming environments in State, semi-intensive polyculture is the dominant system practiced. Basically Assam's aquaculture is carp-oriented and the contribution of other species is marginal. The major culturable fish species are Indian carps viz. Labeo rohita (Rohu), Catla catla (Catla), Cirrhinus mrigala (Mrigal) ,Labeo calbasu (Calbasu), Labeo gonius (Kurhi),Labeo bata(Bhangon) (Bhattacharjya,2000) and Exotic carps viz. Ctenopharyngodon idella (Grass carp),Hypophthalmichthys molitrix (Silver carp) and Cyprinus carpio (Common carp) (Sen,2000). Introduction of other species like Chitala chitala (Chital), Clarias magur (Magur), Channa striatus (Sol), Anabas testudineus (Kawoi), freshwater prawn etc in the culture system has also been coming up in the recent years. The average yield varies according to species group, level of input use and intensity level. Cost structure is primarily composed of the cost for construction/development of the water body, cost of inputs (fish seed, feed, and fertilizer), management and harvesting. There are about 3 lakh fish farmers engaged in fish culture and about 10 lakh fishermen population involved mainly in capture fisheries. Adopting various levels of management practices fish farmers are producing fish in their individual ponds and community tanks covering about 60,230 hectare of water area. Fishery sector contributes 2.42% towards GDP of State. During 2014-15, total fish production in the State was 282 thousand ton which is around 10% higher than that of the ending year of the 11th five year plan i.e. 2011-12. Considering the potential and development prospect of the fisheries sector, government has come up with schemes to help the cause of the farmers. Horizontal expansion is being accomplished through creation of new ponds and reclamation and renovation of existing areas followed by fish culture through community/Co-operative and Self Help Groups. On the other hand thrust on vertical expansion is given through productivity enhancement with adoption of improved & advanced culture techniques and better sustainable management practices. Emphasis has also been laid down for making the best animal protein source in the form of fish available to all as well as creation of self-employment opportunities. The present paper has assessed the present scenario and potentialities of fisheries sector in Assam

Fisheries in Assam:

Fisheries sector is an important sector in the state of Assam which provides employment opportunity to a large number of people besides providing nutritional security. Majority of people of state are fish eaters which is approximately 95% of total population. Hence demand of fish in the state is very high. The importance of fisheries in the rural economy of Assam is next to agriculture. In Assam, fishing activity by profession was confined to only few castes. Over the last few years, there has been a paradigm shift towards modern fish farming practices throughout the state irrespective of the, caste and gender. Thus the activity is no longer caste specific and the practice of culture fishery has become acceptable to all sections of society. These efforts however do not always follow the best practice models derived from scientific studies and thus needs improvement. There is need to implement new technology of fish farming to augment the fish production of state and farmers to be equipped accordingly. It can be mentioned here that the present level of annual fish production in the state is 2.82 lakh mt (2014-15) against nutritional requirement of around 3.25 lakh mt, estimated at minimum of 11 Kg per capita per annum. The economic demand stands for over 2.94 lakh mt. The gap between the present production and demand is partially met by importing fish of

about 0.12 lakh mt annually from other states such as Andhra Pradesh, Uttar Pradesh, Bihar etc. With the growth of State economy and increase in purchasing power of the people, the demand and consumption of fish has increased manifold. This indicates huge potentiality for development of this sector in the state (Borah and Bania, 2013). In addition to fishes, aquatic resources of the state includes Gangatic river dolphin, turtle, aquatic lizards, frogs, crabs, insects etc. along with many aquatic vegetation and diverse zoo plankton and phytoplankton in vast floodplain wetlands, rivers and streams (Motwani et al,1962).
Aquatic Resources of Assam

Aquatic Resources of Assam

Table 1: The resource wise break-up of aquatic resources and their present status of utilization are given below.

Sl no	Resources	Nos	Water area (ha)	Present Utilization
1	Farmers pond and individual tank	3,60,348	54,566	Semi intensive farming covering around 12,000 ha. Rest is under traditional farming.
2	Community Tank	6308	5141	Extensive and semi intensive farming
3	Beel Fisheries	Registered: 430 Unregistered:767	60,215 40,600	Extensive farming on about 10,000 ha approximately. Rest unscientific and traditional management
4	River	Main river: 2 Tributaries: 53	2,05,000	Unscientific/unexploited/Traditional
5	Derelict water bodies/Swamps/ Low-lying area	3887	1,16,444	About 5000 ha developed. Rest unutilized.
6	Reservoir fisheries	1	1713	Unutilized
7	Forest Fisheries	71	5017	No fishing, mainly under conservation.
	Total		**4,88,696**	

(Source: Department of Fisheries, Government of Assam)

Role of Department of Fisheries, Government of Assam:

Immediately after independence in 1948, the Government of Assam created an unit under Department of Cottage Industries to look after all aspects of fishery, basically to coordinate the various activities of fishery in the state, more so in the matter of settlement of fisheries even if it was for the limited purpose of earning revenue for the Government. Two years later the unit was detached from the Cottage Industries Department and attached to the Agriculture Department. It continued till 1963 when it was again decided that the fishery unit be attached to Department of Veterinary and Animal Husbandry. During this period, the post of Director of Fisheries was created in 1968. In December 1991, a decision was taken to create a separate Department of Fisheries, from when it was free to grow on its own from strength to strength and acquire the status it deserved. The Fisheries Department is located in Assam Sachivalaya, Dispur, Guwahati. There is one Directorate, namely Directorate of Fisheries through which the Department implements various schemes and programmes. The Directorate is located at ‘Meen Bhawan’, Gopinath Nagar, Guwahati. The Assam Fisheries development Corporation Limited (AFDC) is the only corporation under the Department.

Responsibility of the Department:

The prime objective of the Department is to develop fishery in the State by adoption of appropriate technology. The Department implements its schemes and policies etc. through the Directorate of Fisheries and Assam Fishery Development Corporation Ltd. Modern practices are to be disseminated to the fish farmers in the State through the extension machinery. The Department endeavours to promote private fish farmers for increasing the fish and fish seed production in an eco-friendly manner. The aquaculture and fisheries potentialities of the State are explored with the view to achieve not only self-sufficiency in the production of fish in the State but also to export marketable surplus to the neighbouring states and countries.

Organizational structure (Set up):

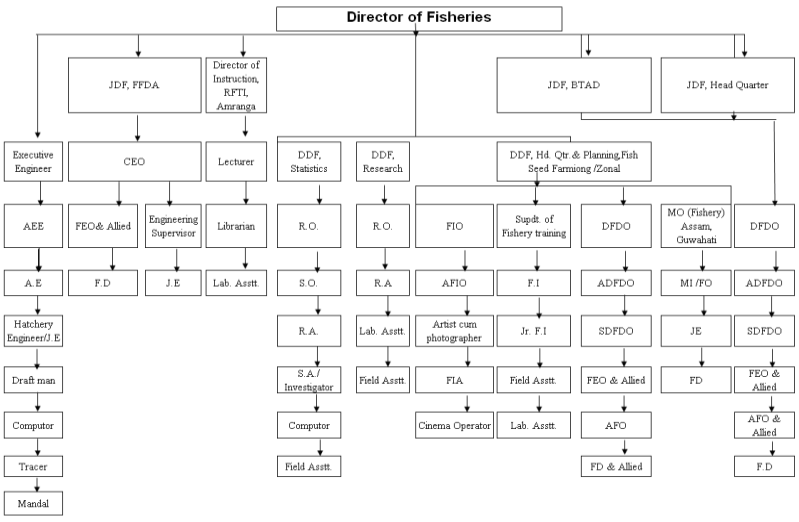
The Fisheries Department is located in Assam Secretariat at Dispur, Guwahati-6. There is one Directorate, located at "Meen Bhawan", Gopinath Nagar, Guwahati-16 to implement various schemes and programmes. The Assam Fisheries Development Corporation Ltd. which is located at VIP Road, Sixmile, Chachal, Borbari, Guwahati: 36 is the only Corporation under the Department.

a) Administrative set up:

Minister of Fisheries
↓
Principal Secretary
↓
Deputy Secretary
↓
Under Secretary
↓
Office Superintendent
↓
Ministerial Staff

Sl.	Category	Sanctioned strength	Total staff in position	Vacancy
1	Class-I	250	175	75
2	Class-II	29	6	23
3	Class-III	706	563	143
4	Class-IV	361	288	73
	TOTAL	1346	1032	314

Organisational Structure of the Department



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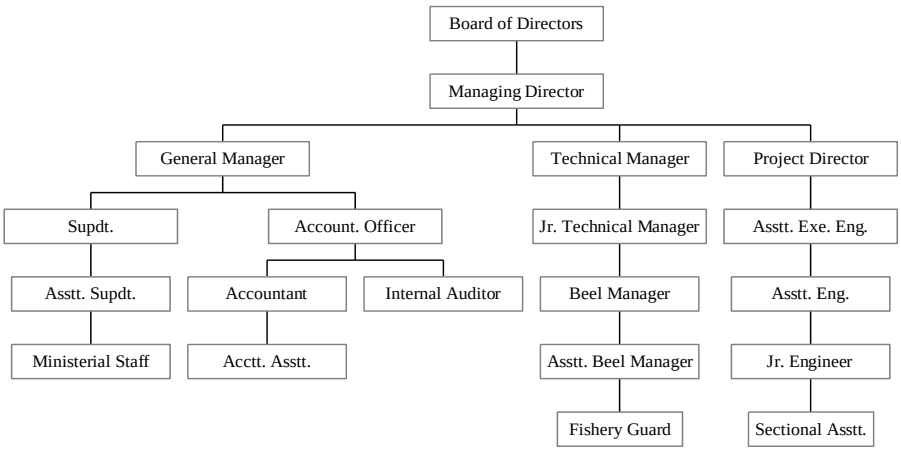
d. (Organizational structure of Assam Fisheries Development Corporation Ltd.:



e. Staffing at Assam Fisheries Development Corporation Ltd.

Sl. No.	Name of the Corporation	Sanctioned strength	Staff position	Vacant Posts
1	Assam Fishery Development Corporation Ltd.	107	77	30

(A) AQUACULTURE INFRASTRUCTURE

Sl. No.	Aquaculture Infrastructure	Nos.
1.	Nos. of Eco-hatchery (Govt.)	18
2.	Nos. of Eco-hatchery (Pvt.)	373
3.	Departmental farm (Govt.)	141
4.	Feed Mill (Govt.)	1
5.	Feed Mill (Pvt.)	7
6.	Departmental training centre	9
7.	Hapa breeding farm (Pvt.)	400

(Source: Handbook of Assam, Government of Assam)

(B) FISH RESOURCES

Sl. No.	Fisheries resources	Nos.
1.	Total identified fish species	216
2.	Species having ornamental importance	150
3.	Species with overseas ornamental value	50
4.	Major fish species for culture	
(i)	Indian major carps: Rahu, Catla and Mrigal	
(ii)	Exotic carps: Silver carp, Grass carp and Common carp	

(Source: Department of Fisheries, Government of Assam)

D) FISH SEED PRODUCTION of last six years

Year	Production (Million nos. fry)	% increase over preceding year
2009-10	3326	-3.0
2010-11	4264	2.8
2011-12	4490	5.3
2012-13	4364	-2.8
2013-14	4545	4.14
2014-15	4585	0.88

(Source: Department of Fisheries, Government of Assam)

(E) FISH PRODUCTION of last six years

Year	Production (Million kg.)	% Increase over Preceding Year
2009-10	218	5.83
2010-11	232	6.42
2011-12	243	4.74
2012-13	254	4.52
2013-14	267	5.11
2014-15	282	5.62

(Source: Department of Fisheries, Government of Assam)

F) INFLOW OF FISH FROM OTHER STATES DURING LAST SIX YEARS

Year	Quantity (Thousand tons)
2009-10	18.87 thousand metric ton
2010-11	17.92 thousand metric ton
2011-12	17.56 thousand metric ton
2012-13	16.45 thousand metric ton
2013-14	12.83 thousand metric ton
2014-15	12.00 thousand metric ton

(Source: Department of Fisheries, Government of Assam)

(F) DEMAND v/s SUPPLY in the year 2014-15

	FISH (IN LAKH MT)
Nutritional demand	3.25
Economic demand	2.94
Total production	2.82
Fish coming from other states (A.P, U.P, Bihar, etc.)	0.12
Fish going outside the state (N.E states and North Bengal)	0.05

(Source: Department of Fisheries, Government of Assam)

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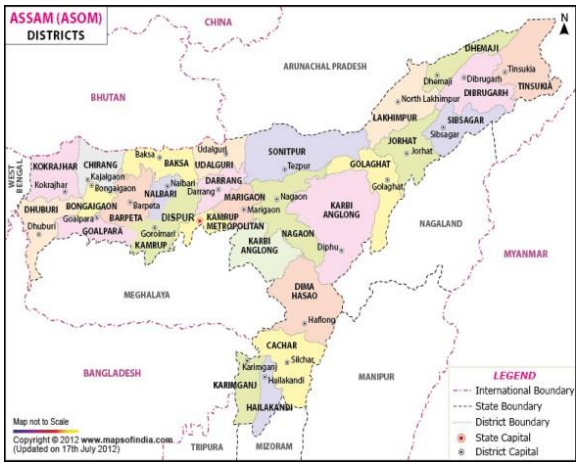

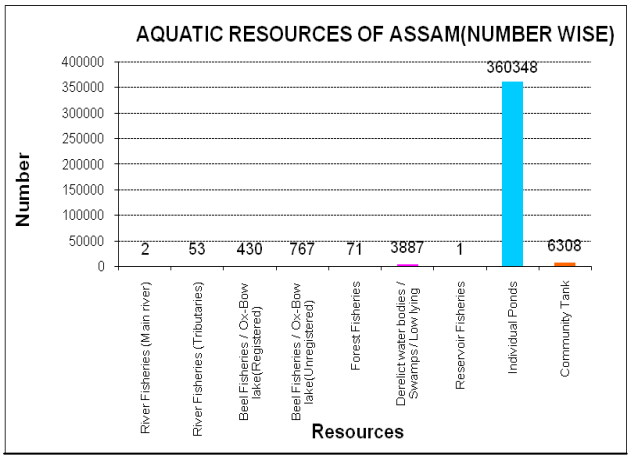

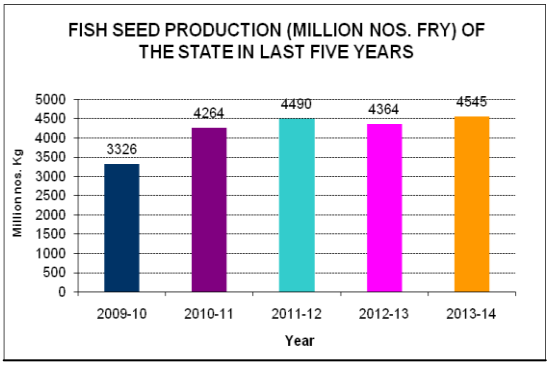

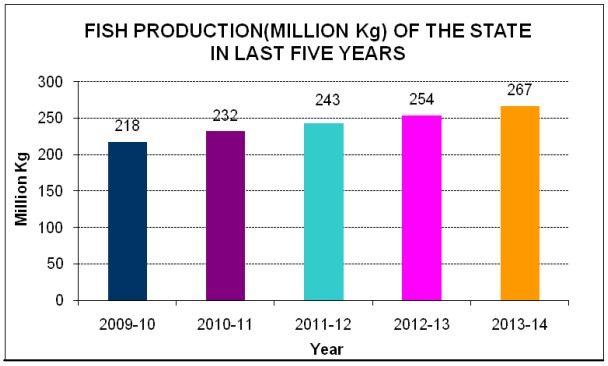

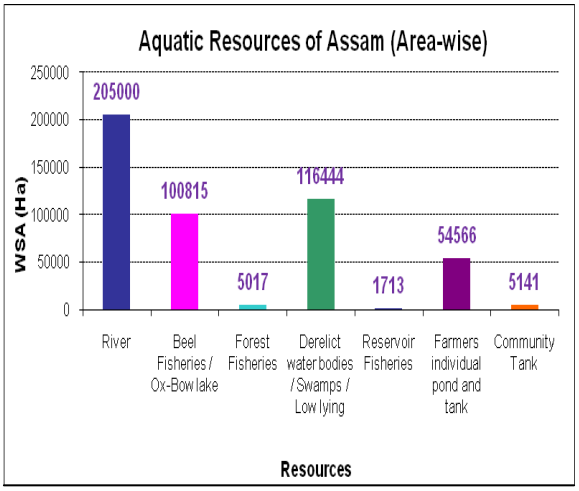

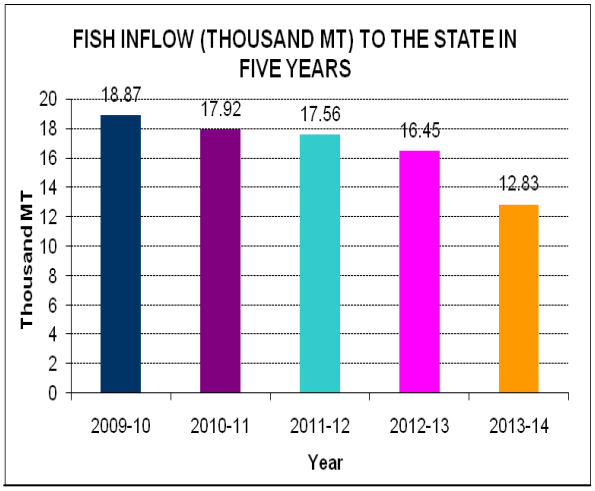

Acts and Rules of the department:

1. The Assam Fishery Rules, 1953 (Amended in 2005)
2. The Assam Fish Seed Act, 2005 (Gazette notification in 2010)
3. The Assam Fish Seed Rule 2010

The Assam Fish Seed Act, 2005 came into force on 18th April, 2005, to regulate the quality fish seed production, marketing and stocking in water bodies in the State of Assam. This is the first such kind of Act in the country. On that basis, the Government of Assam has notified the Assam Fish Seed Rules, 2010 on 8th December, 2010 under which it has been made mandatory for seed producers/growers/vendors/exporters & importers to have registration/licenses. With the framing of these Rules, the seed production activities in the State will be constantly supervised by Departmental officials to ensure production and distribution of quality fish seeds. The fish seed producers in the state have been sensitised to these issues.The Department of Fisheries is taking up a comprehensive plan for development of the sector to

enhance State fish production and productivity so that State can become self sufficient in fish by the year 2015-16.The department is implementing various programmes and few of important are:

1. Development of aquaculture through investment of community/SHG etc.
2. Reclamation of derelict water bodies, Farmers tank and community tank.
3. Development of beel and open water fisheries
4. Training and extension of fisheries
5. Construction of dwelling house for the fisherman community
6. Development of low lying areas and derelict water bodies into aquaculture estate
7. Strengthening of database and information networking for fisheries sector
8. Integrated fish farming.
9. Fresh water prawn farming.
10. Development of aquarium trade and ornamental fish culture.

Constraints and opportunity:

The state is facing tremendous constraint with regard to increasing productivity and fish production. The productivity is low because of low levels of input application, ineffective management; lack of knowledge of improved modernization of culture techniques. This warrants effective extension services and education of the farmers about the improvised culture and management techniques.

Non-availability of standard size quality fish seed in adequate numbers is the first and foremost constraints in the state as inbreeding and hybridization practices are common in almost all the hatcheries in the state and sufficient water spread area for rearing tank, is the second constraint. Critical shortage of inputs such as fish feed, fertilizer and even lime are major constraints for aquaculture development in the state.

In order to make aquaculture practices organized, infrastructure facilities, marketing channels, preservation technology and insurance coverage have to be ushered. Mass awareness among the farming community would have to be generated, so that the benefit of improved aquaculture technology reaches farmers and entrepreneurs of the state.

Suggested Measures:

For all round development of fisheries sector, it is necessary to harmonise fisheries policies in concurrence with the recent developments at state level. Recommended points to develop fisheries sector are as follows:

1. Planning and Development through bottom up approaches and encourages community participation at all levels
2. Enhancement of inland fish production by sustainable resource utilization.
3. Implementation of the projects of ornamental fisheries for socio-economic development of rural fisheries, particularly woman fisher folk.
4. Strengthening and up gradation of domestic market infrastructure and funding avenues for export earnings.
5. Organizing training for officials at various levels to enable them acquaint fisher folk with farming prospects based on modern technology (Sharma and Goswami,2012).
6. Improvement in the harvesting and food processing for value addition.
7. Creation of storage and transportation infrastructure.
8. Introduction and implementation of information technology and computer networking.
9. Setting up of an awareness centre on restoration of dying wetlands (beels) and wetland resources.
10. Application of geographic information system and remote sensing satellite in fisheries sector and conduct census survey in inland fisheries.
11. Restoration and reorganization of fisheries co-operatives.

12. Last but not least, proper utilization of highly trained and technically qualified manpower of the state for development of this sector.

Conclusion:

With a view to address some of the constrains attributed to inadequate fish production in the State, Govt. has taken up several measures with holistic approach. Department of Fisheries, Assam has taken up necessary steps for growth of the fisheries sector in the State through different developmental programmes. Some of important are implementation of Assam Agricultural Competitiveness Project- a World Bank aided project with an aim to poverty alleviation through enhancement of fish production in pond, tanks, beels. Rastriya Krishi Vikash Yojana (RKVY)- a fisheries development programme with renovation and reclamation of existing water bodies and excavation of ponds; various schemes under State plan for vertical & horizontal expansion of fishery sector; Schemes under Fish Farmers Development Agency (FFDA); Schemes under National Fisheries Development Board; schemes under Rural Infrastructure Development Fund (RIDF). Under central sector scheme department is also implementing "National Welfare Scheme for Fishermen" with a view to construct low cost house, tube well, community hall etc. for poor fisherman in selected villages.

The growth of fishery sector is mainly measured through total fish production in the state which is a function of various factors such as increase in water area through reclamation and new creation, quality fish seed production, public awareness for conservation of fish and fishery resources, strengthening of fishery co-operatives,socio economic development of fishermans,adoption and promotion of advanced technologies, availability of fish culture inputs, capacity building and development of related infrastructures etc. which can effectively be possible with cumulative efforts of all the institution and organizations working towards development of fishery sector.

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Evaluation of Growth Performance of Silver Carp (*Hypohthalmichthys molitrix*. Ham) in acidic water based polyculture system in North Eastern state of Tripura

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Abstract

An experiment of poly culture for 8 months of carps @ 10,000 seed ha-1 in 4:3:3 surface, column and bottom feeder species ratio respectively was carried out in acidic water (soil pH 6.3 to 6.8 water pH 6.3- 7.3) based earthen ponds of Tripura where Silver carp was stocked @ 50% and 100% replacing Catla as surface feeder in replicate on natural productivity and supplementary diet (23.8% CP at 3-5% of biomass) to ascertain the performance of Silver carp in acidic water in polyculture. Silver carp when stocked with Catla (50%) as surface feeder, exhibited significantly higher in growth (245.10 ±18.43 g) and survival (60.55 ±4.81%) to Silver carp (100%) without Catla resulting 12.2% additional individual growth and 7.6% total weight gain compared. No significant variations in nutrient contents of Silver carp were noticed among the treatments (moisture 71.41± 0.21 to 71.30±1.20%, protein 16.5±0.20 -17.21±0.02%) and lipid 6.52±0.03 - 7.12±0.14%). Among all the species Amur carp(Common carp- Amur variety) recorded highest growth (280.50 ±70.20 to 313.93 ±7.71 gm) followed by Mrigal (294.26 ±28.81 to 311.33 ±99.38gm) and Silver carp (202.39 ±13.14 to 245.10 ±18.43gm). Maximum weight gain was noticed during March to September. The study revealed that Silver carp along with Catla as same niche dweller was more effective in individual and oval all weight gain compared to Silver carp as only surface feeder. This may be due of stiff competition between the two surface feeders for natural food and more concentration towards supplementary food. In NE aquaculture, Silver carp may be stocked with Catla up to 50:50 ratio without much affecting the growth of Catla and other co species for higher yield.

Key words: Silver carp, Acidic water, Polyculture, Amur carp

Introduction

Fish culture in the North East region is mainly restricted to Indian major carps and exotic carps. The quantum of exotic carps in total fish yield basket in North East region is important as most of the traditional and commercial farmers incorporate three exotic carps along with three Indian major carps. The exotic carps namely Silver carp, Grass carp and Common carp are already established in polyculture systems of Tripura along with Catla, Rohu and Mrigal. Among them in growth, compatibility and contribution wise and being filter feeder Silver carp plays a vital role in polyculture system in the state. Presently the international concentration is on the intervention in the water column of the entire pond through the addition of Silver carp (Hypophthalmichthys molitrix). This fish has ecological and socio-economic potential advantages: it is expected to have a strong impact on the pond ecology because it is a very efficient filter feeder (Milstein et al., 1985a, Milstein et al., 1985b and Milstein 1992), and also on the farmers' family nutrition because it is a cheap fish that the family can afford to eat instead of selling. Most of the farmers of Tripura stocked Silver carp as surface feeder candidate species in polyculture systems along with Catla for high return in limited period of time though the pond systems are mostly acidic in nature and average yield is low due to low productivity. The performance of Silver carp alone or with same niche dwelling carp felt necessary to be studied in way to ascertain the growth, seasonal manifestation and cultural economic importance including interference if any for fine tuning of polyculture.

2. Methodology:

2.1. Experimental Design

The experiment was undertaken for a period of 10 months i.e. April, 2011 to January, 2012 in the earthen ponds of College of Fisheries, Lembucherra, Tripura. The experiment had two treatments as follows:

1) Polyculture with silver carp (T1) with a stocking density of poly culture @ 10,000 no fingerlings ha-1 where 50% of surface feeder would be Silver carp fingerlings.

2) Polyculture with Silver carp but without Catla (T2) with a stocking density @ 10,000 no fingerlings as same habitat dwelling carp where 100 % surface feeder species will be silver carp. Rohu, Mrigal, Grass carp and Common carp (Amur carp) were stocked as other candidate species of the poly culture experiment.

Soil based pond was used for the experiment in replication for each treatment. Raw Cow Dung @ 15,000 Kg ha-1 yr -1 used as organic manure used. Diet with 24.0% CP level was prepared by finely powdered feed ingredients i.e., rice bran, mustard oil cake, soybean meal and fish meal. The supplementary feed was provided to the experimental fishes @ 3-5% of total biomass following standard package of practices (ANON, 1985). The proximate analysis of feed and silver carp in season was analyzed following standard procedures (AOAC, 2005).

Table 1 Feed formulation for cultured fishes

Ingredients	**Percentage incorporated**	**Protein (%)**
Rice bran	**40**	**24%**
Mustard oil cake	**40**	
Soybean meal	**10**	
Fish meal	**10**	

2.2 Sampling schedule

The experiment was conducted for 10 months and the sampling for various parameters was carried out at a definite time interval. For growth study, first sampling was done on 0 day of stocking and subsequent samplings were done every 3.5 months. Proximate analysis of fish muscle was carried out initially and then every 3.5 months. Analysis of physico chemical parameter of water in monthly interval and that of soil initial and final was carried out.

Stocking:SC-60nos,Rohu-40nos,GC10nos,M-20nos,Amu-20nos Treatment.1(With Catla)

Treatment.1(Silver carp with Catla)	**Treatment.2(Silver carp without Catla)**
Pond no.01 Water Area(m^2):133 Depth:1.5(m) Stocking Density :10000/Ha Stocking:SC-30nos,C-32nos,Rohu40nos,GC-10nos,Mrigal-20nos,Amur carp-20nos	Pond no.01 Water Area(m^2):133 Depth:1.5(m) Stocking Density :10000/Ha Stocking:SC-60nos,Rohu-40nos,GC10nos,Mrigal-20nos,Amur carp-20nos
Treatment.2(Without Catla)	**Treatment.1(With Catla)**
Pond no.02 Water Area(m^2):133 Depth:1.5(m) Stocking Density :10000/Ha Stocking:SC-60nos,Rohu-40nos,GC10nos,M-20nos,Amu-20nos	Pond no.02 Water Area(m^2):133 Depth:1.5(m) Stocking Density :10000/Ha Stocking:SC-30nos,Catla32nos,Rohu-40nos,GC-10nos,Mrigal-20nos,Amur-20nos

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Treatment.$_1$(With Catla)	Treatment.$_2$(Without Catla)
Pond no.03 Water Area(m^2):133 Depth:1.5(m) Stocking Density :10000/Ha Stocking:SC-30nos,Cctla-32nos,Rohu-40nos,GC10nos,Mrigal-20nos,Amur carp-20nos	Pond no.03 Water Area(m^2):133 Depth:1.5(m) Stocking Density :10000/Ha Stocking:SC-60nos,Rohu-40nos,GC-10nos,Mrigal-20nos,Amur carp-20nos

Table 3 Treatment wise seed stocking rate (stocking density @ 10,000 seed /ha)

Species	T_1(Number)	T_2(Number)
Silver carp	180	90
Catla	-	90
Rohu	120	120
Mrigal	60	60
Amur carp	60	60
Grass carp	30	30

Plate 1 Experimental ponds

Results and discussion

3.1 Growth study: In the growth study of Silver carp in polyculture system in earthen pond fed on both natural and supplementary feed , the highest rate of survival was found in the treatment T1 (60.55 ±4.81) compare to T2 (54.81 ±3.39). Highest growth in terms of length (31.37cm) and weight (245.10 ±18.43 gm) was observed in the treatment T1 (Silver carp without Catla) compare to T2 (length: 28.07cm and weight: 202.39 ±13.14gm), exhibited 12.2% additional growth in weight to T2. The result indicated that individual growth of silver carp is higher in association with Catla as co-surface feeder without significant difference. This tendency may be due to benefit from synergic effects between the two fish species different food spectrum in same niche and thus better utilization in natural as well as complementary diets in competition. In polyculture, better and complete utilization of natural feed, as a fish species, even with a wide food spectrum, does not fully utilize all pond tropic resources. Present study upholds the result obtained by Sumumaran, et. al. (1968) in their study on compatibility and competition between Silver Carp, Hypophthalmicthya molitrix(C.&V.) and Catla catla (Ham). Growth and survival of Hypopthtalmicthys molitrix (Silver carp) was found higher in the presence of Catla catla (Catla) compared to when only Silver carp was present as surface feeder: this may be because of competition among the two surface feeders in taking natural food and hence concentration towards supplementary food more. Whereas while only Silver carp as surface feeder, the filter feeder perhaps was more concentrated in phytoplantonic food rather than supplementary feed led to lower growth rate. Higher growth of Silver carp was noticed during March-September period compare to other seasons of the year of farming in polyculture. It may be due to higher natural food availability and higher metabolic rate in conversion of both natural and supplementary food by Silver carp during summer and monsoon season which was lacking during winter period. Bottom feeder fishes like Mrigal exhibited highest individual growth followed by Amur carp an improved variety of common carp (cyprinus carpio,haematopterus)specially in highest weight gain and survival compared to rest carp species: may be due to more stability

of the species in acidic water as well as conversion of feed both natural and supplementary throughout the culture period.

3.2 Proximate analysis: Proximate analysis of whole body of fish was done to determine the efficiency of transfer of nutrient from the food to the fish. In proximate composition of carcass of Silver carp, in both the treatments not noticed much variations in moisture content during the culture period as with initial value of 71.41± 0.21% to final of 71.30±1.20%. In respect of protein, increment was noticed during July month (17.21±0.02%) compared to initial (16.5±0.20%). However throughout the culture period, increment in protein content was noticed. Same tread was noticed in fat content where initial value was 6.52±0.03 % compared to highest value in both the treatments during July (7.12±0.14%). Not much seasonal variations in the major nutrient profile like protein, fat, carbohydrate was noticed in silver carp throughout the culture period except higher during summer.

3.3. Analysis of pond soil and water parameters: In the present study, the pond soil was found acidic in nature with initial and final sand content of 86% and 83% with an increase of silt content from 10% to 14% respectively. Same way increase in pH was noticed from 6.3 to 6.8 due to fertilization effect. The pond soil was noticed low in fertility. The study correlated the finding of Datta et.al.(2009) and Banerjea,(1967) where the authors observed acidic soil pH with high sand texture in NE pond soil.While analyzing water physic-chemical parameters, the water was initially acidic in nature and ranged between 6.3-7.5 during entire culture period. Water temperature (C0) ranged between 9-31 where as total alkalinity (mgl-1) was low and in between 30-62 and noticed moderate dissolved oxygen (mgl-1) content between 5.2-7.8. Phosphate (mgl-1) content was as low as between 0.0014-0.66 with high Iron(mgl-1) and Aluminium (mgl-1)content 0.157-0.921and 0.369-0.921 respectively. The Gross and net primary productivity (mg c-1m3hr-1) was noticed in lower side between 385.714-460.714 and 124.286-128.571 respectively indicating he poor nature of productivity of sandy acidic type of soil in study.

Table 4 Growth performance of Silver carps in treatments

Silver carp			
Particulars	**Treatment 1**	**Treatment 2**	**P-Value**
Initial weight(g)	1.50±0.00	1.50±0.00	
Final weight(g)	245.10±10.64	202.39±7.58	0.03
Weight gain(g)	243.44±10.50	200.89±7.58	0.03
Initial length(cm)	5.00±0.00	5.00±0.00	
Final length(cm)	31.36±1.93	28.06±0.58	0.17
Length gain(cm)	26.36±1.93	23.06±0.58	0.17
Survival rate (%)	60.54±2.77	54.81±1.95	0.16
Specific growth rate (% per day)	81.23±0.49	66.94±1.70	0.00

Table 5 Average productivity of Silver carp in polyculture in treatments

Treatment	Species	Final Weight (gm)	Final Size(cm)	Survival (%)	Total Production of fish (Kg)
$Treatment_1$ (with Catla)	Silver Carp	245.10	31.37	60.55	66.35
$Treatment_2$ (without Catla)	Silver Carp	202.39	28.07	54.81	61.69

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Plate 1 Experimental ponds

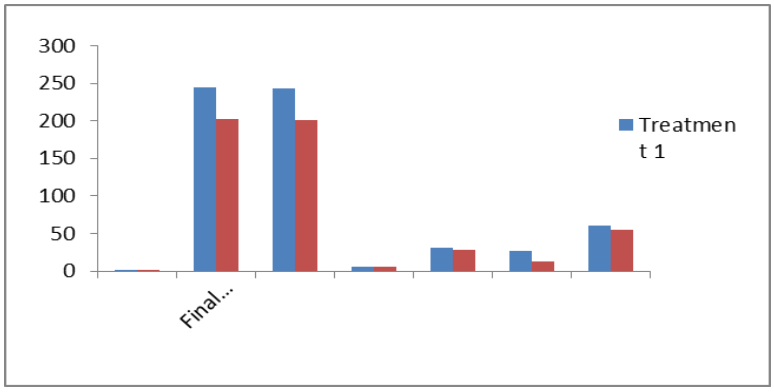

Figure 1: Growth performance of Silver carps in treatments

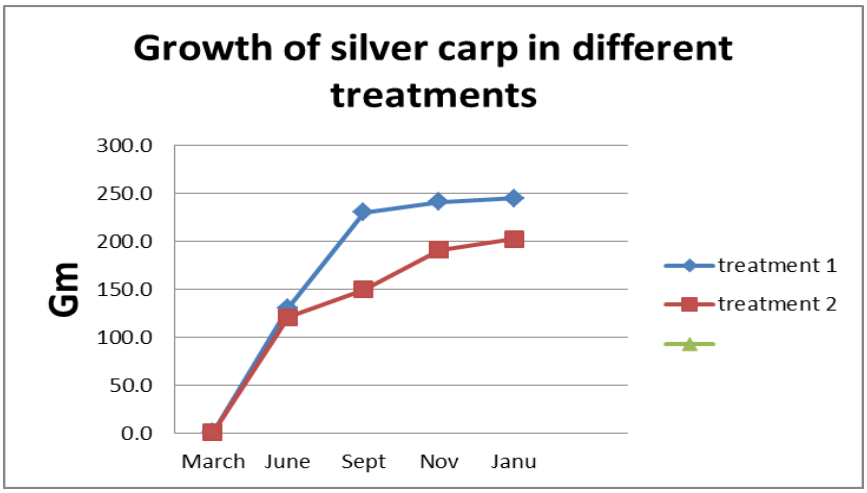

Figure: 2 Treatment wise Growth of silver carp

Table 6: Proximate analysis of silver carp

Name of the Species	Moisture	Protein	Fat	Carbohydrate	Ash
Silver carp(March)	71.28	16.5	6.62	2.53	2.94
Silver carp(June)	70.65	17.66	7.12	1.57	11.08
Silver carp(Sept)	73.62	16.5	6.68	0.52	3.31
Silver carp(January)	71.97	16.74	6.87	0.49	3.51

Table 7: Pond soil parameter

Sampling	Texture				E C ($mScm^{-1}$)	P^H	Organic Carbon (%)	Phosphate (mg/100g)
	Sand (%)	Silt (%)	Clay (%)	Type				
Initial	86	10	4	Sandy	33.1	6.5	0.618	0.016
Final	82	14	4	Sandy	30.1	7	0.857	0.007

Table 8 Pond water physic-chemical parameter

Air Temperature(C^0)	12-35
Water Temperature (C^0)	09-31
Transparency(Cm)	12.5-26
Electrical Conductivity ($mScm^{-1}$)	30-40
pH	6.3-7.5
Total Alkalinity (mgl^{-1})	30-62
Total Hardness (mgl^{-1})	22-50
Dissolved Oxygen (mgl^{-1})	5.2-7.8
Carbon Dioxide(Co_2) (mgl^{-1})	2.64-6.15
Ammonium Nitrogen(NH_4-N) (mgl^{-1})	0.012-0.75
Phosphate (mgl^{-1})	0.0014-0.28
Iron (mgl^{-1})	0.157-0.921
Aluminum (mgl^{-1})	0.369-0.923
Primary Productivity	
GPP(mg $c^{-1}m^3hr^{-1}$)	385.714-460.714
NPP(mg $c^{-1}m^3hr^{-1}$)	124.286-128.571
Respiration(mg $c^{-1}m^3hr^{-1}$)	257.143-296.79

Conclusion

Silver carp, an exotic species being efficient filter feeder found grow well in plankton dense pond ecosystem along with Catla, a same niche habitat carp species in association with other carp species in acidic water based polyculture of NE India. Amur carp an improved variety of common carp (cyprinus carpio, haematopterus), exhibited highest weight gain compared to rest other carp species and can be incorporated in polyculture with silver carps. It is proposed that in NE acidic soil based water bodies , silver carp may be stocked with Catla upto 50:50 ratio without much affecting on the growth of Catla and no impact on other species were noticed where both natural and supplement feed are provided to the fishes. More emphasis may be given on bottom feeder fishes like mrigal and common carp. The generated research outcome would be useful for small and marginal fish farmers for higher economic gain of Tripura state and subsequently for the region. Also the generated data would be the treasure for further study on role of other exotic carps in polyculture in acidic soil based ponds. Further work need to be initiated for validating the results obtain of incorporation of silver carp proportionately and seasonality of culture with Amur carp as bottom feeder in farmers field. The study would be helpful to fish farmers in designing silver carp based polyculture in natural recourse based farming system as well as for quick economic return etc.

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Comparative Study on use of floating pelleted Fish feed and local practice of feeding in composite fish culture in East Siang district Arunachal Pradesh

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Abstract:

A multi locational trial on use of floating pelleted fish feed (FPFF) in Composite Fish Culture (CFC) was carried out to evaluate growth, yield and economic analysis of fish cultured during three successive years 2012-2014 in East Siang District of Arunachal Pradesh. The study revealed that growth of silver carp and catla was higher in comparison to other fish species. Overall fish yield was higher with floating pelleted fish feed as compared that with traditional feeding in CFC system at all locations under study with the highest harvest of 26.7 q ha-1. An augmentation of fish harvest up to 23.3 % was recorded by adopting floating pelleted fish feeding over traditional feeding practices. Gross profit to the tune of Rs. 3, 17,333 and Rs. 2, 61,567 per hectare were recorded from FPFF feeding and local practice with a net profit of Rs. 1, 67,197 and Rs. 1, 38,400 per hectare and benefit-cost ratio of 2.11 and 2.12, respectively. An increase in gross return up to 17.5 % and that in net return up to 26.5 % were recorded in the floating pelleted fish feed feeding system. Hence, study revealed that floating pelleted feeding was both more productive as well as economically more rewarding as compared to traditional method of feeding.

Key words: Floating Fish Feed, Composite Fish Culture, Local Practice, Yield, Benefit- Cost Ratio.

Introduction

People of North Eastern states including Arunachal Pradesh are predominantly non-vegetarian and demand fish in their daily diet. In Arunachal Pradesh, fishes fetch higher price than many other commodity including meat and it is highly revered for its easily digestible nutritious flesh. Local fish availability in Arunachal Pradesh is mostly based on capture from natural resources, however, in view of stagnation and/or decline in the catch vis-à-vis increasing demand due to increasing population and income, fish culture in ponds in monoculture or poly-culture is also being adopted by farmers. There is a large cultivable fresh water area in Arunachal Pradesh in the form of ponds, tanks and beels etc., of which only small part is utilized for fish culture. Though fishery is an important sector of livelihood for the local community, but still the technology of aquaculture has not been well established among them. For which the farmers are not able to harvest desired yield. Most of the farmers practicing Composite Fish Culture (CFC) system feeding the fish with locally available materials viz. rice bran, mustard oil cake, banana leaf, kitchen waste etc. because these are relatively cheap. But, these feed are incomplete, poorly balanced and less digestible, and hence, do not result in optimal growth performance. On the other hand, compound artificial feeds for carps, especially floating types that are produced through extrusion, are relatively expensive but are known to result in better growth and yield performance. There appears to be no report in Arunachal Pradesh detailing relative yield and economic efficiency of traditional feeding and feeding with floating pelleted fish feed (FPFF). Present investigation is an attempt to quantify the yield advantages by using floating pelleted fish feed in CFC over the local traditional feeding system. Effort has also been made to find out economic

sustainability use of FPFF in the study area for logical analysis and adoption by the fish growing community of the district.

Material and methods

In the present investigation, an effort has been made to assess the growth performance of different fish species in Composite Fish Culture (CFC) system and overall fish yield by adopting floating pelleted fish feed feeding against the local method of supplementary feeding of oil cake and rice bran with a mixing ratio of 1:1 was done @ 2-3% of body weight of fishes. The study was carried out during three consecutive years 2012-2014. Fingerlings of Rohu (Labeo rohita), Catla (Catla catla), Mrigala (Cirrhinus mrigala), Grass Carp (Ctenopharyngodon idella), Common carp (Cyprinus carpio) and Silver carp (Hypophthalmichthys molitrix) were stocked in a ratio 2 Catla: 2 Rohu: 1.5 Mrigal: 2 Silver carp: 1 Grass carp: 1.5 Common carp (Mahapatra et.al. 2006) @ 7000 fingerlings per ha. The experiment was carried out in Mangnang, Sille, Mirem and Tabi villages of East Siang District, Arunachal Pradesh geographically located between 27.300° to 29.420° North latitude and 94.420° to 95.350° East longitude with an altitude of 133m in to 300 m.

The management practices in composite fish farming can be categorized as pre-stocking, stocking and post-stocking management. The major steps followed in pre-stocking management were aquatic weed clearance by manual effort, eradication of predatory and weed fishes by repeated netting, manuring by using cow dung 1000 kg/ha/month and liming with quick lime @ 2000 kg/ha/yr for regulating pH of pond water. One third quantity of total amount of lime was applied as initial dose and rest was applied in number of split doses after checking pH of the pond water. In stocking management, transportation of fingerling is one of the most important steps. Improper transportation might lead upto 100% mortality of the seed during transportation as well as after release into the pond. In the present investigation, transportation of fingerlings was done in the early morning hours with oxygen packing from Mini Carp Hatchery located at Dhemaji District, Assam. Acclimatization of the fingerlings was also done before stocking. Feeding was the major factor in post stocking management, which directly affects the survival and better growth of fishes (De Silva 1991). Supplementary feeding was done with pelleted floating fish feed (3 mm) manufactured by College of Fisheries, Agartala, Tripura. The feed was produced through extrusion technology utilizing ingredients namely rice bran, mustard oil cake, broken corn, broken wheat, wheat bran, and dry fish waste. The proximate composition of the feed was as follows: Crude Protein content 20-22 %, Crude lipid 3-5 %, Crude Fiber < 13-15 %, Ash ≤ 10-11 %, Digestible carbohydrate 40-45 %. Pellets floats in water for 30 to 60 minutes. Feeding was done @ 5-6 % of the body weight of advance fingerlings and later stages it had been reduced to 3-4 %. Time to time manuring was also done to maintain water quality of the ponds. Sampling for checking the health and growth were also done once in two months.

Results and discussion

Present study revealed that feeding of fish with floating fish feed in Composite Fish Culture resulted in markedly higher body weight gains for all species and net fish yield at all locations. (Table 1). Different fish species viz. Silver carp, Catla, Mrigala, Grass Carp, Common carp and Rohu harvested from Mangnang, Mirem, Sille and Tabi villages of East Siang District showed that growth of silver carp and catla was prominent over that of other fish species in CFC (Table 1). Silver carp and catla was recorded to grow faster with an average size of 833.8 g and 888.4 g respectively in eight months of culture period. This might be attributed to greater genetic potential of growth and feeding with floating pellets as these fishes are primarily surface feeders, and hence, would have competitive advantage as well as bioenergetic advantage over other species of CFC with regards to consumption and/or

utilization for growth. Furthermore, manuring of pond under CFC was also performed and resultant greater production of phytoplankton and zooplankton biomass in culture ponds which were basic food for silver carp and catla, respectively might also have contributed to greater growth performance (Wohlfarth and Schroeder 1979). Moreover, these two fish species had the adaptability to withstand prevailing low temperature of the pond water (Table 2). In all the locations under study congenial water temperature for fish growth was observed from April to October. Pre-monsoon rainfall in the month of April, May followed by monsoon rainfall during June to September favoured fish culture in the district (Fig. 1).

It was noted that, the fish yield was higher in FPFF feeding system than that of traditional feeding system at all locations under study. Average fish yield recorded with FPFF was 24.5 q ha-1, 23.8 q ha-1 and 24.9 q ha-1 during 2012, 2013 and 2014 respectively as compared to 20.1 q ha-1, 19.3 q ha-1 and 20.9 q ha-1 during the aforesaid period (Table 3). This might be attributed superior feed and a well defined feeding management. Similar observations were also made by Murty et.al., 1978 and Yadava et.al., 1992. An increment of fish harvest to the tune of 21.9 % , 23.3 % and 19.1 % was recorded by adopting FPFF in CFC in the year 2012, 2013 and 2014 respectively (Table 4).

One of the general apprehension of famers is that floating pellets although result in higher fish yield, it does not result in better economic performance. Such presumption is primarily based on fact that floating pellets are relatively more expensive. The economic analysis of use of FPFF in CFC and local practice of feeding was made to evaluate the sustainability of FPFF. Average total cost of production over the period of 2012-2014 was Rs. 1, 50,136 and Rs. 1, 23,167 in FPFF feeding and local feeding practice respectively (Table 5). Variation in the cost of production in different years was due to variation in cost of inputs. Mean Yield of fishes obtained from these two systems were 24.4 q ha-1 and 20.1 q ha-1. Gross profit to the tune of Rs. 3, 17,333 and Rs. 2, 61,567 per hectare were recorded from FPFF feeding and local practice with a net profit of Rs. 1, 67,197 and Rs. 1, 38,400 per hectare respectively. This gave an average benefit-cost ratio of 2.11 and 2.12 for the above mentioned two fish feeding systems respectively. The result reflects that production of fishes and profitability is more in FPFF feeding system over the local feeding practice which is because of adoption of good management practices. Biswas et al. 1991 reported that those farmers, who have a tendency to maximize their earnings, have higher adoption of Composite Fish Farming System.

Floating Pelleted Fish Feeding system could be beneficial venture for increasing productivity of land and water resources of East Siang District of Arunachal Pradesh. Moreover, it has the benefit of supplying fish as a source of high quality protein. This aspect may be particularly relevant for the nutrition of tribal community of the region.

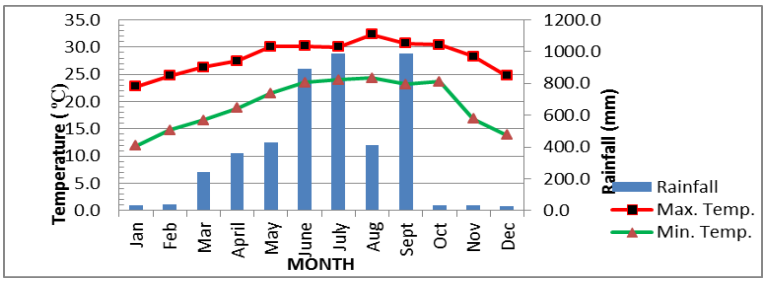

Fig. 1. Average Maximum Temperature, Minimum Temperature and Rainfall of East Siang District during 2012-2014 ***(Courtesy: Section of Agrometeorology, Department of NRM, College of Horticulture and Forestry, CAU, Pasighat, Arunachal Pradesh)***

Table 1. Final Average Weight (g) of fishes during the study period.

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Fish Spp.		Villages under study				
		Mangnang	Mirem	Sille	Tabi	Average
Silver Carp	FPFF	830.5	805.3	832.5	866.7	833.8
	Local Feed	750.8	715.8	789.8	822.4	769.7
Catla	FPFF	915.6	875.6	816.7	945.7	888.4
	Local Feed	827.8	710.5	730.8	825.8	773.7
Mrigala	FPFF	485.7	495.9	587.7	585.2	538.6
	Local Feed	390.5	383.4	453.5	450.7	419.5
Grass Carp	FPFF	712.0	700.5	686.7	748.6	711.9
	Local Feed	579.6	567.2	553.5	624.3	581.2
Common Carp	FPFF	525.00	516.9	593.4	678.7	578.5
	Local Feed	409.7	435.6	509.5	568.4	480.8
Rohu	FPFF	482.7	453.2	526.8	537.5	500.0
	Local Feed	338.5	314.4	414.5	415.7	370.8

FPFF: Floating Pelleted Fish Feed

Table 2. Average water temperature (ºC) and pH of the pond water obtained from different villages during the year 2012-2014.

Month	Temperature (ºC)		pH	
	Range	Average	Range	Average
January	18.0 – 20.0	19.2	6.0-7.9	7.4
February	19.5 – 22.5	20.7	6.0-7.8	7.0
March	22.0 - 25.0	23.5	6.1-7.8	7.1
April	23.0 - 25.7	24.2	5.9-7.7	6.9
May	23.7- 27.1	24.7	6.1-7.8	7.3
June	24.0 - 28.0	26.3	5.9-7.6	6.9
July	25.5 - 29.0	27.4	5.6-7.6	6.9
August	25.0 - 30.0	28.3	5.7-7.8	6.7
September	24.5 - 29.0	27.5	5.8-7.9	7.1
October	24.0 - 27.5	25.0	6.2-7.5	6.8
November	22.0 - 25.0	22.6	6.0-7.8	7.0
December	19.0 - 23.0	21.1	5.8-7.7	7.3

Table 3. Year wise average yield (q ha^{-1}) of fishes feeding with Floating Pelleted Fish Feed and local practice in CFC during the study period

Year	Mangnang	Mirem	Sille	Tabi	Average
	Average yield (q ha^{-1}) of fishes in CFC with Floating Pelleted Fish Feed				
2012	25.1	26.3	23.7	22.9	24.5
2013	25.6	23.3	22.1	24.4	23.8
2014	26.7	23.8	25.5	23.7	24.9
Average yield (q ha^{-1}) of fishes in CFC with local practice					
2012	20.5	21.7	19.8	18.4	20.1
2013	21.0	18.6	17.9	19.8	19.3
2014	22.3	20.4	21.5	19.3	20.9

Table 4. Yield parameter observed in different villages

Year	Average Yield of Fishes with Floating Pelleted Fish Feed (q ha^{-1})	Average Yield of Fishes in local feeding practice (q ha^{-1})	Fish yield Increase with Floating Pelleted Feed over local practice (%)
2012	24.5	20.1	21.9
2013	23.8	19.3	23.3
2014	24.9	20.9	19.1

Table 5. Economics of fish farming using Floating Pelleted Fish Feed and local practice during the study period

Parameter (Average of different location)	Floating Pelleted Fish Feed				Local practice			
	2012	2013	2014	Avg.	2012	2013	2014	Avg.
Total Cost of production (Rs. ha^{-1})	139650	146370	164389	**150136**	111500	122000	136000	**123167**
Mean Yield of fishes (q ha^{-1})	24.5	23.8	24.9	**24.4**	20.1	19.3	20.9	**20.1**
Total Cost of production (Rs.kg^{1})	57.00	61.50	66.02	**61.51**	55.47	63.21	65.07	**61.25**
Gross profit (Rs.ha^{-1})	294000	309400	348600	**317333**	241200	250900	292600	**261567**
Net returns(Rs. ha^{-1})	154350	163030	184211	**167197**	129700	128900	156600	**138400**
Benefit Cost ratio	2.10	2.11	2.12	**2.11**	2.16	2.06	2.15	**2.12**

- Sale price of fish per kg was Rs.120, Rs. 130 and Rs. 140 in the year 2012, 2013 and 2014 respectively.
- Total cost of production includes cost of labour for pond preparation and management, fertilization application, liming, netting etc. and material cost like fish fingerlings, feed, fertilizer, lime etc.

Table 6. Economics of fish farming observed in different villages

Year	Net returns(Rs. ha^{-1}) With Floating Pelleted Fish Feed	Net returns(Rs. ha^{-1}) With local practice	Increase of Net returnwith Floating Pelleted Feed over local practice (%)
2012	154350	129700	19.0
2013	163030	128900	26.5
2014	184211	156600	17.6

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Effect of different feeds on the growth and survival of zebrafish, *Danio rerio* (Hamilton, 1822)

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Abstract

Present experiment was conducted to evaluate the effect of different types of feeds on the growth and survival of zebra fish, Danio rerio. For this, four different treatment groups viz. T1- mixed zooplankton (control diet, T2- diets with 35% protein, T3- commercially available market feed and T4- mixture of all three previous diets at equal proportion. Aquariums were filled with well conditioned water approximately one week before stocking. Each aquarium was stocked with 20 fish (average weight 0.249±0.007g) in triplicate groups in 50 L aquariums. Feed was given two times a day at 3-5% of their body weight based on their requirement. Growth and survival rate of fish were calculated monthly. The feeding experiment continued for 6 months. Water quality parameters were reported to be within the range of favourable for D. rerio. But, significantly ($p<0.05$) highest weight gain was found in T4 (0.060±0.004) which was similar with T1 compared to other groups. Similarly, highest specific growth rate was reported in T4 (0.111±0.008), which was similar with T1. No different difference ($p>0.05$) in survival percentage was found among the treatments. So, from the present study, it can be summarised that to achieve better growth of Danio rerio, live food such as zooplankton should be provided along with pelleted feed in aquarium condition.

Keywords: Danio rerio, feeding strategies, growth, survival

Introduction

Zebrafish (Danio rerio) has been used as a model organism for molecular genetics, developmental biology, biomedical research (Shin & Fishman, 2002), screening of therapeutic drugs (Rubinstein 2006) and Neurobiology (Lieschke & Currie, 2007). Besides popular model organism, the fish is very popular as pet or ornamental fish since it is attractive in colour, peaceful in nature, hardy and compatible with other ornamental fish. This fish is small and measures only about 3-4 cm long. They have alternating dark and light/silvery horizontal stripes on the side of the body like zebra, hence the name came. The zebrafish is an ideal ornamental fish for beginners because it can tolerate a wide range of water parameters. Although this fish is used as a major model species for molecular genetics, developmental biology, biomedical research and neurosurgery, very little work has been done on the nutritional requirements of this cyprinid. Nutrition has an important influence on growth and survival of ornamental fish and various live feeds have been used for rearing of these fish (Sales & Janssens, 2003; Kasiri et al., 2012).

Protein, lipid and carbohydrate are the major nutrients that provide energy for fish metabolism, growth and reproduction (Izquierdo et al., 2001). It is important to know the nutritional requirement of ornamental fish. Dietary proteins are the source of essential amino acids which are necessary for maintenance, growth, reproduction and health of fish (NRC, 1993). The protein requirement in ornamental fish is reported to be relatively high compared to terrestrial animals. A wide range of variations of 29-50% protein and 6-10% lipid requirement has been estimated for freshwater ornamental fish (Lochmann & Phillips 1994; Ling et al., 2006). The protein and energy requirement of some freshwater ornamental fish species has been studied. Relatively, little attention has been paid to the nutritional requirement and effect of protein levels on the growth and reproductive performance of zebrafish and because of this several commercially available products are used in the feeding practices of zebrafish culture (Westerfield 2000). Since the information on the specific type of feed requirement of zebrafish has not been properly studied, the present study was planned

to investigate the relative effect of different types of feeds on the growth and survival of zebrafish under captive condition.

Materials and methods

Experimental diets

Dietary treatments that were evaluated consisted of four different groups viz. T1- mixed zooplankton (control diet), T2- diets with 35% protein, T3- commercially available market feed and T4- mixture of all three previous diets at equal proportion. Mixed zooplankton which was considered as control was collected from College ponds using plankton net during morning hours. The laboratory prepared diet was formulated to contain 35% crude protein from locally available feed ingredients (Table 2). The proximate analysis of all the ingredients used for formulating the diet was evaluated before preparation of the diet (Table 1). The commercial feed (Tokyu) was purchased from the aquarium shop in Agartala. The proximate composition of the diets including mixed zooplankton was conducted according to the standard procedure of Association of Official Analytical Chemists (AOAC, 2005) and presented in Table 3.

Fish and experimental design

The experiment was performed over a period of seven months in the wet laboratory of the College of Fisheries, Central Agricultural University, Lembucherra, Tripura, India. For this purpose, about 400 zebrafish fry were collected from the drain of the college farm. The fry were stocked and acclimatized in a rectangular cemented tank of 1000 L capacity for two months prior to start of feeding trial. Twelve glass aquariums of 50 L capacity were used and equipped with sponge filter through which pressurized air was bubbled to supply sufficient oxygen to the fish and filter the water. To begin the trial, 240 zebrafish juvenile were gently acclimatized with aquarium water. The fish were then counted into groups of 20 fish each, group weighed and stocked into twelve aquarium tanks with three replicate tanks per diet. The experimental fish were then reared using experimental feeds under laboratory conditions for seven months.

Feeding and maintenance of aquarium tanks

Initial mean body weights of experimental fish were recorded before stocking. Fish were fed two times a day @ 3-4% of body weight with the experimental diets. The treatment 1 (control) group of fish was fed with live feed (mixed zooplankton) twice daily till satiation. Daily, feed intake was checked and all aquariums tanks were cleaned by rubbing the tank. Faecal matter and leftover feed were extracted out from bottom of each aquarium tank by siphoning daily and 20% of the water volume was changed daily. Fish were kept in the wet laboratory with a photoperiod of 12:12 h light: dark cycle. Temperature was monitored three times a week using a thermometer. At the beginning of experiment, temperature was in the range 27-280C. During winter, temperature was maintained at 220C using temperature controlled thermostat heaters. Other water quality parameters such as dissolved oxygen, carbon dioxide, alkalinity, hardness, pH and ammonia were monitored fortnightly. Dissolved oxygen was maintained at 6-8 mg L-1, pH ranged between 6.8-7.4 and ammonia concentration was 0.01-0.6 mg L-1 throughout the experiment. Water quality was measured according to the standard procedure of APHA (2005).

Evaluation of growth parameters

At the beginning, mean body weights of experimental fish in each aquarium was measured. At an interval of 30 days, all fish in each aquarium were collected and weight was taken. Mean body weight (g) was calculated at 30 days intervals by dividing the total weight of

experimental fish by total number of fish in each aquarium tanks. The parameters analyzed were;

i. Mean weight gain (g) = Mean final weight – mean initial weight.

ii. Specific growth rate (SGR % day-1) = [(lnWt- lnWi)/T] ×100.

Where, Wt = mean final weight, Wi = mean initial weight and T = total experimental days

iii. Brood survival rate (%) = (Final total numbers /Initial Total numbers) × 100.

Statistical analysis

One-way ANOVA and Duncan's Multiple Range Tests (DMRT) at $p<0.05$ level were used to analyze the data to determine the significance of the difference among the means of treatments by using the suitable statistical method with SPSS windows 16.0 software. The data are presented as mean ± S.E. of three replicate groups.

Results

Growth Parameters

Table 5 showed different growth parameters of zebrafish using different diets. The highest mean weight gain (MWG) and specific growth rate (SGR) was obtained in zebrafish fed the control diet (mixed zooplankton) (T1), which was similar with T3 and T4 groups and significantly ($p<0.05$) lowest values were reported in T2 (Tokyu feed). The highest numbers of fish survival and survival rate of fish were recorded in fish fed with mixed zooplankton (T1) and the lowest in fish fed with T2 (Tokyu feed). However, there was no significant difference ($p>0.05$) in fish survival numbers and survival percentage among all the treatments.

Water quality parameters

The water quality parameters were reported within the acceptable range of zebrafish (Table 4). Temperature and pH of water in broodstock experimental tanks under different treatments ranged between 22.0-28.50C and 6.89-7.49, respectively. Dissolved oxygen (DO), carbon-di-oxide (CO2), alkalinity, hardness and ammonia of water in aquarium tanks in all treatments ranged between 6.88-9.05, 2.62-8.8, 36-68, 38-102 and 0.022-0.471 mg L-1, respectively.

Discussion

The present study indicates that feeding with live food containing higher levels of protein influenced the growth performance of zebrafish, Danio rerio. In this study, mean weight increased significantly with increasing dietary protein levels of 35% in the formulated diet and 54% crude protein in live food in compared to the other commercial diet (Tokyu feed) having 21.48% crude protein. Zebrafish fed live feed/mixed zooplankton (control), 35% crude protein diet and mixed diet had significantly higher mean weight gain (MWG) and specific growth rate (SGR) than fish fed with 21% crude protein Tokyu diet. This may be due to the increase in protein utilization and digestibility with the increase in dietary protein level. The decrease in MWG and SGR in zebrafish fed 21% protein diet (Tokyu) may be due to decrease in protein utilization and digestibility below 35% protein level in the diet. Another reason may be that 21% protein diet may not contain required protein level for growth. The present study is in accordance with the earlier results reported by Bahnasawy (2009) who showed that the weight gain and specific growth rate increased significantly with increasing dietary protein level from 17% to 30% with non significant increase by the diet of 35% CP when fed Nile tilapia with 17%, 25%, 30% and 35% protein diet. The present study also had some support from the work of Deng et al. (2013), who observed that weight gain and SGR of juvenile barbless carp, Cyprinus pellegrini increased with the increasing dietary protein level up to 44%. It has been reported that decrease in body weight occurs when the fish is fed with low protein diets (Dabrowski, 1977). The result of present study also gets some support

from the work of Ergün et al. (2010) who reported 40% and 35% dietary protein level resulted in higher mean weight gain and specific growth rate in freshwater ornamental fish. In the present investigation, there was no significant difference (p>0.05) in brood survival percentage of zebrafish among the treatments.

The importance of broodstock nutrition has been stressed earlier by Izquierdo et al. (2001) while Abidin et al. (2006) reported that dietary protein levels influenced parameters such as weight gain and proximate composition of fish. Olvera-Novoa et al. (1996) observed that survival rate in Cichlasoma synspilum was higher at 40 to 50% protein diet and least at 30% protein diet, however, no significant difference were observed in 35, 40, 45, and 50% protein fed group, which supports the present findings.

Based on the results of zebrafish Danio rerio in the present study, it is evident that live food like mixed zooplankton either alone or in combination with a diet having 35% protein level is optimum for better growth. However, using different diets fish survival was unaffected. Zebrafish, which was similar to other omnivorous ornamental fish such as 30-40% for guppy, Poecilia reticulata (Shim & Chua, 1986), 42 % for tin foil barb, Barbedous altus (Elengovan & Shim 1997), and 41% for redhead cichlid, Cichlasoma synspilum (Olvera-Novoa et al., 1996).

Thus, based on the results obtained from the present study, it can be concluded that the diet containing 35% crude protein is considered optimal and economical for growth and survival of zebrafish, Danio rerio. It is also evident that live food such as zooplankton should be provided in aquarium condition to achieve better growth and survival of zebrafish.

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Table 1: Proximate composition of feed ingredients (g/100g) on a dry weight basis

Parameters	Fish meal	soybean	Mustard oil cake	Wheat bran
Dry matter	88.62 ± 0.44	87.37 ± 0.20	89.16 ± 17	88.93 ± 0.13
Moisture	11.38 ± 0.44	11.63 ± 0.20	10.84 ± 0.17	11.07 ± 0.13
Crude protein	51.14 ± 0.14d	50.15 ± 0.26c	32.63 ± 0.35b	14.45 ± 0.24a
Crude fat	10.08 ± 0.12d	1.15 ± 0.11a	8.15 ± 0.09c	1.84 ± 0.11b
Crude fibre	1.49 ± 0.30a	4.85 ± 0.31b	5.70 ± 0.60b	2.66 ± 0.51a
Ash	14.31 ± 0.17d	6.87 ± 0.05b	8.71 ± 0.03c	3.89 ± 0.42a
Nitrogen Free Extract (NFE)	22.99 ± 0.21a	36.98 ± 0.14b	44.80 ± 0.78c	77.15 ± 0.32d

Mean values with different superscript in a row are significantly different. Values are in mean ± S.E. (n=3)

Table 2: Feed ingredients and formulation of the formulated diet (g 100g diet $^{-1}$)

Ingredient	Inclusion level (%)
Fish meal[1]	25
Soybean meal[2]	25
Mustard oil cake[1]	20
Wheat bran[1]	14.4
Cod liver oil[3]	2
Sunflower oil[4]	2
Vit + mineral mix[5]	1.5
CMC(Carboxymethylcellulose)[6]	0.4
BHT (Antioxidant)[6]	0.1

1Obtained from College of Fisheries, CAU, Lembucherra, Agartala, India;
2Procured from Golbazar local market, Agartala, Tripura, India;
3Universal Medicine Pvt. Ltd., Bhiwandi, Thane, Maharashtra, India;
4Ruchi Soya Pvt. Ltd., Raighad, India;
5Agrimin Forte Powder, Virbac, Mumbai, India, per kg: Vitamin A 7,00,000 IU, Vitamin D3 70,000 IU, Vitamin E 250 mg, Nicotinamide 1000 mg, Cobalt 150 mg, Copper 1200 mg, Iodine 325 mg, Iron 1500 mg,

Magnesium 6000 mg, Manganese 1500 mg, Potassium 100 mg, Selenium 10 mg, Sodium 5.9 mg, Sulphur 0.72%, Zinc 9600 mg, Calcium 25.5% and Phosphorus 12.75%.
6Himedia Laboratories Ltd., Mumbai, India.

Table 3: Proximate composition of the test diets (g/100g) on a dry weight basis

Parameters	Mixed zooplankton (T1)	35% CP (T2)	Tokyu (T3)
Moisture	90.38 ± 0.35^{c}	9.48 ± 0.33^{b}	8.39 ± 0.19^{a}
Crude protein	54.18 ± 0.37^{c}	35.12 ± 0.16^{b}	21.48 ± 0.21^{a}
Crude fat	12.95 ± 0.67^{c}	3.86 ± 0.18^{b}	1.53 ± 0.15^{a}
Crude fibre	6.44 ± 0.33^{b}	3.41 ± 0.11^{a}	8.08 ± 0.35^{c}
Ash	6.15 ± 0.42^{a}	8.17 ± 0.16^{b}	9.42 ± 0.30^{c}
Nitrogen Free Extract (NFE)	20.28 ± 0.39^{a}	39.96 ± 0.48^{b}	59.49 ± 0.86^{c}
Energy (Kcal/100g diet)	414.37 ± 5.16^{b}	335.01 ± 0.67^{a}	337.70 ± 1.90^{a}

Mean values with different superscript in a row are significantly different. Values are in mean ± S.E. (n=3)
Digestible energy (Kcal/100g) = (4 x Crude protein %) + (9 x Lipid %) + (4 x Carbohydrate %)
T1= Live food (mixed zooplankton); T2= 35% CP feed; T3= Tokyu.

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A hematological study in different sexes of walking cat fish, *Clarias magur* (Hamilton, 1822) in captive environment

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Abstract:

The hematological parameters in male and female fishes of Clarias magur have been studied during their culture in circular cemented cistern during pre-breeding period (December, 2012 – February, 2013) and post breeding period (August – October, 2012). Seven hematological parameters are observed in experimental findings which include haemoglobin (Hb), total erythrocyte count (TEC), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and differential leucocytes count (DLC). A comparative account has been prepared between the male and female in two different reproductive periods (pre-breeding and post breeding) in respect of the studied parameters during captive culture. The values of hematological parameters (Hb, RBC & PCV) were higher in male compared to female in both the periods. However, differential leucocytes count (eosinophil %, monocytes % & neutrophil %) in both the sexes are found to be higher in pre-breeding period than in the post breeding period barring lymphocytes (%), which is reverse in both the sexes. The percentage of neutrophils is found higher among the differential count of leucocytes in both the sexes.

Key words: Hematological parameters, Clarias magur, captive environment.

Introduction:

Clarias magur is considered as the most coveted catfish species with high market demand deserving its potential culture under aquaculture policies of the country. This species is declared as endangered species by IUCN, 2010. The population of this species is declining day by day due to shrinkage of its habitats. Human interference in general and use of pesticides in the paddy fields (the breeding ground) besides overfishing in particular are serious threats to its population. This silurid species belonging to the family Clariidae is considered as one of the most potential cultivable catfish, popularly known for its medicinal values among the rural masses probably due to its delicacy and high nutritive value (Debnath, 2011). Moreover the species is very hardy to thrive for a long period in water due to presence of accessory respiratory system, which is advantageous to culture in shallow water habitats. It is believed to contain higher percentage of protein and iron as compared to other edible species of fish. In natural environmental condition they are founds in swamps, marshy, shallow and small ponds, ditches etc. Generally, these water bodies are usually shallow with decaying vegetation and low pH, oxygen and primary productivity. Hematological studies in fishes have acquired greater importance due to the increasing emphasis on Pisciculture (Kandari and Rauthan, 2015) and widely used as a basic tools for assessing the health of fishes in aquatic environment (Pradhan, 2011). As the production criteria of fish changes from capture fisheries, and traditional fish farming stage to the well-developed sophisticated aquaculture and culture fisheries, monitoring of physiological and pathological changes in fishes is most essential. Monitoring of blood cells, blood biochemistry are useful for the diagnosis of diseases and assessing the physiological status of fish (Stoskopf, 1993). Blood parameters are good indicators of various external stimuli, which reflect in the changes of these parameters. Leucocytes are the first line of defense against any foreign bodies of an organism. All the five vertebrate taxa including fish, natural stressors or exogenous administration of stressors in the environment elicit a stress response in their leucocytes

profile (Davis et al., 2008). The aims of the present study is to finds out the baseline reference values of hematological parameters of the walking catfish in two periods i.e. pre breeding period (PreBP) and post breeding period (PBP) based on sexual differences. This study could help in understanding the health status of this fish in captive environment.

Materials and Methods:

Healthy live fish samples were procured before three months in each period from the local market of Jogripam (Bhabanipur) Barpeta, Assam and treated them with KMnO4 (1 mg.l-1) for 1 t0 2 minutes to remove external parasites. A set of three (3) circular cement cisterns, each having volume of 0.34 m3 was used for culture of adult fishes to study hematological parameters. The bottom of the cistern was filled with muddy soil to a thickness of 10 cm for providing natural environment. Aquatic plants (Ottelia alismoides) were planted and duck weeds were provided to create natural environment. The surfaces of the cisterns were shaded by coconut leaves during sunny days to prevent high solar radiation. The whole cistern was filled with 70% pond water and 30–40% water of it was changed every 15 days. Ten (10) numbers of live individuals (Clarias magur) were reared in each cistern, and fed twice a day with boiled chicken egg protein paste with trash fish at the rate of 5% body weight at 11 A.M and 6 P.M.A total number of 36 live samples of Clarias magur were examined from the culture in circular cemented cistern during pre-breeding period (PreBP) (December, 2012 – February, 2013) and post breeding period (PBP) (August – October, 2012) for haematological studies. In every month of PreBP and PBP, six (6) samples (n=3 per sex) were collected from the rearing circular cistern and blood samples were taken by puncturing the heart (Pradhan et al., 2011 and Gupta et al., 2013) using sterile syringe (Disovan) and transferred to anticoagulation Vials (RAP-T) for the study. Three replicas were made from each sample of the fishes.

The experiment was carried out following the protocol of Ghai (2004) and Gahlawat et al. (2007). The weight ranges of the live samples of male and female respectively were 97.11 ± 8.11 g and 99.32 ±7.88 g during PreBP and 95.73 ±8.60 g and 97.63 ± 7.24 g during PBP.

The hemoglobin estimation was done by Sahli's methods. The total erythrocytes count (RBC) was counted with the help of improved Neubaur's haemocytometer slide (Rohem, India) using Hayem's (RBC diluting fluid) solution. The hematocrit or PCV values were estimated by using Wintrobe's tube (Ghai, 2004). For differential count of WBC, blood film stained with Leishman's stain. Two hundred cells of uniform blood smears were taken for differential count of the sample and observed under Labovision (IS-8275) binocular microscope at 100X under oil immersion.

The erythrocyte indices viz: mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were calculated from the total erythrocyte count (TEC), hemoglobin % (Hb) and hematocrit % (PCV) values by using standard formulae as follows :

(a) MCV (Mean Corpuscular Volume):

This is calculated from

$$MCV = \frac{PCV\ (\%) \times 10}{RBC\ in\ million/mm^3}$$

(b) MCH (Mean Corpuscular Haemoglobin):

This is an amount of haemoglobin in average blood cells and was calculated as

$$MCH = \frac{Hb\ in\ (g/dl)\%\ x\ 10}{RBC\ in\ millions}$$

(pg: pictogram, 1pg = 10^{-12})

(c) MCHC (Mean Corpuscular Haemoglobin concentration):

This is the portion of the average red cells containing haemoglobin, which was estimated by using the following formula:

$$MCHC = \frac{Hb\ (g/dl)\ \%}{PVC\ \%} \times 100$$

Results:

1. Haemoglobin concentration (Hb g/dl)

The haemoglobin concentration of *Clarias magur* oscillates in both the sexes during post breeding period (PBP) (Aug. – Oct., 2012) and pre-breeding period (PreBP) (Dec, 2012 – Feb, 2013). In mature male fishes, haemoglobin (Hb) concentration ranges between 11.7 g/dl and 16 g/dl (13.44 ± 1.12 g/dl) during pre-breeding period and between 10 g/dl and 14 g/dl (11.78 ± 1.48 g/dl) during post breeding period. In female, concentration of haemoglobin varies from 11.8 – 14.4 g/dl (13.28 ± 1.20 g/dl) in pre-breeding period and 10.5 – 11.8 g/dl (11.38 ± 0.46 g/dl) in post breeding period (Table –1 & 2).

2. Total erythrocytes count (RBC $10^6/mm^3$)

Fluctuation of RBC has been observed in both the sexes through the periods. In mature male, during pre-breeding period (PreBP) and post breeding period (PBP), the total RBC count ranges between 1.81 x 10^6 mm^3 and 2.56 x 10^6 mm^3 with an average of 2.10 ± 0.21 x 10^6 mm^3 and between1.05 x 10^6 mm^3 and 2.13 x 10^6 mm^3 (1.51 ± 0.35 x 10^6 mm^3) respectively (Table –1&2).

Similarly, the total RBC count of mature females fluctuates between 1.51 x 10^6 mm^3 and 2.18 x 10^6 mm^3 (1.87 ± 0.23 x 10^6 mm^3) during PreBP, and between 1.14 x 10^6 mm^3 – 1.64 x 106 mm^3 (1.46 ± 0.17 x 10^6 mm^3) during PBP (Table -1 & 2).

3. Packed Cell Volume percentage (PCV %)

Variation of PCV has been recorded in both males and females during PreBP and PBP as depicted in the Table –1 & 2. In mature male, the PCV percentage ranges from 36 – 49.3% with a mean 42.16 ± 3.41% during PreBP and 32 – 45.2% with a mean value 37.12 ± 4.47% during PBP. Similarly, in mature females, during PreBP and PBP, the PCV remain in a range between 34% and 46.1% (41.36 ± 4.89%) and between 35% and 38.9% (36.92 ± 1.39%) respectively**.**

4. Mean corpuscular volume (MCV)

Corpuscular volume of male ranges from 185.57 – 232.04 fl with a mean (201.53 ± 14.07 fl) during PreBP and 212.21 – 317.14 fl (252.27 ± 33.60 fl) in PBP. Similarly, the MCV of female ranges from 206.06 – 249.01 fl with mean 221.86 ± 15.94 fl during PreBP and 228.40 – 307.02 fl with mean 254.40 ± 26.27 fl during PBP (Table–1 & 2).

5. Mean corpuscular haemoglobin (MCH):

Mean corpuscular haemoglobin value of male ranges from 60.31 – 71.82 pg with mean 64.20 ± 3.55 pg during PreBP and 65.73 – 95.24 pg with mean 79.88 ± 8.97 pg during PBP. Similarly, the MCH of female ranges from 66.06 – 78.15 pg with mean 71.4 ± 3.74 pg during PreBP and 70.99 – 92.11 pg with mean 78.40 ± 7.31 during PBP as shown in the Table-1 & 2.

6. Mean corpuscular haemoglobin concentration (MCHC%):

The mean corpuscular haemoglobin concentration (MCHC) value ranges from 30.95 – 32.50 % (31.88 ± 0.51 %) in male during PreBP, and 30.03 – 34.74 % (31.75 ± 1.26 %) during PBP, whereas in female fish, it varies from 31.23 – 34.71% (32.24 ± 1.42 %), which is slightly higher than the MCHC (30.00 – 31.77 %, 30.85 ± 0.57 %) shown by the female in PBP (Table- 1 & 2).

7. Differential leucocytes count (DLC):

Differential leucocytes count (DLC) of *Clarias magur* exhibits certain fluctuations in both male and female during PreBP and PBP (Table–3 & 4). The percentage of neutrophils (77.37 ± 10.37%) is maximum in male followed by the percentage of lymphocytes (20.5 ± 10.92%) > eosinophils (1.62 ± 0.91%) and monocytes (0.62 ± 0.74%) during PreBP. Similar trend is also recorded during PBP in male, showing that the percentage of neutrophil (62.31 ± 15.43%) is maximum followed by the percentage of lymphocytes (36.93 ± 15.68%) > eosinophil (0.43 ± 0.81%) and monocytes (0.31 ± 0.60%) (Figure-1).

Like male fishes, the female shows similar trend during both PreBP and PBP. The percentage of neutrophils (62.87 ± 4.96%) is found to be maximum which is followed by the percentage of lymphocytes (35.12 ± 5.02%) > eosinophils (1 ± 0.92%) and monocytes (1 ± 0.92%) during PreBP. It was also observed that in PBP an identical trend of DLC is maintained with the highest count of the neutrophils (55 ± 14.32%) > lymphocytes (44.22 ± 14.40%) > eosinophil (0.55 ± 1.04%) > monocytes (0.27 ± 0.46%) (Table–3 and Table-4) (Figure-1). In the present study, in both male and female during PBP and PreBP, no basophil is recorded.

Table-1: Haematological parameters of *Clarias magur* (male and female, n=9 per sex) during post breeding period (August, – October, 2012).

Haematological parameters	Male Mean ± SD	Female Mean ± SD
Hb (g/dl)	11.78 ± 1.48 (10–14)	11.38 ± 0.46 (10.5–11.8)
RBC (10^6/mm^3)	1.51 ± 0.35 (1.05–2.13)	1.46 ± 0.17 (1.14–1.64)
PCV (%)	37.12 ± 4.47 (32–45.2)	36.92 ±1.39 (35–38.9)
MCV (fl, femtoliters)	252.27 ± 33.60 (212.21–317.14)	254.40 ±26.27 (228.40–307.02)
MCH (pg, picograms)	79.88 ± 8.97 (65.73–95.24)	78.40±7.31 (70.99 –92.11)
MCHC (%)	31.75 ± 1.26 (30.03–34.74)	30.85 ± 0.57 (30.00–31.77)

Table-2: Haematological parameters of *Clarias magur* (male and female, n=9 per sex) during pre breeding period (Dec, 2012 – Feb, 2013).

Haematological parameters	Male Mean ± SD	Female Mean ± SD
Hb (g/dl)	13.44 ± 1.12 (11.7–16)	13.28 ± 1.20 (11.8–14.4)
RBC (10^6/mm^3)	2.10 ± 0.21 (1.81–2.56)	1.87 ± 0.23 (1.51–2.18)
PCV (%)	42.16 ± 3.41 (36–49.3)	41.36 ± 4.89 (34–46.1)
MCV (fl, femtoliters)	201.53 ± 14.07 (185.57–232.04)	221.86 ± 15.94 (206.06–249.01)
MCH (pg, picograms)	64.20 ± 3.55 (60.31–71.82)	71.40 ± 3.74 (66.06–78.15)
MCHC (%)	31.88 ± 0.51 (30.95–32.50)	32.24 ± 1.42 (31.23–34.71)

Table-3: Differential count of leucocytes (WBC) in *Clarias magur* (male, n=9).

Month/period	Eosinophil% (mean±SD)	Monocyte% (mean±SD)	Lymphocyte% (mean±SD)	Neutrophil% (mean±SD)	Basophil% (mean± SD)
Aug.– Oct., 2012 (post breeding period)	0.43±0.81 (0–2)	0.31±0.60 (0–2)	36.93±15.68 (13–69)	62.31±15.43 (31–87)	Nil
Dec., 2012 – Feb., 2013 (pre breeding period)	1.62±0.91 (0–3)	0.62±0.74 (0–2)	20.5±10.92 (7–33)	77.37±10.37 (67–90)	Nil

Table-4: Differential count of leucocytes (WBC) in *Clarias magur* (female, n=9).

Month/period	Eosinophil% (mean±SD)	Monocyte% (mean±SD)	Lymphocyte% (mean±SD)	Neutrophil% (mean±SD)	Basophil% (mean±SD)
Aug.– Oct., 2012 (post breeding period)	0.55±1.04 (0–4)	0.27±0.46 (0–1)	44.22±14.40 (23–67)	55±14.32 (33–77)	Nil
Dec., 2012 – Feb., 2013 (pre breeding period)	1±0.92 (0–3)	1±0.92 (0–2)	35.12±5.02 (24–40)	62.87±4.96 (59–73)	Nil

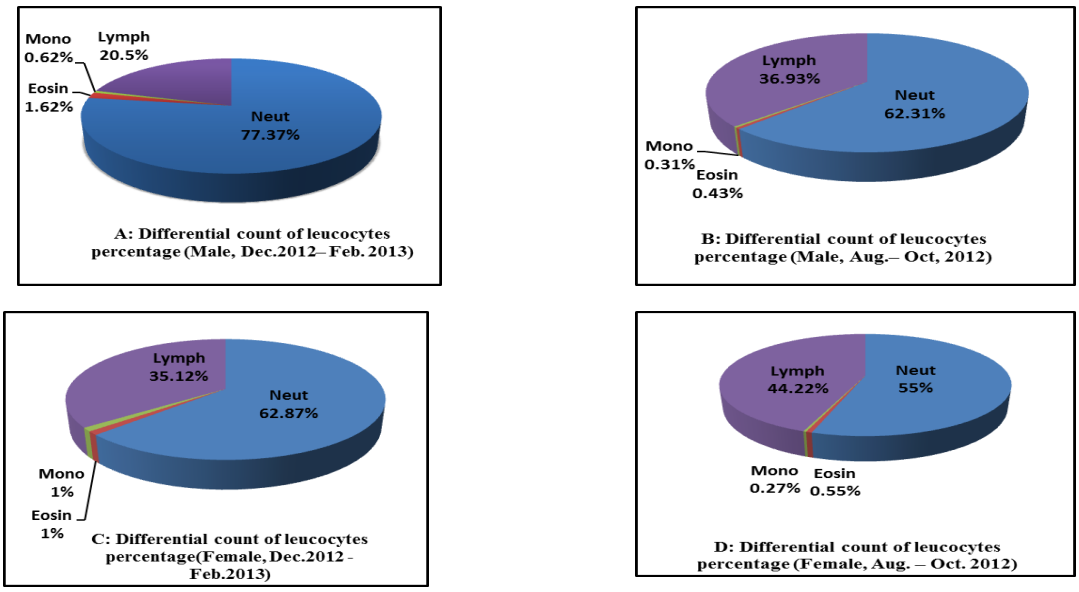

Figure-1: Pie-diagram showing the percentage of leucocytes of *Clarias magur* in both male (A, B) and female (C, D) in two different periods (pre- breeding and post breeding period).

Discussion

The haematological studies are considered as a valuable diagnostic tool in evaluating fish quality (Anderson and Klontz, 1956; Hesser, 1960; Bhaskar and Rao, 1985, 1990; Kori-Siakpere et al., 2005; Oluyemi et al., 2008). In the present findings, higher values of Hb, RBC and PCV are observed in both male and female during PreBP than the PBP (Table-1 and 2), which may be due to metabolic stress in the captive environment during colder months supplemented by high energy demand for incoming breeding preparation (Bidwell and Heath, 1993; Gupta et al., 2013). The MCV value of female is found to be higher than male in both PreBP and PBP (Table-1 and 2), which may be due to lower value of PCV (Acharya and Mohanty, 2014). Similarly, it is also observed that MCH value of female is higher than in the male, which may be due to occurrence of macrocytic anemia in females (Robbins et al., 1974). Fluctuations of haematological attributes in fishes have taken place

due to various factors such as fish size (Garcia et al., 1992), gender (Siddique and Naseem, 1979; Collazos et al., 1998); malnutrition (Casillas and Smith, 1977); environmental stress (Hickey, 1982) and seasonal differences and breeding efficiency (Cech and Wohlsch lag, 1981). Poston (1966) also reported that hematocrit value for male fish does increase prior to the time of spawning. The value of Hb concentration is found to be higher in male during both the observed periods which corroborates the finding of Fourie and Hatting (1976) and Raizada et al. (1983). This may be attributed to the fact that the Hb concentration in male fishes over females, as observed in present investigation, are found to be higher (Table-1 and 2) due to more activeness in males than the females (Orun et al., 2003; Pradhan, 2011; Acharya and Monhanty, 2014).

Leucocytes are the first line of defense against any foreign bodies of an organism. All the five vertebrate taxa including fish, natural stressors or exogenous administration of stressors in the environment elicit a stress response in their leucocytes profile (Davis et al., 2008). In the present investigation, fluctuation of differential leucocytes count (DLC) is evident in both male and female during both PreBP and PBP. However, eosinophils (%), monocytes (%) and neutrophils (%) in both the sexes are found to be higher in pre-breeding period than in the post-breeding period (Table-3 and 4). Indeed reverse is the case for lymphocytes (%) during pre-breeding period and post breeding period as observed in both male and female (Table-3 and 4). Marked variation of lymphocyte and neutrophil percentage in both the sexes are also observed in two periods. The neutrophil (%) is found higher than lymphocytes (%), which contradicts the earlier finding of Summarwar (2012) and Gupta (2013). This may be due to the stress condition of the fish in captivity than in the natural environment (Srivastava, 2010). Infection in fishes is indicated by an increase in the percentage of neutrophils and eosinophils (Sahan et al., 2007). Lymphocytes numbers are known to show variability to the physiological condition of fish (Klontz, 1972). Decreased lymphocyte numbers were observed under stress conditions – hypoxia, cortisol induced or during handling and transport (Ellsaesser and Clem, 1986, 1987). An association between leukocyte profiles and glucocorticoids levels have been demonstrated to exist in many vertebrates and higher neutrophils : lymphocyte ratio is considered to be reliably indicative of higher glucocorticoid levels (Davis et al., 2008) i.e. stressful condition. Reduction in lymphocyte counts has been reported in case of catfish – Ictalurus (Ellsaesser and Clem, 1987) and Rhamdia quelen (Barcellos et al., 2004). In the present study, during captive culture of Clarias magur, no basophil was found to exist. Similar finding are also reported by Zexia, 2007; Kohanestani, 2013; Acharya and Monhanty, 2014.

Conclusion

On the basis of present findings it could be concluded that variation of haematological parameters in Clarias magur is observed in different sexes as well as in different reproduction periods in captive environment. From the differential leucocytes count (DLC), it is indicative that the fishes were in mild stress condition in captive environment. As the production criteria of fish changes from capture fisheries, and traditional fish farming stages to the well developed sophisticated aquaculture and culture fisheries, more research will be necessary to determine the effects of microhabitat, nutritional status and seasonal variations on the fish haematological parameters.

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Haematological alterations in air breathing catfish, *Heteropneustes fossilis* exposed to copper and cadmium

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Abstract

The present study is aimed to investigate the haematological parameters such as haemoglobin (Hb), red blood cells (RBC), white blood cells (WBC), haematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) in the blood of fresh water air breathing catfish, Heteropneustes fossilis exposed to sub-lethal concentration of copper and cadmium for a period of 30 days. Heteropneustes fossilis showed alterations in haematological parameters on exposure to both Cu and Cd. Both Cu and Cd caused a reduction in RBCs, Hb and HCT as compared to control ($p<0.05$) whereas, there was an increase in WBC count and higher in each case than in the control ($p<0.05$). Red blood cell indices such as MCV and MCH showed a decrease in their level on exposure to Cu and Cd and decreased with increasing period of exposure time. However, MCHC showed an increase in its level on exposure to both Cu and Cd and gradually increased with increasing period of time. Cu showed higher toxicity than Cd and the sequence of alteration in haematological parameters indicated by two metals was Cu > Cd. The alterations in blood parameters may be the result of direct damage to blood cells or indirectly to the target organ. The dysfunction induced by the toxicants and these parameters can be used as a rapid and reliable indicator of environmental contamination.

Keywords: Cadmium, Copper, Haematological alterations, Heteropneustes fossilis

Introduction

Among various animal species, fishes are the inhabitants that cannot escape from the detrimental effects of pollutants (Olaifa et al., 2004) and are therefore very susceptible to physical and chemical changes which may be reflected in their blood components (Wilson and Taylor, 1993). Fish blood is being studied increasingly in toxicological research and environmental monitoring as a possible indicator of physiological and pathological changes in fishery management and disease investigations (Bansal et al., 1980). Blood parameters have been used as sensitive indicator of stress in fish exposed to different water pollutants and toxicants and are considered as pathophysiological indicators of the whole body and therefore are important in diagnosing the structural and functional status of fish exposed to toxicants (Adhikari et al., 2004). The responses of fish to particular stressor vary according to their characteristics, however there are features of stress reaction common to the majority of most forms of environmental stressors which are known to alter their blood characteristics thereby leads to disruptions in metabolic activities (Ajani et al., 2007), reduced growth rate and impairment of reproductive process (Mgbeka et al., 2005) suppression of immune system (Auta, 2001) and in extreme cases results in mortality (Akinrotimi et al., 2009).

The use of haematological parameters in assessment of fish physiology was proposed by Hesser (1960), since then haematology has been used as an index of fish health status in a number of fish species to detect physiological changes, as a result of exposure to different stressful condition such as handling, pollutants, metals, hypoxia, anaestehtics and acclimation (Ogbulie and Okpowasili, 1999; Alwan et al., 2009). Haematological parameters are considered to be reliable approach in the assessment of toxicity of different chemicals (Jezierska and Witeska, 2001). Changes in these parameters depend on the magnitude of

impact of contaminants (concentration), the duration of exposure besides fish species, their age and health status (Jezierska and Witeska, 2001). Haematological indices such as haemoglobin (Hb), haematocrit (Hct), Red Blood Cells (RBCs), White Blood Cells (WBCs) and so on are therefore, ready tools used by fish biologists and researchers in many parts of the world in diagnosing stress and have also been used as an indicator of metal pollution in the aquatic environment (Shah and Altindag, 2004a). This is so because, fish are closely associated with aquatic environment and the blood becomes an indicator of slightest change within the body of fish, well before there is any visible sign of disease (Fernandes and Mazon, 2003) and is also an effective tool for detection of alterations in functional state of organism (Rambhaskar and Rao, 1987).

Materials and methods

Experimental animal and chemical

The air-breathing catfish H. fossilis were procured from the commercial source and care was taken to minimize stress incurred by the fish during transportation. After transportation to laboratory, the specimens were given prophylactic treatment by bathing them in 0.05 % KMnO4 solution for five (5) min to avoid any dermal infections. The specimens were fed with chicken liver and rice cake. The fecal and other waste materials were siphoned off daily to reduce the ammonia content in water. All the necessary precautions for maintaining the fish were laid down as per the recommendations of APHA (2005). For the present study, technical grade copper sulphate, pentahydrate, A.R. (CuSO4) and cadmium chloride, monohydrate, A.R. (CdCl2) manufactured by HiMedia Laboratories Pvt. Ltd. Mumbai, India, were procured and used.

Experimental Design

For chronic toxicity tests, three groups (Grp I- control, Grp II with copper and Grp III with cadmium) were set up and to each group 10 healthy fish were introduced. One-tenth (0.3 ppm and 2.4 ppm) of the 96 h LC50 value of the CuSO4 (3 ppm) and CdCl2 (24 ppm) respectively as determined during preliminary bioassay study (unpublished) were taken as sub-lethal concentrations. The pH of the experiment was maintained to be 7.0±0.5 which was adjusted using ultra pure NaOH and was continuously monitored during the toxicity test (using a Lutron PH-206 pH meter), with adjustments made as required. The physico-chemical characteristics of water used in the experiment were determined in accordance with the standard methods (APHA, 2005) (temperature 17.0 ± 1.00oC, specific conductivity 0.12 to 0.14 mS, dissolved oxygen 6.58 to7.82 mgl-1, alkalinity 34-38 mgl-1 CaCO3, and total hardness 30 to 35 mgl-1 CaCO3). Experiment was conducted for a period of 30 days and the observations were taken at an interval of 10, 20 and 30 days. This study was conducted in the static test conditions following the OECD guideline No. 203 (OECD 1992).

Haematological analysis

At the end of each exposure period, fish from control and toxicant treated tanks were randomly collected and were anaesthetized with MS222 (Ethyl 3-aminobenzoate methanesulfonate salt, Sigma), and blood samples were taken from the caudal vein of each fish with a sterile syringe containing EDTA solution as an anticoagulant. The collected blood samples were immediately subjected to haematological analysis. The blood was diluted with appropriated diluting fluids for RBC and WBC counts and was determined using improved Neubauer haemocytometer and calculated (Blaxhall and Daisley, 1973). Replicated counts were made for each blood samples. Sahli's haemoglobinometer was used to estimate haemoglobin (Hb) percentage (Hb%). Haematocrit (HCT) was determined using micro haematocrit capillaries filled with blood and centrifuged at 8,700xg for 5 min and expressed

as percentage of total blood volume (Wintrobe, 1974). Mean corpuscular volume (MCV), mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC) were calculated from the average values of RBC and Hb % (Dacie and Lewis, 1984).

Statistical analysis

The data obtained were statistically analyzed using SPSS package (version 17.0) computer software. One way analysis of variance (ANOVA) was applied to compare the means between the control and the treated. The values for all biochemical constituents are expressed as mean ± SD (n=3). Significant differences were defined at $p \leq 0.05$.

Results

H. fossilis showed alterations in haematological parameters on exposure to 0.3 ppm of Cu and 2.4 ppm of Cd (Table 1). Both Cu and Cd caused a reduction in RBCs, Hb and HCT in all exposure periods, as well being in each case lower than in the control ($p<0.05$). While WBCs increased with increasing duration of days on exposure to both Cu and Cd and higher in each case than in the control ($p \leq 0.05$). RBC indices such as MCV and MCH showed a decrease in their level on exposure to Cu and Cd and decreased with increasing period of exposure time. However, MCHC showed an increase in its level on exposure to both Cu and Cd and gradually increased with increasing period of time.

Discussion

Changes occurring in the haematological characters of fishes provide a sensitive measure to assess the health of fish fauna. Further, the fish blood is a valuable diagnostic tool for the investigation of diseases and physiological or metabolic alterations. The quality and quantity of blood cells (RBCs and WBCs), which are prime important blood parameters are used in evaluating the health of the animals. Any type of fluctuation in these parameters is the reflection of stress, caused by some contaminant in the environment (Tierney et al., 2004). The toxic substances cause fluctuations in haematological parameters, either by enhancing their number or by suppressing their biosynthetic sites (Scott and Sloman, 2004). The present results showed a significant decrease in RBC count in H. fossilis exposed to both Cu and Cd. These results are in agreement with Gill and Epple, 1993 and Karuppasamy et al., 2005 who found a significant reduction in RBC count in American eel, Anguilla rostrata and the air breathing catfish Channa punctatus after exposure to Cd. Ramesh (2001) also reported similar results in Cyprinus carpio exposed to copper sulphate. Ruparelia et al. (1990) also found a significant reduction in RBC count when O. mossambicus exposed to 0.1-10.0 µgl-1 of Cd. Van vuren et al., 1994 also found a significant decrease in RBC count when catfish Clarias gariepinus exposed to background Cu. Reduction in the count of RBC in the present study may be related to target organ damage and impaired osmoregulation.

Haemoglobin (Hb) is a sophisticated oxygen delivery system that provides the desired amount of oxygen to the tissues under a wide variety of circumstances (Voet and Voet, 1990). According to Blaxhall and Daisley, 1973 the determination of Hb can be a good indication of anaemic conditions. There was a significant decrease noticed in H. fossilis exposed to Cu and Cd in the present study. According to Pamila et al. (1991), the reduction in haemoglobin content in fish exposed to toxicant could also be due to the inhibitory effect of the toxic substance on the enzyme system responsible for synthesis of haemoglobin. The decrease in Hb concentration signifies that the ability of the fish to provide sufficient oxygen to the tissues is restricted considerably and will result in a decrease of physical activity (Wepener, 1990; Nussey 1994).

The present investigation revealed experimental fishes exposed to Cu and Cd, exhibited erythrocytosis and increase in Hb content following 30 days of stress after initial

decrease. This can be due to impairment of gas exchange by the gills and lining of operculum (Osman et al., 2009; Bhatkar, 2010) and the consequent excitation or stimulation of erythropoiesis or compensatory erythropioesis (Adeyemo, 2007).

Decrease in Hb%, RBC count and HCT% values leading to anaemia. Significant decreases in the haematocrit values recorded after exposure to cadmium are indicative of anaemia and haemodilution possibly due to gill damage or/and impaired osmoregulation (Larsson et al., 1985). Anaemia, under copper induced stress, may also be due to blood cell injury and disrupted heamoglobin synthesis (Mckim et al., 1970; Gross et al., 1975). Joshi et al. (2002) suggested that heavy metal exposure also decreased the RBC, Hb% and HCT % due to impaired intestinal absorption of iron. Anaemia is an early manifestation of acute and chronic intoxication of heavy metals. Significance of these changes may be understood in terms of reduced oxygen consumption in fish resulting in death due to heavy metal pollution (Christensen et al., 1972).

The most important function of WBCs or leucocytes is the immune reaction to protect the body against stressors, infections, pathogens and chemical irritants (Christinsen et al., 1978).The increase WBC count in the present study may be likely caused by migration of WBCs from the spleen to the blood circulation, or mobilization of neutrophils and monocytes from the bone marrow reserves into the blood stream as reported by Barcellos et al., 2004 in Tagogomphus guineensis subjected to varied water pH. The increase WBC count in H. fossilis exposed to Cu and Cd suggests enhanced body defense mechanism to overcome increasing stress levels. Similar results have also been reported by Van vuren et al., 1994 in C. gariepinus when they found an increase in the count of leucocytes on exposure to Cu. The hypersensitivity of WBCs to Cu and Cd and the enhancement of antibody production to cope with the heavy metal stress in fish H. fossilis corroborate the present study (Singh et al., 2008). In the present investigation depletion in WBC count was observed after 30 days of exposure. The depleted WBC count along with depleted Hb content and RBC count indicates dysfunctioning of haemopoietic systems along with dysleucopoisis. This is most probably due to bone marrow depression and liver dysfunction (António et al., 2007; Osman et al., 2009).

It was observed that MCV values decreased significantly in treated fish over the period of exposure. The MCV is an indication of the size or status of RBCs and reflects an abnormal or normal cell division during eythropoiesis (Larsson et al., 1985). A decrease in MCV indicates that the erythrocytes have shrunk, either due to hypoxia or stress (Kumar et al., 1999). Van Vuren (1986) found similar decrease in MCV when Labeo umbratus was exposed to various chemical pollutants. The reduction in RBC, HB, HCT, MCV and MCH in the present study might be due to the destruction of mature RBCs, or the inhibition of erythropoiesis due to degeneration of erythropoietic tissue in the kidney and spleen leading to haemolytic anaemia and, it also impaired oxygen supply to various tissues, resulting in a slow metabolic rate and low energy production (Iwama et al., 1976). However, the results of the present study indicate a significant increase in the MCHC in the treated fish may be attributed to swelling of RBCs due to increased CO2 in blood, hypoxia or stressful procedures (Iwama et al., 1976; Nandan and Nimila, 2011).

Conclusion

Alterations in haematological parameters may be the result of target organ damage, and the dysfunction induced by the toxicants and these parameters can be used as a rapid and reliable indicator of environmental contamination following exposure to Cu and Cd.

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Table 1 Haematological parameters of *H. fossilis* on chronic exposure to copper sulphate (0.3 ppm) and cadmium chloride (2.4 ppm) at different exposure period (10, 20 and 30 days). The values are expressed as mean ± SD (n=3).

Parameters	Control (0 days)	Treatment	Exposure Period (in days)		
			10	20	30
RBC ($x10^6/mm^3$)	4.86 ± 0.49	Cu	4.13 ± 0.13*	3.51 ± 0.18*	3.99 ± 0.19*
		Cd	4.67 ± 0.24	3.76 ± 0.13*	4.11 ± 0.12*
WBC ($x10^3/mm^3$)	24.20 ±1.31	Cu	26.13 ± 2.29*	32.71 ± 2.19*	28.23 ± 1.76*
		Cd	25.14 ± 2.17	26.93 ± 2.14*	25.37 ± 2.03*
Hb (g/dL)	14.85 ±0.61	Cu	12.15 ± 0.13*	10.19 ± 0.29*	11.12 ± 0.12*
		Cd	13.72 ± 0.23*	10.76 ± 0.19*	11.16 ± 0.12*
HCT (%)	41.77 ±1.53	Cu	33.53 ± 1.19*	27.19 ± 1.24*	29.56 ± 1.31*
		Cd	37.95 ± 1.27*	29.01 ± 1.19*	29.05 ± 1.51*
MCV (fL)	85.95 ±3.12	Cu	81.19 ± 2.25*	77.46 ± 2.10*	74.09 ± 1.76*
		Cd	81.26 ± 2.15*	77.15 ± 2.21*	70.68 ± 1.54*
MCH (pg)	30.56±1.94	Cu	29.42 ± 1.75*	29.03 ± 1.37*	27.87 ± 1.45*
		Cd	29.38 ± 1.29	28.62 ± 1.67*	27.15 ± 1.48*
MCHC (g/dL)	35.55 ±2.77	Cu	36.24 ± 2.21	37.48 ± 2.52*	37.62 ± 2.11*
		Cd	36.10 ± 2.321	37.09 ± 2.51	38.41 ± 2.34*

*$p \leq 0.05$

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Histopathology of gills of common carp (*Cyprinus carpio* L.) inhabiting Umiam Reservoir in Meghalaya

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Abstract

Organs and tissues respond to stimuli, either physiological or pathological, in various ways, many of which can be identified and studied by histology. The present study highlights the histopathological changes observed in the gills of common carp inhabiting a polluted Umiam reservoir through light microscopy. Anomalies observed in the gills are hyperplasia, hypertrophy of the epithelial cells, lifting of the lamellar epithelium, fusion of the lamellae, disorganized pillar cells, lamellar aneurysms and hemorrhages. All these histological abnormalities in the gill of fish are discussed with the help of relevant literature.

Key words: Histopathology; Cyprinus; Umiam; Reservoir; Gills; Lamellae

Introduction

Histopathological changes have been widely used as biomarkers in the evaluation of the health of fish exposed to contaminants, both in the laboratory (Wester & Canton, 1992; Thophon et al., 2004) and field studies (Hinton et al., 1992; Teh et al., 1997). These morphological changes can provide the clues necessary to establish a diagnosis (Morrison et al., 2010), and also help to identify target organs of toxicity and mechanism of action (Wester et al., 2002).Umiam reservoir, the fourth largest reservoir in North-East India, located in Ri Bhoi district of Meghalaya, suffers tremendously from pollution loads, which are being increased day by day. An estimated total of 20 to 25 tonnes of solid waste finds their way into the drains, rivers and then into the reservoir Umiam every day. On that consideration, the present study has been undertaken to determine the adverse effects of contaminated reservoir Umiam on some aquatic biota. While assessing the adverse impact of environmental pollution on aquatic organisms, such as fish, studies on gills appears to be relevant.

The gills are in direct contact with the external environment and are considered as the primary target to a variety of noxious agents in the water (Poleksic & Mitrovic-Tutundzic, 1994; Mazon et al., 2002; Fernandes & Mazon, 2003). The gill is a very complex organ which involves not only in gas exchange, ion exchange and acid-base balance, but also in nitrogenous waste excretion (Pawert et al., 1998; Evans, 1987). The secondary lamellae are the sites of gas exchange, with blood-to-water distances of less than one micrometer in active species and 1 to 10 µm in sluggish fishes (Evans, 1987). Thus, the gill is one of the vital organs of fishes, and due to the fact that it is in direct contact with the surrounding water, any change in the water body is likely to affect this immediately. As pointed out by some authors, the gills are very sensitive to different environmental conditions and can undergo pathological changes which may be mediated by parasites including microbes and viruses (Regar and Bhatnagar, 2006). Moreover, fish gills are sensitive to many classes of chemical pollutants dissolved in water and therefore, any damage to their structure can interfere with respiration and the ionic homeostasis (Machado and Fanta, 2003). In the study of anthropogenic effects on the aquatic environment, morphologic responses of fish can be used as indicators for toxicants (Lindesjo and Thulin, 1994). Thus, changes in the morphology and more importantly, changes in the cells and tissues of the fish may indicate that the organism is living in highly toxic environment.

The present study was undertaken to have an in-depth knowledge on the adverse effects of the polluted reservoir Umiam on the gills of a representative fish species, common carp inhabiting it. Fish grown on a clean water body, Rural Resource and Training Centre (RRTC), was used as control. The study focuses on histological alterations in the filaments and lamellae and therefore, appears to be relevant in understanding the effect of pollution on the fish in view of the fact that abnormal structural feature of these cells are bound to cause disturbances in the functional physiology leading to impairment of respiratory and osmo-regulatory functions. Further, the nature of abnormalities may throw light on the possible types of pollutants (present in the water body) affecting the fish.

Materials and methods

C. carpio were collected from reservoir Umiam and RRTC Umran, anesthetized by exposing them to a freshly prepared solution of tricane methane sulphonate in water to a final concentration of 1: 4000 (McFarland and Klontz, 1969). Histological analysis of the gills of control and pollution-exposed fish was conducted following the standard procedure (Verma and Srivastava, 2002). The tissues were cut into small pieces and fixed in Bouin's fluid for 24 hours, washed in running tap water overnight, and dehydrated through ascending series of alcohol (30 %, 50 %, 70 %, 90 %, and 100 %) for 10 minutes each. The tissues were then transferred to xylene for 15 to 20 minutes.

In the meantime paraffin wax was kept in the oven set at 60 0C to melt. The tissues were infiltrated in rising concentrations of paraffin wax to xylene before embedded in pure wax and kept in the oven overnight at 60 0C. Blocks were prepared by putting the tissues in melted wax poured in paper boats. After proper cooling, the tissues were trimmed and sectioned with the microtome at 5 µm thick. The ribbons obtained were placed in clean slides smeared with albumin and stretched using hot water and a hot plate. When the ribbon was fully stretched, the water was drained off from the slide and air dried.

Dried slides were dipped in xylene to remove the wax surrounding the sections and then rehydrated through descending series of alcohol grades (100 %, 90 %, 70 %, 50 %, 30 % and distilled water for 5 minutes each). The sections were stained with aqueous Haematoxylin for 1 minute, washed in tap water to remove the excess stain and differentiated in acid water. Then the sections were dehydrated through ascending series of alcohol grades (30 %, 50 %, and 70 % for 5 minutes each), stained in alcoholic eosin-phloxine stain for less than one minute and dipped again in 70 % alcohol. Slides were then transferred to 90 % and 100 % alcohol grades for 7 minutes each, cleared in xylene and mounted using DPX. Dried slides were observed under Labomed LX 400 optical microscope at X10, X40 and X100 magnifications. Photographs were taken using the attached Canon EOS 1000D camera.

Results

In the control fish, gill filaments or the primary lamellae are long and narrow projections lateral to the gill arch that taper at their distal end. Secondary lamellae are evenly distributed along a filament's length (Fig.1a). There are spaces between the lamellae which act as channels through which water flows (Figs.1a, b). At higher magnification, an individual lamella reveals the presence of two epithelial sheets, held apart by a series of pillar cells (Fig.1b). The epithelium that covers the gill filaments and lamellae is composed of primarily the pavement cells (PVCs) and chloride cells, also known as mitochondrion-rich cells (MRCs). While PVCs are found in all regions of gill filaments, MRCs are usually more common on the afferent (trailing) edge of filaments, as well as the regions that run between individual lamellae, termed the interlamellar region (Fig.1b).

In the pollution-exposed fish, common histological anomalies observed include hyperplasia, hypertrophy of the epithelial cells and lifting of the lamellar epithelium (Figs.1e, f). At some

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locations where hyperplasia is more severe partial fusion or complete fusion of the lamellae are also observed (Figs.1e, f). Besides these, the lamellae become so disorganized that the pillar cells which occupy the middle part of the lamellae and form some bead-like structures have lost their distinct feature and no longer occupy the middle part of the lamellae (Figs.1d, f). Moreover, alterations such as blood congestions, lamellar aneurysms and hemorrhages with rupture of the lamellar epithelium are also observed (Figs.1c, d).

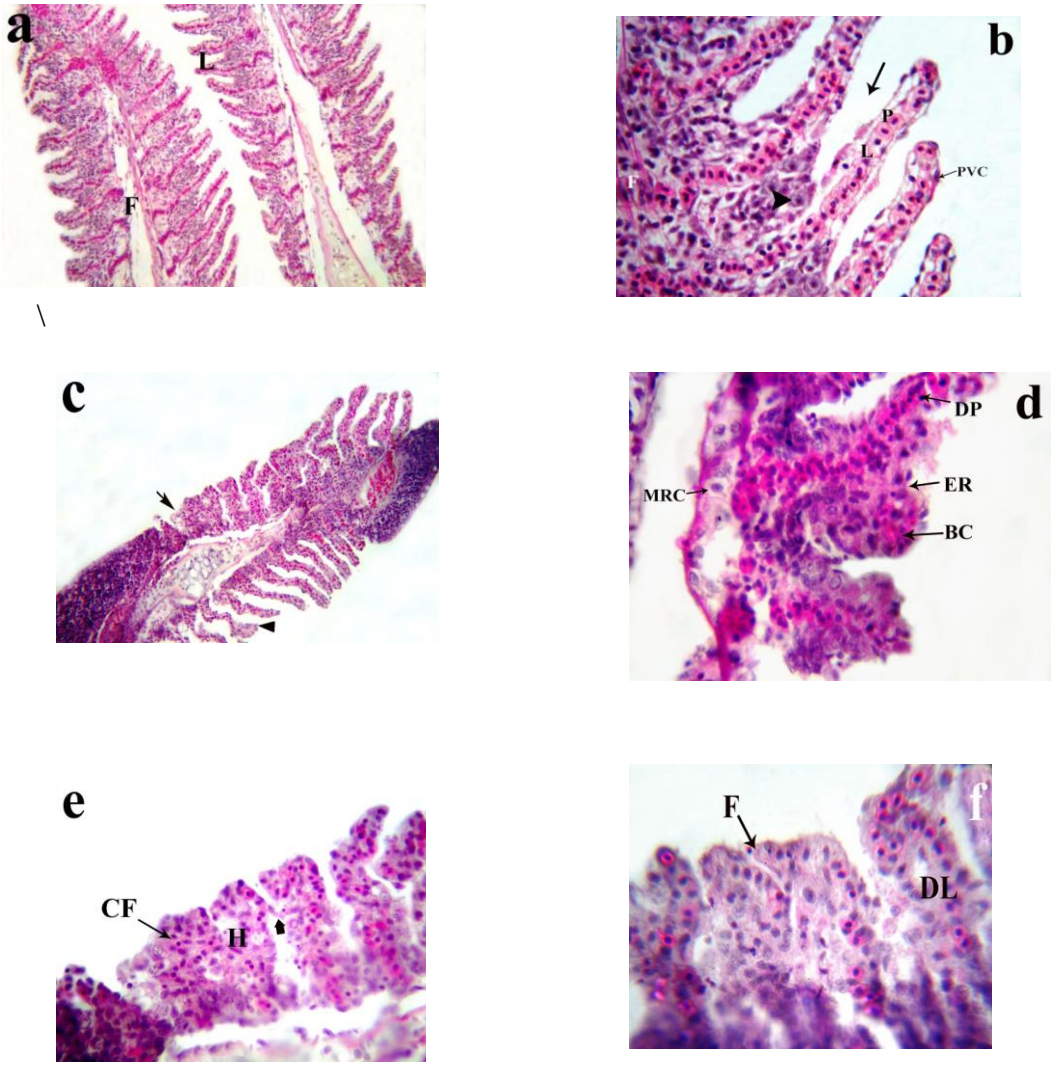

Fig. 1. Photomicrographs of the Gill of C. carpio. (a) Control, showing primary lamellae or filament (F) and the secondary lamellae (L), X100. (b) Enlarged view of Figure (a) showing lamellae (L), filament (F), water channel (black arrow), pillar cell (P), pavement cell (PVC) and mitochondrial rich cell (arrow head), X400. (c-f) Pollution-exposed fish. (c) Hyperplasia, shortening and fusion of lamellae on one side (black arrow), swelling of lamella and lamellar aneurysm (arrow head), X100. (d) Hyperplasia of mitochondrial rich cell (MRC), Epithelium rupture (ER), disorganized pillar cells (DP) and blood congestion (BC), X400. (e) Lamellae with hyperplasia of the epithelial cells (H), complete fusion of lamellae (CF), epithelial lifting (arrow), X400. (f) Fusion of lamellae (F) and lamellar disorganization (DL), X1,000.

Discussion

In fish, gills are critical organs for their respiratory, osmoregulatory and excretory functions. In this study, structural alterations in the gills which include hyperplasia of gill epithelium, shortening, swelling and fusion of the lamellae, lamellar aneurysm, rupture of the epithelium, disorganized pillar cells, blood congestion, lamellar disorganization and epithelial lifting are largely non-specific alterations, and may be induced by a variety of contaminants or pollutants such as heavy metals, organic compounds and chemicals. The degree of the alteration in the gill is related to the level of pollution of an aquatic system in which the total fusion of two secondary lamellae is considered as exposure to a highly polluted environment.

Alterations such as epithelial lifting, hyperplasia and lamellar fusion may reflect a physiological adaptation of the organisms to stress and thus, are examples of defense mechanisms, since, in general, these alterations result in the increase of the distance between the external environment and the blood and thus serve as a barrier to the entry of contaminants. Olurin et al. (2006) suggested that one of the adaptations by which an organism protects its underlying tissues from any irritant is by increasing the number of normal cells or hyperplasia. Moreover, hyperplasia and fusion of the lamellae have always been regarded as defense mechanisms by many authors (Mallatt, 1985; Hinton & Laurén, 1990; Poleksic & Mitrovic-Tutundzic, 1994; Fernandes & Mazon, 2003).

Hyperplasia of the secondary lamellae has also been reported in fish exposed to highly polluted streams (Pawert, 1998). Similar findings were reported by Chezhian et al. (2010) in fishes exposed to industrial effluents. Epithelial lifting of the gill lamellae which is also seen at certain locations in the current study was reported in carps (C. carpio) and tilapias (Oreochromis mossambicus) after exposure to effluents from a wastewater treatment plant by Coutinho & Gokhale (2000). Similar alterations in the gills have also been reported in the fishes exposed to metals (Ribeiro et al., 2000; Cerqueira and Fernandes, 2002; Martinez et al., 2004), and combined anthropogenic activities derived from industries and agriculture (Domingos et al., 2009).

However, increase in the thickness of epithelial layers and fusion of adjacent lamellae as a result of hyperplasia would not only decrease the surface area available for oxygen extraction, but also would increase the oxygen diffusion distance between water and blood. According to Machado and Fanta (2003), cell proliferation in the interlamellar region reduces the respiratory surface and makes gaseous exchange more difficult. Besides, the massive surface area reduction due to lamellar fusion might also inhibit the respiratory, secretory and excretory functions of the gills putting severe stress on fish (Sahoo et al., 2003; Olurin et al., 2006). Thus, alterations such as hyperplasia and fusion of the lamellae which are the results of exposure of the fish to pollution could lead to hypoxia and death of the organism.

Alterations in blood vessels may also occur when fish suffer a more severe type of stress. The pillar cell is the type of modified endothelial cell that spans the lamellar blood space and is a cell type unique to the fish gill. The ends of the pillar cell flare out as thin flanges and extend to neighboring pillar cells enclosing the blood spaces (Wilson and Laurent, 2002). The flanges ranging from 0.02 - 1 µm in thickness (Hughes, 1984) minimize the blood to water diffusion distance. Disorganized pillar cells observed in the present investigation are indications of the adverse effect of pollution on the respiratory function of the organism. Damaged pillar cells can result due to increased blood flow inside the lamellae, causing dilation of the marginal channel, blood congestion or even aneurysm which can be interpreted as a reflection of the direct action of toxic agents on the tissue. Aneurysm is related to the rupture of the pillar cells (Martinez et al., 2004) due to a bigger flow of blood or even because of the direct effects of contaminants on these cells. Moreover, Van den Heuvel et al. (2000) reported that death of the pillar cells caused aneurysm in the tissue. Poleksic &

Mitrovic-Tutundzic (1994) stated that aneurysm is a severe type of lesion, recovery from which is possible, but more difficult than the epithelial changes.

Conclusions

Histopathological changes observed in the gill of common carp in the present study suggest that the reservoir Umiam is highly polluted. The study also suggests that histology is an important tool in studying adverse effects of pollutants in fish tissues.

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Breeding, Hatchery Management and Conservation Stretegy of golden mahseer (*Tor putitora*)

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Abstract

Mahseer, the king of freshwater scaly fish belong to the genus *Tor* and *Neolissochilus* is distributed in the entire North East Himalayan region The importance of mahseer as a world famous game and sport fish is well known. It also fetches high market price and having excellent nutrient composition in terms of quality protein and fatty acid profile. Keeping the importance of this fish in Himalayan and peninsular rivers, streams and lakes, mahseer has all the qualities to become the national fresh water fish of India. However, the population of this fish is declining in natural water bodies and it is considered as an endangered fish as per IUCN status due to various natural and anthropogenic factors. Therefore, standard protocol for breeding and hatchery management is necessary for its rehabilitation and conservation. Suitable policies at different levels need to be formulated and implemented for improving its status and to bring this fish in mainstream of aquaculture. The protocol for artificial breeding and hatchery management of golden and chocolate mahseer has been standardised. Hatchery produced seed has been transported to the different states of India and stocked into the lakes/reservoirs/ rivers/ streams for enhancing the population. The paper will describe the status of mahseer resources in NE Himalaya, its breeding and hatchery management practices, conservation issues and policies, so that we can perceive this fish in the mainstream of aquaculture in near future.

Introduction

Golden Mahseer which is scientifically referred to as *Tor* putitora are large cyprinids, inhabiting the clear, pristine and fast flowing waters of Asia, from the cool waters of Himalayan streams to the tropical rivers of South East Asian jungles. They are highly sought after fish, valued for their excellent taste, ornamental beauty and fighting skills. Mahseer, the big-scaled carp attracts the anglers as well as naturalists from all over the world. Mahseer in the Indian sub-continent described as the 'King of Indian Aquatic Systems' encounters in the *Tor* zone (600 -1200 m) of the glacier-fed Himalayan Rivers with much more extended distribution to the lower reaches in the peninsular Indian rivers (Sarma *et al*., 2010)

Mahseer (also called *sahar* or *mahasheer* - *Tor putitora*) is a well-acknowledged, highly valued indigenous fish of the Himalayan belt. The species is distributed in many rivers, streams and lakes of all along the Mid Himalayas belt, Assam, J& K, Sikkim, as broadly, Afghanistan, Bangladesh, China, Myanmar, Thailand, Cambodia, Laos, Nepal, Pakisthan, Vietnam, Indonesia and Malaysia. Mahseer is one of the potential fish species of Trans-Himalayan countries for fishery development, including aquaculture. In natural systems the fish is known to reach 45 kg of body weight in large rivers.

Mahseer means great mouth in India, an apt name for the long slim creature known to be the toughest fighter amongst fresh water sports fish. The undisputed king of Indian rivers is the Mahseer. A large, powerful fish, it is the largest member of the carp family in the world. Their habitat has high currents & fast flowing so this fish is an ultimate swimmer, this fish swims upstream & can go through rapids of 20-25 knots. Not much is know about the life span of this fish but so expert guess that they live upto age of 20-25 years, the largest specimen even caught was 121 lbs.

Spawning

Golden mahseer as an intermittent breeder and reported that the fish lay eggs at intervals like a chicken through out the year, but main spawning occurs in monsoon. The

intermittent breeding behaviour of *T. putitora* has been established practically in Nepal. It was reported based on gonado-somatic index (GSI) that May to August may be appropriate period for the maturation of this fish in natural waters. The mahseer prefers clean water for breeding and its migratory habits for the purpose are well known. During the floods, the mahseer ascends to upper reaches of the river, traversing long distances for fresh breeding grounds for spawning. There they lay their eggs in sheltered rock pools, a batch of eggs at a time, repeating the process several times in a season. It was observed that Mahseer most certainly breeds at the commencement of the rains. Breeding season as well as spawning in hill-stream fishes are concerned, it is a specific combination of temperature, pH, velocity, turbidity and rains, which collectively induce the fish to spawn and Golden Mahseer also follow the same pattern. Mahseer breeds several times a year. It was identified five distinct stages in breeding females as Stage I (immature virgins), Stage II (maturing virgins), Stage III (ripening), Stage IV (ripe) and Stage V (Fully ripe).

Hatchery operation

In order to save mahseers from extinction, it is necessary to culture them and propagate their seed on a large scale and transport them to streams, lakes and reservoirs. Seed of mahseer is generally collected from natural sources but is recently produced through artificial fecundation and hypophysation (Sarma *et al*., 2009).

Water Supply

In successful aquaculture programme the selection of site for a farm is most important. The available quantity of water is also to be taken into consideration for the capacity and type of farm to be developed (Sarma *et al*., 2009).

The ideal requirement of water in term of quantity at various stages of mahseer rearing is as below:

Water flow	Rearing capacity
1 L/m	Incubation & rearing 2000eggs at 20-28°C.
3-4 L/m	Rearing 2000 fry (0-3 months) at 20-27°C
4-6 L/m	Rearing 1500 fingerlings (4-9months old)

Flow through hatchery

Overhead tank	1000 L installed at a height of 5 m above
Hatchery tanks	Galvanized iron sheets or fiber glass of 200x60x30cm of size
Hatching trays	50x30x10 cm with synthetic netting cloth of 1mm mesh size. 5000-6000 eggs can be stocked.

Artificial Breeding and Rearing

With the approach of spawning season, the brood fish leave their safe haunts in deep pools of rivers, lakes and reservoirs and ascend shallow areas for breeding. The brood stock is obtained from natural grounds in rivers, lakes and reservoirs. Where ripe fish congregate at the breeding grounds in the streams and at the outfall of the streams in the lakes/reservoirs are carefully collected either by cast net or gill net. The selected ones are stripped of their eggs and milt by exerting pressure on the caudal portion of the fish in a particular manner. The stripped eggs are collected in the plastic trays and the milt is spread over the eggs. The eggs and milt are thoroughly mixed with the help of a bird's quill and allowed to stand for 5 minutes. After that, the eggs are washed thoroughly with clean oxygenated water 3-4 times to remove the excess milt. Then the trays containing eggs are filled with fresh water and allowed to stand for 15-20 minutes in shade to allow the eggs to swell and harden before

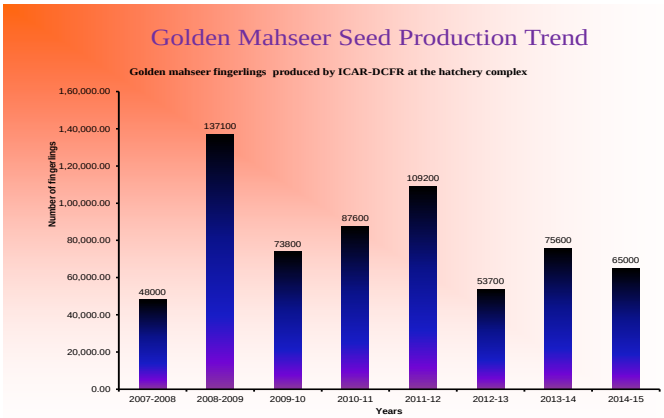
releasing them in hatching trays. The fertilized eggs are demersal, lemon yellow or brownish golden in colour. The percentage of fertilization is about 90-100%. Hatching period of *Tor putitora* is 80-96 hours in water temperature 22-24.0 °C (Sehgal, 1991). Once the yolk-sac is completely absorbed and swim up fry start moving freely, the stock is shifted to nursery tanks and stocked @ 8,000 - 10,000/tank with water flow of 2-3 lit per minute (Raina *et at.*, 1999). The young ones are fed with artificial feed. With a view to develop table size fish or brood stock, the natural seed or hatchery reared seed can be stocked in the earthen ponds, cement ponds, running water ponds or cages (Sarma *et al*., 2012).

Air transport of eggs

To facilitate the distribution of Mahseer seed to distant places, Mahseer eggs are being transported in moist cotton by air. Fertilized eggs after water hardening process were placed between the layers of moist cotton in 2-3 layers and then kept in plastic boxes. As the minimum hatching period is 70 hours, sufficient time is available to transport the eggs to long distances. The eggs can be hatched in normal manner (Sarma et al., 2009).

Mahseer seed ranching

The lack of a well established hatchery technology for Mahseer and for rearing of its seed was one of the major obstacles in introducing the Mahseer ranching. The Directorate of Coldwater Fisheries Research, ICAR, India has taken a very bold step for seed production Golden Mahseer in the Hatchery Complex of the Directorate and releasing the seed in the different streams/rivers/lakes in all over India as well as abroad to increase the population of this fish in the natural habitat and also to conserve the germplasm from extinction. The hatchery produced seed has been transported to Department of Fisheries, West Bengal, Department of Fisheries, Sikkim as well as other Institutions. The seed also has been transported to Papua New Guinea to stock in the Ramu River. Directorate of Coldwater Fisheries Research has also stocked golden mahseer in Shyamlatal Lake in Kumaon, India in 2001 wherein it has survived very well, grown to mature sizes and now turning out to be an attraction for tourists. It can be expected that stock so introduced may continue for generations and may be served as natural sanctuaries. These kinds of efforts can be suggested in all the regions wherever mahseer exists (Sarma *et al*., 2014).



Golden Mahseer Seed Distribution	
Year	***Distributed to:***
2007-08	**Supplied to Dept. of Fisheries, Dist. GTA Darjeeling, West Bengal; Released in Bhimtal lake**
2008-09	**Supplied to Dept. of Fisheries, Dist. GTA Darjeeling, West Bengal; Supplied to Dept. of Fisheries, Govt. of Sikkim; Released in Kherna Mahseer Reserve, Uttarakahnd**
2009-10	**Supplied to Dept. of Fisheries, Dehradun, Govt. of Uttarakahnd; Supplied to MP Fish Federation, Bhopal; Released in Bhimtal lake for rehabilitation.**
2010-11	**Supplied to Dept. of Fisheries, Govt. of Sikkim; Supplied to ICAR-NER, Barapani; Stocked in Bhimtal lake for rehabilitation.**
2011-12	**Stocked in Mehao lake, Arunachal Pradesh; Supplied to MP Fish Federation, Bhopal; Supplied to College of Fisheries, Pantanagr, Uttarakhand; Supplied to Sattal Estate Association, Sattal, Nainital, Uttarakhand; Rearing in cages and ponds of DCFR**
2012-13	**Supplied to Dept. of Fisheries, Govt. of Sikkim; Department of Fisheries, Govt. of Himachal Pradesh, Supplied to MP Fish Federation, Bhopal; Ranched in Bhimtal lake; Released in Dighali puhkuri tank, Guwahati, Assam; Rearing in cages and ponds of DCFR**
2013-14	**Supplied to College of Fisheries, Pantanagr, Uttarakhand; Ranching at Bhimtal lake and Naukuchiatal lake; Rearing in cages and ponds of DCFR**
2014-15	**Supplied to MP Fish Federation, Bhopal and Dept. of Fisheries, Dist. GTA Darjeeling, West Bengal; Stocked at Nonmahir lake, Meghalaya; Ranched at Nainital lake; Released at Sariyatal lake and Kosi river, Ramnagar.**

Conservation and future R&D in mahseer

It was observed that environmental degradation and human greed are the main factors responsible for sharp decline in Mahseer fisheries. Since conservation and rehabilitation of endangered mahseers are of national importance, the production of stocking material through artificial propagation is important to stock those water bodies, which are having facility of natural breeding and nursery grounds Mahanta *et al*., (1994). Some of the research and management suggestions are listed below for their conservation and propagation in the country (Mahanta and Sarma, 2010).

- Illegal killing, netting or any destructive fishing methods must be strictly prohibited.
- Suitable devices for facilitating the crossing of the barriers during migration of the fish need to be developed.
- Detailed survey and mapping for the available resources of the juveniles and adults need to be conducted.
- Strict enforcement of closed season for commercial fishing of mahseer is needed.
- Proper sanctuaries of mahseer must be identified and developed.
- Creel census of the natural water bodies must be taken up.
- Modern hatcheries in the vicinity of water bodies inhabited by mahseer must be developed.
- The techniques of induced breeding of mahseer must be standardized.
- Intensive stocking practice technology must be developed for stagnant and running water systems involving monoculture or polyculture along with indigenous and exotic fishes.
- Nutritive artificial feeds for different stages of mahseer development must be developed.
- Selective breeding must be adopted for developing healthy and fast growing mahseer.
- Pen and cage culture must be taken up near the breeding / chasing areas of brooders in the reservoirs during natural breeding migration.
- Removal of sand, pebbles and stones in the mahseer breeding grounds must be banned.

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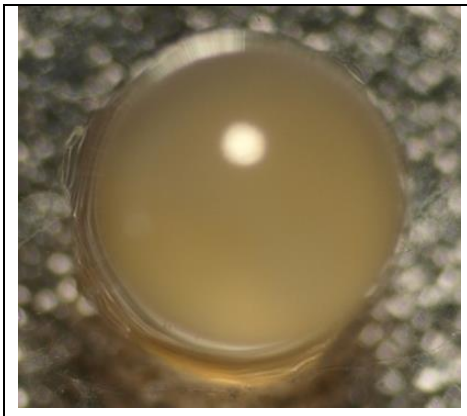
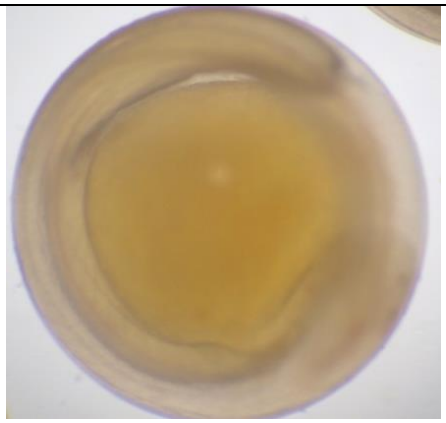
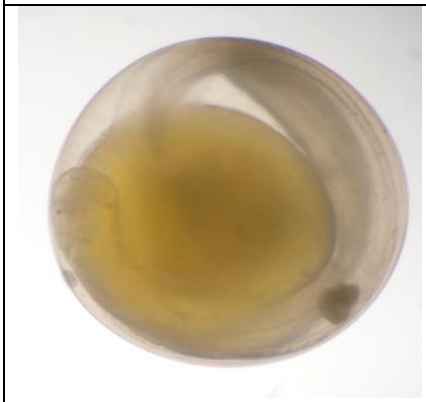
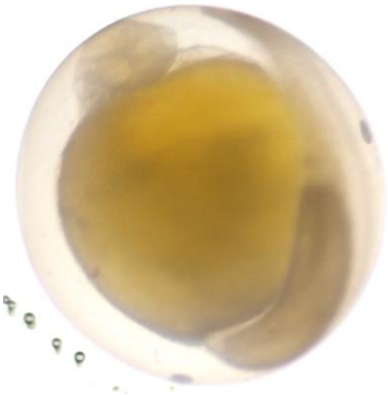
Stripping

Fertilization of eggs

Measurement of mahseer eggs

Egg Incubation

	
Marula	**Gastrulation**
	
Formation of pigmented eye	**Formation of Muscle structure**
	
One day larvae	**7 days larvae**
	
One month old fry	**3 months old fry**

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	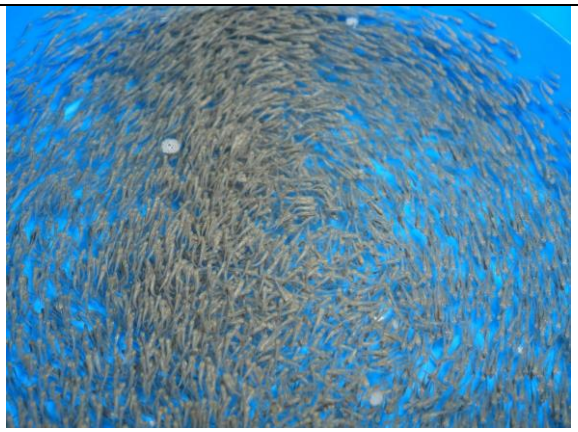
Feeding of the fry	**Hall of mahseer fry**
	
Brood stock development in captivity	**Ranching in Nainital lake**
	
Packaging of mahseer seed for transportation	**HRD Training**

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A check list of helminth parasite infection of the fishes of Sone Beel, Assam India

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Abstract

Fishes are one of the important elements in the economy of many nations as they have been a stable item in the diet of many people. Parasites (in the larval stage) consumed in uncooked or undercooked seafood can present a human health hazard. Fish disease due to helminth parasites is one of the important problems in fish culture and fish farming. The importance of the fish parasites is related directly to the importance of the fish they may affect. There is a bewildering array of fish parasites and probably all the fish species harbour one or more parasite species. Twenty one different species of parasitic helminthes, 11 nematodes, 4 Cestodes, 3 Trematodes and 2 Acanthocephalan are reported from various fish hosts from 61 different species of fishes belonging to 46 genera, under 22 families and 7 orders. Cypriniformes contribute 24 species which is followed by Siluriformes, Perciformes with 15 and 14 respectively but Clupiformes with only 1 fish species. One of the trematode newly report. The descriptions of all the helminth parasites were new locality report because they had different morphology as compared to other which had already described. The prevalence and intensity is highest in Clarias batrachus (54.76%, 10.13) and lowest in Pethia ticto (6.00%, 4.67) of Sone Beel.

Key Words: Helminthes, Nematode, Cestodes, Trematode

Introduction

A fish is any member of a paraphyletic group of organisms that consist of all gill-bearing aquatic craniate animals that lack limbs with digits. Included in this definition are the living hagfish, lampreys, and cartilaginous and bony fish, as well as various extinct related groups. Most fish are ectothermic (cold-blooded), allowing their body temperatures to vary as ambient temperatures change, though some of the large active swimmers like white shark and tuna can hold a higher core temperature. (Fishbase.org and Carey, F.G.; Lawson, K.D. 1973). Fish are abundant in most bodies of water. They can be found in nearly all aquatic environments, from high mountain streams to the abyssal and even hadal depths of the deepest oceans. At 32,000 species, fish exhibit greater species diversity than any other group of vertebrates. (Goldman, K.J. (1997). North-Eastern (NE) is endowed with huge fishery potential, also Assam possesses immense fishery resources in the form of rivers, Beels, swamps, ponds, tanks, forest, fisheries and paddy fields. Fishery is considered to be the important sectors for the economy of the state (Das, et al. 2014). Fish are an important resource for humans worldwide, especially as food. Commercial and subsistence fishers hunt fish in wild fisheries or farm them in ponds or in cages in the ocean. Fishes are one of the important elements in the economy of many nations as they have been a stable item in the diet of many people. Fishes are very important and most acceptable food by consumers because its nutritive value, so much emphasis is given to fish production in India. (Puinyabati, H. et al. 2010). Helminths are multicellular eukaryotic animals that generally possess digestive, circulatory, nervous, excretory, and reproductive systems. Some are free-living in soil and water. Helminths are studied in microbiology because they cause infectious diseases and most are diagnosed by microscopic examination of eggs or larvae. Helminths infect more than one-third of the world population. Helminth infections differ from bacterial or protozoan infections because the worms do not usually increase in number in the host. Symptoms are usually due to mechanical damage, eating host tissues, or completing for

vitamins. In this exercise, we will examine prepared slides of parasitic helminthes. Parasite is an important group of pathogen causes infection and diseases of fish both in freshwater and marine environments. With the increasing interests in aquaculture parasitic infestations are becoming threats for fish health management and aquatic crop production throughout the world. It is therefore an essential area for proper attention to be given by the scientists for sustainable aquaculture production. (Chandra, K.J. 2006). There is a bewildering array of fish parasites and probably all the fish species harbour one or more parasite species. (Chubb, 1977, 1979, 1980 and 1982) illustrated the studies of seasonal occurrence of helminthes in freshwater fishes in different climatic zones of the world. Work of Yamaguti (1951, 1961) related the occurrence of helminth parasite in vertebrate host is of immense importance, (Gupta, 1961) described new cestodes from freshwater fishes. Jha (1989) studied the characterization of parasite fauna of fishes of Muzaffarpur, Bihar. Shomorendra and Jha (2006) studied the acanthocephalan parasites of certain fishes from Manipur. Kar (2007) made detailed study of the limnology and ichthyofauna of the water bodies of north-east India including disease in fishes. Kar, D. and Sen (2007) studied the systematic list and distribution of fish biodiversity in Mizoram, Tripura and Barak drainage in North East, India. Kar, D. et al. (2008) studied the panorama of fish biodiversity in certain rivers and wetlands protected areas in Assam. Binky, Kh. et al. (2011) studied the diversity of helminth parasites in fishes of Karbhala wetland in Cachar District of Assam. (Das, et al. 2014 studied on the prevalence, abundance and intensity of fish parasites in Monopterus cuchia. Das, D. and Goswami, M.M. (2014) made a details study on helminth infection in Anabas testudineus of three wetlands of Goalpara, Assam. Das, B.K. et al. (2014) Multiple Infection of Helminths in the stomach and Intestine of Clarias gariepinus. Distribution of Helminth parasites in different organs and their seasonal rate of infestation in three freshwater fishes of Goalpara, Assam, India D. and Goswami, M.M. (2014). Ngasepam, R.S. and Kar, D. (2014) give a detail report on Abundance and Distribution of Helminth Parasites in the Fishes of Sone Beel, the biggest wetland in Assam. Das, G. et al. 2015 made a detail study on parasitic study of Indian Major Carp Catla catla. Fish disease due to helminth parasites is one of the important problems in fish culture and fish farming. The importance of the fish parasites is related directly to the importance of the fish they may affect. There is a bewildering array of fish parasites and probably all the fish species harbour one or more parasite species. In this regards the present research paper is established on check list of helminth parasite infection of the fishes of Sone Beel, Assam India which will quit helpful to young researcher.

Materials and Methods

The fish hosts examined for the helminthes infection in the present study were collected during survey work in January 2012 to December 2014 from Sone Beel of Assam. Sone Beel is the biggest wetland in Assam. (Kar, D. 2013). It is in Karimaganj district of southern Assam. Sone Beel is accessible from Hailakandi and Karimaganj towns. The lake is 12.9 km long and 3.9 km wide, with a 35.4 km shoreline. It lies between 24° 40' 00" N, 92° 26' 10" E. (Figure: 2)

Before examination of helminthes parasites, the weight, total length and sex of fish were entered as host data on an accession card with a reference number for each fish specimens. The fishes were examined thoroughly for external and internal helminth parasites. The sex of the fish was determined by inspecting the urino-genital papillae which is pointed and narrow in males and broad and square in females (Miller, 1984) and by observing the reproductive organs.

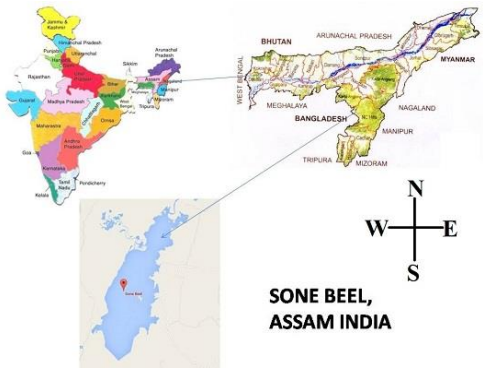
First of all a checklist of fish species present study site will be prepared following with the help of standard taxonomic keys like Jayaram, K.C. 2010, Vishwanath, W. 2002 and Kar, D. 2007. Small fishes were killed by pithing and somewhat larger specimens by blow on the top

of cranium. The external body surfaces as well as the internal body organs (alimentary canal, liver, heart, kidney, gonads, and swim bladder) were thoroughly examined for the parasites. The parasites collected were being fully relaxed, were fixed in the fixatives prescribed for different helminthes group. The Trematodes were fixed in AFA (alcohol-formalin-acetic acid) solution and stored in 70% alcohol, acanthocephalan fixed and preserved in AFA, Cestodes in 5% formalin and nematodes after immersing in warm 70% alcohol were finally stored in 70% alcohol. (Bylund, et al. 1980). To facilitate identification of the worms, the Trematodes and the Cestodes were stained in alum carmine, dehydrated in glacial acetic acid, cleared in methyl salicylate and mounted in Canada balsam while in the case of nematode and acanthocephalan the worms were cleared in Lactophenol and mounted in glycerin jelly. (Margolis, L. et al. 1982)

Result and Discussion:

Sone Beel contribute 61 species of fishes belonging to 46 genera, under 22 families and 7 orders. Cypriniformes contribute 24 species which is followed by Siluriformes, Perciformes with 15 and 14 respectively but Clupiformes with only 1 fish species. (Table: 1). A total of 1200 fishes were sacrifices during my investigation, 61 different fish species were examined for helminth parasites infection. Of these 745 fish inviduals belonging to 14 fish species are found to be parasitized with a total of 797 helminth parasites. Total intensity infection rate is 5.14 and percentage of prevalence infection is 20.81%. The prevalence and intensity is highest in Clarias batrachus (54.76%, 10.13) and lowest in Pethia ticto (6.00%, 4.67) of Sone Beel. (Table: 3 and Figure: 1) About 21 species of parasite groups (viz. 12 Nematode=NT, 3 Trematodes=TR, 2 Acanthocephalan=AC and 4 Cestodes=CT) were recorded from Sone Beel. (Table: 2). On the other hand, the hosts of intermediate length and weight groups were found more found more infected with helminth parasites than the host of very large length and weight groups. (Table: 4 and Table: 5).The sex of a particular fish playing a key role in infection of parasites. It is also found that female fishes were more infected than the male fishes in this study. (Table: 5). the cause of intensity in female fishes may be ecological habitat and sex hormones responsible for depressing the level of infestation. Ngasepam, R.S. et al. 2015 has reported 61 different fish species under 24 family, 7 order and 41 genera. According to Aloo et al. (2004) the main reason for the differences in the parasitic load with sex is physiological. Our study also observed that the prevalence and intensity of parasite of different groups varied for sex of host. Diseases affect the normal health conditions and cause and reduction of growth, abnormal metabolic activities and even death, thus results great economic loss. Healthy of population depend on the control of diseases and maintenance of a healthy relationship between living creature and their environment (Snieszko, 1983). Five factors directly influence the parasitic fauna of the fishes like age, diet, abundance of the fishes, independent number of the parasites within fish and season (Kabatta, 1985). Srivastava, (1975) also stated that the characteristic of any form of water body can influence and determine its parasitic fauna and when environment conditions such as water, food and temperature become flavourable for mass reproduction of parasites, the disease may spread very quickly. The parasitic infection is greatly influenced by the season, which basically interferes with ecology and physiology of the fish. During the breeding season of fish lesser number of parasites invades the host because of the presence of the estrogen (Rahman and Jahan 2002). The presence of certain helminth parasites, especially larval trematode is known to eliminate or reduce the reproduction in molluscs (Rahman and Jahan 2005). Singh, N.R. et al. 2013 observed that fish disease due to helminth parasites is one of the important problems in fish culture and fish farming. The importance of the fish parasites is related directly to the importance of the fish they may affect. Ngasepam, R. S. and Kar, D. 2014 discuss that the fish internal organs are disturbed (bulging of stomach and intestine) by the parasites. The

infestation rate was lower in males than females. Helminth parasites inhabit in stomach, intestine, liver, body cavity, duodenum and airbladder. Hosts of intermediate length and weight were found to be more infected than the hosts of smaller and larger length. From this study it has been observed that the seasonal variation of parasites existed among the studied location and also in respect of fish species investigated. Further research need to be carried out for studying parasites as well as diseases of other species in the country to depict elaborate and full information of fish diseases of Sone Beel, Assam. Fish diseases are the great threat in our fish culture system. Many fish species affects by various types of diseases every year and as a result, production of fishes decreases significantly in Assam. Proper steps should be taken to prevent fish diseases and to protect these important fish species from extinction. From overall study it was observed that the parasites were most important pathogen for diseases outbreak. It was also observed that there was a direct relation between disease outbreak among fishes and environmental factors.



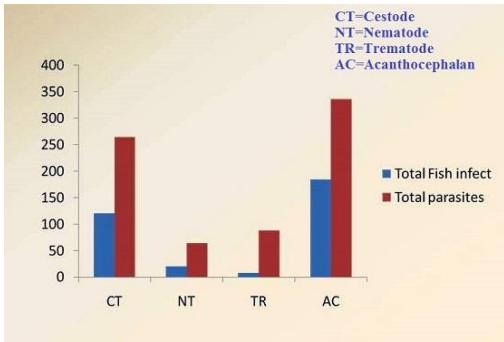


Figure: 1&2 showing the Study Site Sone Beel, Assam India (Ngasepam, R.S. *et al.* 2015) & Helminth Parasitic burden of Sone Beel, Assam during study period

Table 1: List of helminth parasites recovered from the fishes of Sone Beel

Sl. No.	Fish host	Cestode	Nematode	Trematode	Acanthocephala
1	*Clarias batrachus*	*Lytocestus indicus Djombangia penetrans, L. fossilis. Lytocestus sp.*	*Procamallanus spp., Rhabdochona spp.*	*Nil*	*Nil*
2	*Monopterus cuchia*	*L. fossilis*	*Nil*	*Nil*	*Pallisentis sp.*
3	*Mystus bleekeri*	Nil	*Contracaecum sp.*	*Nil*	*Nil*
4	*Anabas testudineus*	*Nil*	*Camallanus anabantis, Zeylanema sp., Paraquimperia manipurensis. Zeylanema anabantis.*	*Nil*	*Nil*
5	*Channa punctata*	*Nil*	*Philometra sp.,*	*Metaclistomum thaparus, M. srivastava*	*Pallisentis ophiocephali, Pallisentis sp.*
6	*Heteropneustes fossilis*	*Lytocestus indicus spp., L. fossilis*	*Nil*	*Nil*	*Nil*
7	*Pethia ticto*	*Nil*	*Contracaecum sp.*	*Nil*	*Nil*
8	*Channa striata*	*Nil*	*Nil*	*Nil*	*Pallisentis ophiocephali*
9	*Puntius sophore*	*Nil*	*Physalootera sp.*	*Nil*	*Nil*
10	*Nandus nandus*	*Nil*	*Physalootera sp.*	*Nil*	*Nil*
11	*Johnius coitor*	*Nil*	*Rhabdochona spp.*	*Nil*	*Nil*
12	*Macronegthus aral*	*Nil*	*Nil*	*Aphallus spp.*	*Nil*
13	*Channa orientalis*	*Nil*	*Nil*	*Metaclinostomum thaparus, M. srivastava*	*Nil*
14	*Mystus cavasius*	Nil	*Pseudoproleptus spp. & Hysterothylacium spp.*	*Nil*	*Nil*

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Table 2: Fish diversity of Sone Beel during study period 2012-2014 (Ngasepam, R.S. *et al.* 2015)

SL. NO.	Name of Fish	Order	Family
1	*Labeo rohita* (Hamilton, 1822)	Cypriniformes	Cyprinidae
2	*Labeo gonius* (Hamilton, 1822)	Cypriniformes	Cyprinidae
3	*Labeo calbasu* (Hamilton, 1822)	Cypriniformes	Cyprinidae
4	*Cyprinus carpio* Linnaeus, 1758	Cypriniformes	Cyprinidae
5	*Cirrhinus mrigala* (Hamilton, 1822)	Cypriniformes	Cyprinidae
6	*Catla catla* (Hamilton, 1822)	Cypriniformes	Cyprinidae
7	*Hypophthalmichthys molitrix* (Valenciennes,1844)	Cypriniformes	Cyprinidae
8	*Crossocheilus latius* (Hamilton, 1822)	Cypriniformes	Cyprinidae
9	*Cabdio morar* (Hamilton, 1822)	Cypriniformes	Cyprinidae
10	*Cirrhinus reba* (Hamilton, 1822)	Cypriniformes	Cyprinidae
11	*Devario devario* (Hamilton, 1822)	Cypriniformes	Cyprinidae
12	*Danio dangila* (Hamilton, 1822)	Cypriniformes	Cyprinidae
13	*Osteobrama cotio* (Hamilton, 1822)	Cypriniformes	Cyprinidae
14	*Rasbora daniconius* (Hamilton, 1822)	Cypriniformes	Cyprinidae
15	*Amblypharyngodon mola* (Hamilton, 1822)	Cypriniformes	Cyprinidae
16	*Esomus danricus* (Hamilton, 1822)	Cypriniformes	Cyprinidae
17	*Puntius sophore* (Hamilton, 1822)	Cypriniformes	Cyprinidae
18	*Puntius chola* (Hamilton, 1822)	Cypriniformes	Cyprinidae
19	*Systomus sarana* (Hamilton, 1822)	Cypriniformes	Cyprinidae
20	*Pethia ticto* (Hamilton, 1822)	Cypriniformes	Cyprinidae
21	*Lepidocephalicthys guntea* (Hamilton, 1822)	Cypriniformes	Cobitidae
22	*Botia dario* (Hamilton, 1822)	Cypriniformes	Cobitidae
23	*Lepidocephalicthys berdmorei* (Blyth, 1860)	Cypriniformes	Cobitidae
24	*Acanthocobitis botia* (Hamilton, 1822)	Cypriniformes	Nemacheilidae
25	*Anabas testudineus* (Bloch, 1792)	Perciformes	Anabantidae
26	*Chanda nama* Hamilton, 1822	Perciformes	Ambassidae
27	*Parambassis ranga* (Hamilton, 1822)	Perciformes	Ambassidae
28	*Parambassis baculis* (Hamilton, 1822)	Perciformes	Ambassidae
29	*Trichogaster fasciata* Bloch & Schneider, 1801	Perciformes	Osphronemidae
30	*Trichogaster labiosa* Day, 1877	Perciformes	Osphronemidae
31	*Trichogaster lalius* (Hamilton, 1822)	Perciformes	Osphronemidae
32	*Glossogobius giuris* (Hamilton, 1822)	Perciformes	Gobiidae
33	*Oreochromis mossambicus* (Peters, 1852)	Perciformes	Cichlidae
34	*Channa punctata* (Bloch, 1793)	Perciformes	Channidae
35	*Channa striata* (Bloch, 1793)	Perciformes	Channidae
36	*Channa orientalis* Bloch Schneider, 1801	Perciformes	Channidae
37	*Badis badis* (Hamilton, 1822)	Perciformes	Badidae
38	*Nandus nandus* (Hamilton, 1822)	Perciformes	Nandidae
39	*Clarias batrachus* (Linnaeus, 1758)	Siluriformes	Clariidae
40	*Wallago attu* (Bloch & Schneider, 1801)	Siluriformes	Siluridae
41	*Ompok bimaculatus* (Bloch, 1794)	Siluriformes	Siluridae
42	*Sperata aor* (Hamilton, 1822)	Siluriformes	Bagridae
43	*Eutropiichthys vacha* (Hamilton, 1822)	Siluriformes	Schilbeidae
44	*Bagarius bagarius* (Hamilton, 1822)	Siluriformes	Sisoridae
45	*Heteropneustes fossilis* (Bloch, 1794)	Siluriformes	Heteropneustidae
46	*Mystus bleekeri* (Day, 1877)	Siluriformes	Bagridae
47	*Mystus cavasius* (Hamilton, 1822)	Siluriformes	Bagridae
48	*Mystus tengara* (Hamilton, 1822)	Siluriformes	Bagridae
49	*Mystus vittatus* (Bloch, 1794)	Siluriformes	Bagridae
50	*Gagata cenia* (Hamilton, 1822)	Siluriformes	Sisoridae
51	*Gagata gagata* (Hamilton, 1822)	Siluriformes	Sisoridae
52	*Erethistes pusillus* Müller & Troschel, 1849	Siluriformes	Erethistidae
53	*Clupisoma garua* (Hamilton, 1822)	Siluriformes	Schilbeidae
54	*Macrognathus aral* (Bloch & Schneider, 1801)	Synbranchiformes	Mastacembelidae
55	*Macrognathus pancalus* Hamilton, 1822	Synbranchiformes	Mastacembelidae
56	*Mastacembelus armatus* (Lacepède, 1800)	Synbranchiformes	Mastacembelidae
57	*Monopterus cuchia* (Hamilton-Buchanan)	Synbranchiformes	Synbranchidae
58	*Notopterus notopterus* (Pallas, 1769)	Osteoglossiformes	Notopteridae
59	*Chitala chitala* (Hamilton, 1822)	Osteoglossiformes	Notopteridae
60	*Xenentodon cancila* (Hamilton, 1822)	Beloniformes	Belonidae
61	*Gudusia chapra* (Hamilton, 1822)	Clupiformes	Schilbeidae

Table 3: Showing prevalence and intensity of helminth parasites of Sone Beel

Sl. No.	Fish species	Total fish examined	Total fish infected	Total no. of parasites	Intensity	Prevalence (%)
1	*Clarias batrachus*	42	23	233	**10.13**	**54.76**
2	*Monopterus cuchia*	17	9	18	2.00	52.94
3	*Mystus Bleekeri*	24	1	1	1.00	4.17
4	*Anabas testudineus*	51	10	19	1.90	19.61
5	*Channa punctata*	379	73	379	5.19	19.26
6	*Heteropneustes fossilis*	54	13	21	1.62	24.07
7	*Pethia ticto*	50	3	14	**4.67**	**6.00**
8	*Channa striata*	11	1	1	1.00	9.09
9	*Puntius sophore*	22	3	6	2.00	13.64
10	*Nandus nandus*	21	5	13	2.60	23.81
11	*Johnius coitor*	19	4	11	2.75	21.05
12	*Macronegthus aral*	17	3	20	6.67	17.65
13	*Channa orientalis*	18	5	48	9.60	27.78
14	*Mystus cavasius*	20	2	13	6.50	10.00
	Total	**745**	**155**	**797**	**5.14**	**20.81%**

Table 4: Effect of Weight in *Channa striata* in helminthes parasites infection

Weight group (g)	Total no. of fish examined	Total no. of fish infected	Total no. of Parasites	Prevalence (%)	Intensity
0 - 30	112	52	80	46.43	1.54
31 - 60	44	24	48	54.55	2.00
61 - 90	**12**	**12**	**24**	**100.00**	2.00
91 - 120	32	16	60	50.00	3.75
121 - 150	16	12	32	75.00	2.67
150 - 180	32	28	36	87.50	1.29
181 - 210	28	16	20	57.14	1.25
TOTAL	**276**	**160**	**300**	**57.97**	**1.88**

Table 5: Effect of length of *Channa striata* in helminthes parasites infection

Length group (mm)	No. of fish examined	No. of fish infected	No. of parasite	Prevalence	Intensity
60 - 90	8	4	4	50%	1.0
91 - 120	28	16	28	57%	1.8
121 - 150	28	20	40	71%	2.0
151 - 180	64	28	40	44%	1.4
180 - 210	52	20	72	38%	3.6
211- 240	**48**	**40**	**64**	**83%**	1.6
241 - 270	40	20	48	50%	2.4
271 - 300	0	0	0	0%	0
301 - 330	**4**	**4**	**8**	**100%**	2
TOTAL	**272**	**152**	**304**	**56%**	**2**

Table 6: Effect of Sex on the infection of parasites

SL. No.	Name of fish	No. of fish examined		No. of fish infected		No. of worm collected		Prevalence %		Intensity		Abundance	
		M	F	M	F	M	F	M	F	M	F	M	F
1	*Clarias batrachus*	29	11	17	6	80	153	58.62	54.54	4.71	**25.5**	2.76	**13.91**
2	*Trichogaster fasciata*	26	26	7	1	20	37	26.92	3.85	2.86	25.5	0.8	1.42
3	*Monopterus cuchia*	11	6	5	4	7	11	45.45	**66.66**	1.4	2.75	0.6	1.83
4	*Mystus bleekeri*	6	18	0	1	0	1	0	5.56	0	1	0	0.06
5	*Anabas testidudineus*	15	18	1	2	5	14	6.67	11.11	5	7	0.3	0.8
6	*Channa punctata*	122	237	42	20	179	**200**	34.43	8.44	4.26	10	1.4	0.32
7	*Heteropneustes fossilis*	9	34	2	9	10	11	22.22	26.47	5	1.2	1.1	0.3
8	*Pethia ticto*	4	46	0	3	0	14	0	6.52	0	4.7	0	0.16
9	*Puntius sarana*	5	51	1	7	4	8	20	13.73	4	1.1	0.8	0.4
10	*Lepidocelichthys guntea*	23	98	4	17	12	40	17.39	17.35	3	2.35	0.5	0.2
11	*Channa orientalis*	2	1	0	1	0	2	0	**100**	0	2	0	0.36
12	*Puntius chola*	10	11	1	2	2	4	10	18.18	2	2	0.2	0.9
13	*Mastacebelus armatus*	6	9	0	2	0	8	0	22.22	0	4	0	0.33
14	*Channa striata*	8	3	0	1	0	1	0	33.33	0	5	0	

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Effect of helminth infestation on the fecundity of some selected fish species.

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Abstract

Parasites are ubiquitous, primarily surviving in a dynamic equilibrium with their host(s) and they are often overlooked in fish health assessments. Parasites have been shown to influence host reproductive potential in a number of ways, ranging from the complete reduction in fecundity as a result of altered host physiology. With unlimited resources, there may be no deleterious effect of the parasite on the fish host, whereas a decrease in resource availability may increase the effect of the parasite (Candolin and Voigt, 2001). A study was carried out from March-2011 to Feb-2013, to observe whether the heavy infestation of parasites effect or not on the fecundity of the three selected hosts collected from three habitats. For the study the size/weight ranges of the host taken were, >8-11cm/>25-40 g for Anabas testudineus, >6-9 cm/>7-10g for Trichogaster fasciata and >4-6 cm/>5-7g for Trichogaster lalius. In the study it was observed that the fecundity of heavily infested hosts decrease in compared to the uninfested hosts. It was observed in the study that in the month of June fecundity decreases in the highest percentage (61.7%) in infected A. testudineus. The highest decrease in mean fecundity of infected Trichogaster fasciata was found to be fall on the month of January (58.1%). In the month of August the effect of parasitic infestation was higher in Trichogaster lalius than the same in other months. During that period mean fecundity decreased by 64% in infected hosts.

Keys: A. testudineus, Trichogaster fasciata, Trichogaster lalius, Fecundity, Helminthes.

Introduction:

The science dealing with the cause of fish disease is called “ETIOLOGY”. The cause of fish disease is rarely taken as a single factor but parasites, bacterium or virus are taken as a main source. Changes in the environment, both anthropogenic and environmental, can alter the parasite/host equilibrium and cause disease or mortality in fish. Therefore it is imperative that one should have knowledge of both parasites and parasitic communities within a host fish population. With the increasing attention in aquaculture throughout the world, parasitic infestation are treated as one of the major threats for fish health management and aquatic crop production.

Parasites often influence their hosts through the diversion of resources either directly by using up energy and nutrients or indirectly by increasing the activity of immune system (Wedekind 1992, Deerenberg et al. 1997, Candolin and Voigt 2001). This causes a trade off between allocations of limited resources used in reproduction and parasite resistance which ultimately reduce fecundity (Candolin and Voigt, 2001). Parasites have been shown to influence host reproduction potential in a number of ways, ranging from the complete reduction in fecundity as a result of altered host physiology (Minchella and Loverde, 1981; Thomas et al., 1996; Dezfuli et al., 1999). According to Jobling et al. (2003), some parasites affect the endocrine system of fish directly, by acting at the level of hypothalamus to restrict GnRH secretion which results in poorly developed gonad that ultimately reduces fecundity.

Materials and Methods:

Present investigation has been carried out during the period from March 2011 to Feb 2013. To investigate the Helminthes parasites three different host species of fishes namely, Anabas testudineus (Bloch), Trichogaster fasciata (Bloch and Schneider, 1801), and Trichogaster lalius (Hamilton, 1822) were examined monthly during the two years study periods.

Digenean trematodes were fixed in AFA solution and nematodes were fixed in 70% ethanol. Permanent slides were made according to Gibson (1984) and identification was carried out by following Yamaguti (1958) and Soota (1983).

To study the fecundity, the size/weight ranges of the adult female host species are taken (>8-11cm/>25-40 g for Anabas testudineus, >6-9 cm/>7-10g for Trichogaster fasciata and >4-6 cm/>5-7g for Trichogaster lalius). To find the effect of parasitism on fecundity, gonad weight of both uninfested and infested matured individuals of female species were recorded. Gonads filled with ova or sub samples of gonads were kept in Gilson's fluid for 3-4 weeks and then counted for fecundity. Parasites were identified and processed for making permanent slides.

Fecundity is estimated by the following formula:

F= n G/g, where 'F' is Fecundity, 'n' is the average no. of eggs, 'G' is the weight of Gonad and 'g' is the weight of sub samples of Gonad. According to the size of eggs, three sub samples from the two lobes of each ovary are taken and the eggs from each were counted under magnifying glass and mean value of eggs were computed.

Result and discussion:

Total 643 individuals of 4 helminth species were found to be infesting the ovaries of the three host species. The parasite species were namely Pallisentis ophiocephali Clinostomum complanatum, Asymphylodora kedarai and Camallanus fotedari (Table-1). In the study it is observed that the fecundity of heavily infested hosts decrease in compare to the uninfested hosts. Fecundities are found to be low from September to March in A.testudineus. . It is observed in the study that in the month of June fecundity decrease in the highest percentage (61.7%) from 21649.2 ± 35.72 to 8611.6 ± 64.09 in infected host (Figure:1A). Figure-1B depicts the differences between the mean fecundities of infected and uninfected Trichogaster fasciata. The mean fecundity in this uninfected host species is recorded to be the highest on the month of August (14094.75 ± 65.97) and in infected host it decreases to 7780.5 ±98.54 with 44.1%. In infected Trichogaster fasciata the highest decrease of mean fecundity is fall on the month of January (58.1%, from 413.5 ± 55.4 to 173.25 ±22.04). Mean fecundity of infected Trichogaster lalius was also found to be decreased than the same of uninfected individuals. From the data (Figure: 1C) it is clear that in the month of August the effect of parasitic infestation is higher than the same in other months. During this period mean fecundity decreases by 64% from 656.25 ± 17.56 in uninfected to 236 ± 32.97 in infected hosts. Contrasting to this, on the month of July minimum decrease in fecundity can be observed from the data (17.8%, 757.5± 19.05 to 623 ± 23.17 viz. from uninfected to infected host). This result is in conformity with Adlard et al. (1994) who studied the interaction between parasitic isopod and coral reef fish, and found that female fish carrying parasite produced only 12% of the number of egg produced by non-parasitized fish of the same size. Deuton (2009) also found that nematode parasites reduce the female body mass and fecundity of live bearing fish Gambusia affinis. Present observation highlights that the helminth parasite affects the reproductive potential of infected hosts. This result is in conformity with those of Ramachandran (1975); Oliva et al.(1992); Hesp et al. (2002) Moravec et al. (1997, 2002) and Heins et al. (2003) who studied the effect of helminth parasites on reproductive biology of Mugil cephalus, Paralabrax humeralis, Glucosoma hebracium, Epinephelus septemfascistus, Epinephelus morio and three spine stickleback respectively. Ahmed Mir et al. (2012) recorded 50% reduction of gonadotropin hormone (LH) in blood serum of Clarius gariepinus infected with nematode parasite Eustrongylids sp. larvae compare to normal one.

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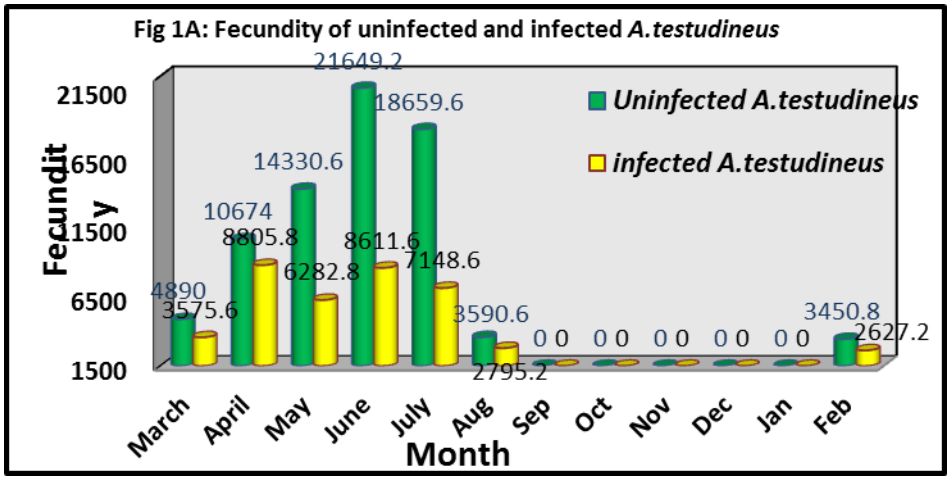
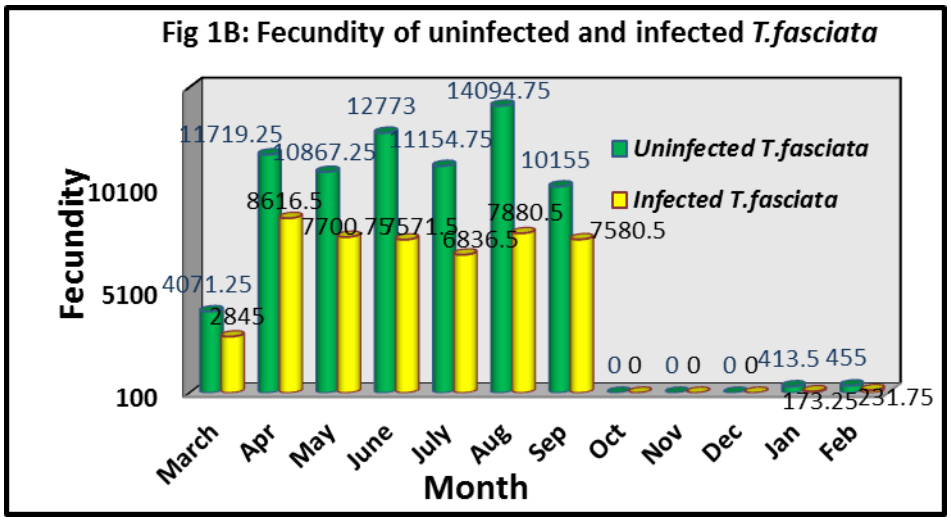
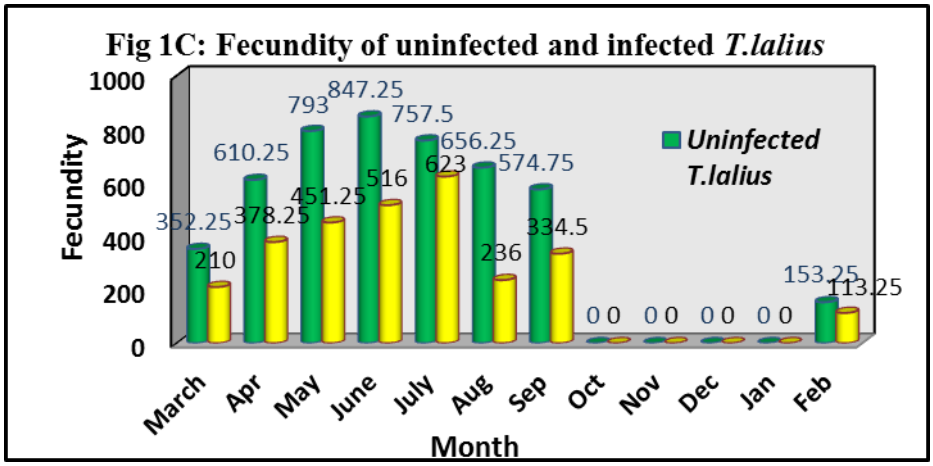
Table-1: Distribution of the helminth parasites.

Host	Helminthes	Phylum	No. of individuals found in ovaries
1. *A.testudineus* 2. *T. fasciata.* 3. *T. lalius.*	*Pallisentis ophiocephali*	Nematoda	216
	Camallanus fotedari	Nematoda	107
	Asymphylodora kedarai	Platyhelminthes	133
	Clinostomum complanatum	Platyhelminthes	187







Conclusion:

The presences of parasite up to large extent are dangerous for fish population. Economic aspects of these parasites effects on fishes involve mass mortality as well as the most important influence is the weight losses of the infected individual and the rejection of many pathologically changed fishes and their parts along with disabled reproductive physiology. So helminthes parasites of fishes should be focused with respect to their diversity as well as proper study should be carried out on their pathological affects on fish fauna.

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Change in fish Assemblage Pattern in a Hill stream over a decade

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Abstract:
Fish assemblages are considered as an important component of aquatic ecosystem and are recognised as sensitive indicators of changes in climate. Evidences show that global changes in climate lead to a shift of habitats in fish populations in accordance to their thermal preferences. According to the Indian Meteorological Department, 2010, the annual mean temperatures during 1901-2010 for the country as a whole rose by 0.56º C. The minimum and maximum annual mean temperatures (ºC) in Guwahati during 1951-2000 were estimated to be 11.7 and 32.1 respectively, while the highest recorded temperature till date was 40.6 ºC on 25th of April, 2014. The present work involves study of fish assemblage in the intermediate zone of a hill stream, Basistha, located at Guwahati, Assam, India. The stream originates from the hills of Meghalaya and harbours true hill stream cold water fishes along with warm water species found in the Brahmaputra drainage. A total of 23 species belonging to 4 orders and 9 families were recorded during the period. The stream at present is observed to harbour a mixed population of 20 tropical and 3 sub-tropical fishes. Analysis of secondary data on fish diversity in this stream nearly two decades back has revealed that 3 warm water species were added to the fish fauna over the years with the inclusion of 11 species not recorded earlier from this stream. The sub-tropical species recorded are *Channa barca*, *Tor tor* and *Pethia conchonius*. The present paper discusses the fish diversity and habitat data in the light of fish assemblage pattern recorded over the past decade.

Keywords: Fish assemblage, temperature gradients, hill stream.

Introduction:

Freshwater ecosystems may well be the most endangered ecosystems in the world (Dudgeon et al., 2006). Overexploitation primarily affects vertebrates, mainly fishes, reptiles, and some amphibians. Apart from the anthropogenic impacts on freshwater ecosystems which lead to their disturbances in the long run, global changes in the climatic patterns disturb the overall balance in aquatic ecosystems. Owing to changes in ecological parameters of habitats due to changes in climatic patterns, species are often predicted to change their habitat preferences. Thus, as a result of this, a species may be replaced by another species in a particular assemblage (Buisson and Grennoilet, 2009).

The Indian Meteorological Department (IMD), 2010 reported on the increase in the annual mean temperatures of the country by 0.56° C during the last 109 years. This warming was reported to be primarily due to the rise in the maximum temperatures across the country. The increase in temperature has also been recorded in the North Eastern part of India, with an annual mean temperature rise of approximately 0.6° C over a century. Hence, with increasing trend of the annual mean temperatures of a region, the ecological impacts are bound to transform gradually and this transformation results in shift of habitats of species towards upstream or downstream gradients.

The purpose of the present study is to observe the impacts of the changing temperature patterns of the city of Guwahati on the fish assemblage pattern of a small hill stream Basistha, located in the heart of the city. The river originates in the hills of Meghalaya, traverses through the hills of Meghalaya and enters Assam near the point of survey, the Basistha stream. Along its course, there are changes in its flow characteristics due to changes

in the terrain hence different zones of the river can be identified. Fishes, being poikilotherms, are unable to adjust their body temperatures to rapid temperature fluctuations; hence their preferences towards a particular habitat are destined to change with changing ecological parameters of the habitats. The present paper discusses monitoring the intermediate zone of the Basistha River for its fish diversity as well as habitat parameters and recording changes in its fish assemblage pattern in the light of its fish assemblage pattern recorded over the past two decades.

Materials and Methods:

The study was carried out for two years, i.e., from June, 2013 to May, 2015. Certain physico chemical parameters of the water like Dissolved Oxygen (D.O.), Free Carbon dioxide (F CO_2), Total Alkalinity, Hardness, and water temperatures were recorded on a monthly basis. Fishes were caught from the Basistha stream at random sites by the use of fishing gears and cast nets of different mesh sizes. Bi monthly collections were made to avoid losing any fish species found in the stream. Collected specimens were photographed and morphometric measurements were taken before fixing them in 8% formaldehyde solution. Identification of the fishes was done following standard literatures (Talwar and Jhingran, 1991), (Jayaram, 2007), and (Vishwanath et al., 2007). Nomenclature of the fishes was given as per FishBase.org, 2015. The conservation status of the fishes was recorded following C.A.M.P. 1998 and IUCN 2015.3.

Results:

A total of 23 fish species belonging to 4 orders and 9 families were recorded during the survey. The list of the fishes recorded with their conservation status has been given in Table 1.

Table1. List of recorded fish species from the River Basistha (2013-2015)

Sl. No.	Species Name	IUCN Status (2015-3)	C.A.M.P. 1998
1.	*Barilius bendelisis**	LC	LRnt
2.	*Devario aequipinnatus**	LC	LRnt
3.	*Tor tor*	NT	EN
4.	*Labeo pangusia**	NT	LRnt
5.	*Neolissochilus hexagonolepis**	NT	NE
6.	*Garra gotyla gotyla**	NA	VU
7.	*Garra gotyla stenorhynchus*	NA	EN
8.	*Garra nasuta**	LC	NE
9.	*Garra gravelyi*	NT	NE
10.	*Pethia conchonius*	LC	VU/N
11.	*Puntius sophore*	LC	LRnt/N
12.	*Puntius chola*	LC	VU
13.	*Esomus danricus*	LC	LRlc
14.	*Psilorhynchus balitora**	LC	NE
15.	*Schistura vinciguerrae**	LC	EN
16.	*Lepidocephalichthys guntea*	LC	NE
17.	*Pseudolaguvia ferula*	DD	NE
18.	*Pseudolaguvia shawi*	LC	NE
19.	*Olyra kempi*	LC	NE
20.	*Badis assamensis*	DD	NE
21.	*Channa barca*	DD	NE
22.	*Channa gachua**	LC	VU/N
23.	*Mastacembelus armatus**	LC	NE

Species marked in asterisks (*) represents recorded baseline data of 1997

The physico chemical parameters of the water that was recorded during our survey have been given in Table 2.

Table 2. Physico-chemical Parameters of the water of Basistha (2013-2015)

Parameters	Winter	Pre- Monsoon	Monsoon	Post-monsoon
Dissolved Oxygen, D.O. (mg/l)	(7.3 – 8.2) 7.77 ± 0.45	(6.6 – 8) 7.47 ± 0.7	(8.4 – 10.8) 9.6 ± 1.7	(7.4 – 8.7) 8.05 ± 0.9
Free Carbon-dioxide, FCO_2 (mg/l)	(5.8 – 7.3) 6.6 ± 1	(6.6 – 8.8) 7.33 ± 1.2	(6.6 – 7.3) 6.95 ± 0.5	(6.6 – 10) 8.3 ± 2.4
Total Alkalinity, T.A. (mg/l)	(65 – 72) 68.5 ± 4.9	(60 – 75) 65 ± 8.6	(46 – 55) 50.5 ± 6.3	(70 – 75) 72.5 ± 3.5
Hardness (mg/l)	(22 – 25) 23.66 ± 1.5	(18 – 20) 20 ± 2	(28.66 – 28.7) 28.7 ± 0.007	(16 – 23.3) 19.6 ± 5.1
pH	(7.2 – 8) 7.6 ± 0.4	(7.9 – 8) 7.9 ± 0.05	(7.5 – 8.3) 7.83 ± 0.4	(7.7 – 8) 7.87 ± 0.23
Water Temperature (ºC)	(16.8 – 22) 20.04 ± 2.8	(21 – 22) 21.5 ± 0.7	(28 – 33) 31.66 ± 3.2	(22 – 28) 25 ± 4.2

Values represent mean ± SD

Discussions:

Evidences show that global changes in climatic conditions lead to a shift of habitats in fish populations in accordance to their thermal preferences and ample evidences prove that the ongoing climate change will irreversibly affect natural species around the globe (Buisson and Grenouillet, 2009), and in recent years, it has been found that freshwater fish species could greatly change their present-day distribution in response to such changes. In studies assessing the impacts of climate change, a species may have the possibility of replacing one species with that of other in a particular assemblage (IPCC, 2002). For the present study, we took the case of the torrential river, Basistha, situated in the heart of Guwahati city. Based on the baseline data recorded in the year 1997 by Das and Bordoloi, we could observe a change in the fish assemblage pattern that has resulted in the inclusion of 11 fish species not recorded earlier from this stream (Table 1). Analysis of secondary data on the fish diversity has revealed that 3 warm water species (sub- tropical species) was added to the fish fauna over the years. The inclusion of these sub- tropical species lays down an inference that the species preferences towards suitable habitats have changed owing to the overall changes in the temperature patterns of the region. The sub- tropical species recorded from this stream during the present survey were *Channa barca*, *Tor tor* and *Pethia conchonius.* Moreover, the stream was observed to lose its torrential characteristics at some points, and due to this, most of the torrential fish species which were recorded earlier were not recorded in the present study.

This study can be correlated with the effect of rising temperatures in the city of Guwahati, which have led to an increase in the surface water temperatures of the water bodies. The maximum and minimum water temperatures recorded during the present study was (16.8ºC – 33ºC) (Table 2.) whereas, the range was observed to be (14ºC - 28ºC) approximately two decades ago. Warming of habitat has led to a habitat preference for those fishes that dwell in water temperatures above 28ºC. Hence, the inclusion of sub- tropical species as well as the record of species not recorded earlier from this river can be an indication of the changing climatic conditions in the city of Guwahati.

Thus, from the present study, a connection between freshwater biodiversity and climate has been discussed with a study of the observed changes in the fish assemblage pattern of Basistha. Increasing trends of temperatures and changes in temperature regimes have led to a change in the composition of fish fauna over the years. With the help of existing literatures, the indication that changes in the climatic conditions affect the assemblage of species and the interactions between them could be traced. The changes in the assemblage of the fishes in the hill stream could bring out significant assessment of the changing environmental scenario with the changing preferences of species towards habitats. If a particular ecosystem is exposed to such changes for a longer period of time, the entire fish assemblage changes, and this depends upon the preferential behaviour of species inhabiting a particular zone.

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Certain Aspects of the Feeding and Reproductive Biology of *Glossogobius giuris* from Upper Assam

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Abstract

The present investigation was conducted to assess the length-weight relationship, condition factors, length at 50% maturity, sex ratio, gastrosomatic index, gonadosomatic ratio, RLG, ova diameter and fecundity of Glossogobius giuris. The mean total length and weight is found 10.6±0.66 cm and 12±2.5 gm respectively. The mean condition factor was found 0.97. The sex ratio is found to be 1:0.59 and length of 50% maturity is under length group 9-11. The mean gastrosomatic index observed as 2.5±.54 in male and 3.1±.35 in female. The mean gonadosomatic ratio is found in male 0.37±0.18 and in female 3.4±1.6. The ova diameter of the specimen is found to be 0.41. The mean total fecundity calculated was 12,306.87±6539.47. Significant variation in fecundity, gastrosomatic index, gonadosomatic ratio was found in the present study. The fish was found to spawn for a prolonged period with two spawning peaks. One in March and other extended from June to October as indicated by the peaks of GSR and fecundity study. The present investigation revealed that G.giuris is high fecund fish compare to its size and value increase with increase its weight. Findings of this investigation highlighted the importance of this species as a potential candidate in aquaculture. This study will help to introduce this species in sustainable aquaculture through proper management and for development of its breeding protocol.

Key words: *Glossogobius giuris*, captive breeding, Reproductive biology

Introduction

Glossogobius giuris, once a very common species in both lentic and lotic systems, is traditionally used as medicinal fish by certain communities in north-east India. It is also considered as a larvicidal fish. However due to various reason the species has been highly depleted in its natural habitat for sometime now. Under this backdrop, Glossogobius giuris may be a good candidate and play role for enhancement of fish production and uplifment of socioeconomic condition in the country. the present paper therefore dealt with certain aspect of the biology of the species from upper Assam.

Materials and Methods

The specimen pertaining to the present study (Glossogobius giuris) were collected from a pond near Badlabeta Tea Estate near Doomdooma in Tinsukia District of Upper Assam and also from a fish landing centre of Dibrugarh district for one year (2014-15). A total of 144 (94 male and 50 female) specimens were studied for different biological aspects. A total of 18 morphometric parameters were studied following Lowe-McConnell (1971) and Grant and Spain (1977). Similarly 6 meristic characteristics were studied as per Holden and Raitt (1974).. Relative gut length was calculated as per Al-Hussainy (1949). Gastrosomatic index (GSI), gonadosomatic ratio (GSR), sex ratio, ova diameter, fecundity was calculated following Biswas (1993). Size at first maturity and 50% maturity (M50) was studied as per Hodgkiss and Mann (1978).

Results and Discussion:

Biometric index: It is observed that certain body parameters increased and some remains almost constant with the increase in total length (Table 1).

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Size group (cm)	Morphological parameters								
	SL	DL	PvL	AnL	PL	CL	HL	ED	BD
5-7	4.2±.44	1.3±.09	1.4±.13	1.1±.07	1.6±.15	1.9±.27	2.2±.08	0.3±0.02	1.3±.1
7-9	6.2±.34	1.4±.04	1.6±.07	1.2±.11	1.7±.17	2.1±.16	2.6±.19	0.3±0.03	1.4±.15
9-11	8.1±.47	1.6±.23	1.6±.17	1.4±.11	1.9±.15	2.3±.19	2.6±.13	0.31±0.02	1.6±.22
11-13	9.2±.73	1.7±.07	1.7±.21	1.5±.1	1.9±.33	2.4±.14	2.7±.07	0.32±0.04	1.7±.31
13-15	10.6±.6	1.7±.09	1.8±.08	1.6±.09	2.1±.16	2.5±.21	2.7±.12	0.33±0.31	1.8±.14

Meristic count: Meristic count was done in Glossogobius giuris. Although meristic characters are species specific, slight variations were recorded particularly in paired appendages (Table 2)-

Fins	Soft rays	Spine
Dorsal	8-9	1
Adipose	-	--
Anal	8-9	1
Pectoral	18-19	1-2
Pelvic	17-19	-
caudal	14	-

Length-weight relationship: The exponent value (b) 3 indicates isometric growth (Simon & Mazlan 2008). Length-weight relationship indicated allometric growth i.e., not a single size group showed b=3 (Table 3). Fluctuation of growth co-efficient (b) is due to many factors viz, availability of prepared food, high degree of intraspecific competition, extreme cold or warmer water temperature and physiological causes. Usually b value in female fish widely fluctuates seasonally. The b value is found lowest in spent fishes and of the highest in ripe or gravid fishes.

Table 3: Monthly variation of length- weight relationship in *G. giuris*

Month	TL (cm)	TW (gm)	b	a	r	Regression equation
January	10.2-12.7	10.2-12.7	4.0	-3.06	1.7	Y= -3.06+4.0X
February	9.8-11.6	9.33-16.9	2.0	-1.006	0.7	Y = -1.006+4.0 X
March	7.2-13.8	3.1-23.9	2.03	-1.2	1.1	Y = -1.2+2.0 X
April	7.1-14.5	7.1-14.5	2.8	-1.8	1.5	Y = -1.8+2.8 X
May	7.6-15.1	4.2-32.6	2.2	-1.2	0.28	Y = -1.2+2.2 X
June	11.2-12.8	11.2-12.8	2.6	-1.5	0.27	Y = -1.5+2.6 X
July	8.5-12.8	8.5-12.8	2.6	-1.5	1.7	Y = -1.5+2.6 X
August	10.2-12.1	8.5-13.1	2.5	-1.4	1.2	Y = -1.4+2.5 X
September	9.6-10.8	8.7-12.1	2.7	-1.7	0.88	Y = -1.7+2.7 X
October	8.3-9.3	5.9-10.02	4.8	-1.1	0.5	Y = -3.5+4.8 X
November	9.4-11.5	7.5-16.6	2.12	-1.1	1.1	Y = -1.1+2.1 X
December	10.1-12.5	10.5-20.5	1.9	-.8	1.01	Y = -0.08+1.9 X

Condition factors: The condition factor was found highest in May and lowest in July. (Table 4) The general pattern in seasonal changes of K values in adult fishes is well known – a decrease during times of low temperature and low availability of food, an increase towards spawning season, a sharp decline after spawning, especially in female and subsequent increase after spawning (Le Cren 1951).

Table 4: Monthly variation in condition factors of *Glossogobius giuris*

Month	TL±SE	TW±SE	Condition factor
January	11.2±0.7	14.0±2.3	0.99
February	10.5±0.5	11.1±2.3	0.96
March	10.6±1.4	12.3±4.4	1.03
April	10.3±1.9	11.8±5.8	1.06
May	11.2±1.8	15.1±7.3	1.08
June	11.9±0.4	16.7±3.3	0.99
July	10.4±1.2	9.6±1.4	0.84
August	10.9±0.6	11.1±1.3	0.85
September	10±0.3	9.6±1.4	0.95
October	9.2±0.8	7.4±1.3	0.93
November	10.6±0.7	11.7±3.3	0.98
December	11.2±0.7	14.1±2.9	1

Relative gut length: RLG of a fish is highly correlated with feeding behaviour. RLG value shows a close relationship with the nature of gut content increases with the increase in vegetable matter and decreases when there is an increment of animal matter, (Dasgupta, 2011). In the case of G.giuris, the value of RLG is significantly low, it ranges from 0.34 to 0.47 (Table 5). The present finding of RLG values are in agreement with the findings of Kuru (2001) and Dasgupta (2011). Based on the RLG value and other related structure associated with mouth, the species appears to be carnivore. Bhiuyan & Haque (1984) reported on cannibalistic food habit of G.giuris in relation to its size and sex.

Table 5: RLG value in various size groups of *G. giuris*

Length range (cm)	Gut length ±SE (cm)	No. of fishes examined	RLG	Mean RLG
5-7	2.04±0.52	12	0.34	0.4
7-9	3.07±0.61	10	0.37	
9-11	4.3±0.72	9	0.43	
11-13	5.3±0.14	11	0.47	

Gastrosomatic index (GSI): GSI indicates the feeding intensity of fish. The GSI value is recorded 2.01±1.3 to 3.72±1.3 and 2.4±8.5 to 4.5±1.08 in male and female respectively (Table 6). The GSI value is more or less similar in all the period of time from January to December study of Glossogobius giuris. Interestingly, the feeding intensity and percentage of active feeders were more during peak breeding season which revealed that no inverse relation

existed between feeding intensity and breeding season in fish. Gorged and Tandon (1962) had done these type of experiment (Rao & Rao 2007).

Table 6 : Monthly variation in GSI of *Glossogobius giuris*

Month	Male	Female
January	3.26±1.5	2.7±0.71
February	3.72±1.3	2.8±1.3
March	2.82±1.8	2.75±1.4
April	1.88±.9	2.5±1.04
May	3.09±0.6	2.7±0.67
June	2.6±1.0	3.1±0.09
July	2.1±1.4	3.4±1.5
August	2.4±1.3	2.5±1.08
September	2.29±0.18	2.4±0.85
October	2.01±0.54	4.5±1.08
November	2.3±0.5	2.8±0.7
December	2.5±0.06	2.9±.05

Sex ratio: Out of 144 specimens studied, 94 and 50 were observed to be male and female respectively (Table 7). Rao (2007) reported the male to female ratio as 1:0.59 which was statistically similar to those of present study.

Gonadosomatic ratio: The GSR value increases with the maturation of fish declining abruptly thereafter. Month wise changes in GSR value of male and female was presented in Table1. Value of GSR ranges from 0.2±.01 to 0.81±3.04 and 0.812±.08 to 5.8±.01 in male and female respectively. The highest value of female was observed June and in male in March. Islam (2004) stated that this species is a prolific breeder that bred throughout the year with a peak in August. On the other hand, Islam and Mollah (2013), stated highest GSR value in April in captive condition. This slight variation may be due to the environmental factors and habitat.

Month	Males	Female	Total no	M%	F%	Sex ratio
January	7	4	11	63.63	36.36	1:0.5
February	7	3	10	70	30	1:0.4
March	10	9	19	52.63	47.36	1:0.8
April	19	11	30	63.33	36.67	1:0.5
May	10	2	12	83.33	16.67	1:0.2
June	6	2	8	75	25	1:0.3
July	8	2	10	80	20	1:0.25
August	4	3	7	57.14	42.85	1:0.7
September	7	3	10	70	30	1:0.42
October	6	4	10	60	40	1:0.6
November	6	4	10	60	40	1:0.6
December	4	3	7	57.1	42.8	1:0.8

Table 8: Monthly variation in GSR of *Glossogobius giuris*

Month	Male	Female
January	0.35±0.15	1.8±0.49
February	0.48±0.21	3.14±0.48
March	0.81±3.03	4.78±2.8
April	0.67±1.8	3.3±1.5
May	0.26±.15	2.6±.42
June	0.21±0.01	5.8±0.01
July	0.36±0.33	3.1±0.32
August	0.46±0.4	5.7±2.1
September	0.21±0.08	5.2±0.85
October	0.24±.04	3.9±0.76
November	0.23±0.11	1.3±0.36
December	0.2±0.1	0.81±0.08

Fecundity: The average fecundity ranged from 8,948±397 to 14,689±120442.54 (Table 9). During the study, it was observed that the ovaries of same size of fishes contained different number of eggs. This may be due to the variation in environmental condition and food intake by the individual. So, variation in fecundity during the study is not an exceptional case. Likewise, Roy et al, Sulistiono and Rao & Rao(2014) reported the fecundity of Glossogobius giuris respectively ranges from 88,948 to 26,4104, 9380 to 29,3664 and 10,640 to 15,0639. Whereas Bhowmick and Doha(1965) observed very few eggs ranged from 10,760-29,580. The highest absolute fecundity was observed in June was observed 15,289±1245.5.

Table 9 : Monthly variation of fecundity in Glossogobius giuris

Month	Stastics	Total length (cm)	Body weight (g)	Ovary weight (g)	Absolute Fecundity	Relative fecundity
March	Mean±SE	10.6±1.4	12.3±4.4	0.58±0.34	14,689±3748.51	922.42
	Range	7.2-13.8	3.1-23.9	0.021-1.2	2300-15,243	231-987
April	Mean±SE	10.3±1.9	11.8±5.8	0.38±0.08	11,689±12042.5	1514
	Range	7.1-14.5	7.1-14.5	0.34-0.90	967-12,432	176-1100
May	Mean±SE	11.2±1.8	15.1±7.3	0.39±0.05	11,377.5±1101.5	691.64
	Range	7.6-15.1	4.2-32.6	0.37-0.76	1127-12763	238-1300
June	Mean±SE	11.9±0.47	16.7±3.3	0.96±0.12	15,289±1245.5	745.8
	Range	11.2-12.8	11.2-12.8	0.78-0.99	8321-18,563	542-982
July	Mean±SE	10.46±1.2	9.67±1.4	0.39±0.03	10624.5±584.5	882.43
	Range	8.5-12.8	8.5-12.8	0.28-0.48	3211-15,211	654-1921
August	mean±SE	10.9±0.69	11.1±1.3	0.63±0.11	11706.5±1173.5	1026.84
	Range	10.2-12.1	8.5-13.5	0.42-0.92	1221-17531	569-2393
September	Mean	10.03±0.36	9.6±1.4	0.49±0.16	14,133±370.09	1372.13
	Range	9.6-10.8	8.7-12.11	0.43-0.68	1217-21,123	752-2214
October	Mean	9.24±0.81	7.4±1.3	0.28±.05	8,948±397	1486.37
	range	8.3-9.3	5.97-10.02	0.18-0.29	987-12,345	845-2453

Length at 50% maturity (L50): L50 is the average size of a species when it starts to reproduce for the first time. Most studies suggest relationships among temperature, population size, and body size at maturity. Growth of a fish species is also density-dependent. Increase in population size may have led to a decrease in per-capita food availability and, thus, a decrease in the size at maturity (Bigler et al., 1996). From the present study the estimated value of M50 is found to be in the size group of 9-11cm. (Table 10).

Table 10: Length of fish at 50% maturity (M50)

Length range (cm)	Total specimen	Stage IV (mature)	Maruration (%)
5-7	14	6	42.4
7-9	8	5	44.4
9-11	15	10	50
11-13	16	9	56.2
13-15	12	8	66.67

Ova diameter and its morphology: The present study reported that the ova diameter of G.giuris ranges from 0.16-0.60mm, maximum being in ripe stages . Kovacic (2007) obtained the oocyte diameter in a ripe ovary of striped goby contained 0.44-0.60 mm (fully ripe oocyte), 0.16-0.24mm (early ripening oocyte) and <0.08mm (numerous, very small one). Rao & Rao (2007) also observed that G.giuris breeding season is prolonged from August to January with a peak in September. They found seven maturity stages and at first maturity is observed 103 mm in female and 114 mm in male.

Table 11: Monthly progression of mean ova diameter of G.giuris

Month	Ova diameter (Range)	Mean± SE
March	0.08-0.21	0.16±0.07
April	0.12-0.25	0.21±0.04
May	0.22-0.38	0.35±0.03
June	0.36-0.51	0.41±0.07
July	0.45-0.57	0.42±0.04
August	0.55-0.62	0.51±0.03
September	0.57-0.63	0.57±0.02
October	0.59-0.68	0.60±0.03

Conclusion:

This present study revealed that the species is carnivore in feeding habits. It can also be concluded from the study that the specimen is high fecund and spawning continues for a prolonged period, extending from March to September.

It is expected that this report will form the base line data for entrepreneurs especially in the field of aquaculture and public health department as the species is reported to be a larvicidal fish, voraciously feeding on mosquito larvae. Lastly, it must be said that the identification and conservation of indigenous fishes are important as it has its own economical importance.

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Fish Processing and Value Addition in the Perspective of Northeast India

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Abstract

Fish plays a major role in human nutrition. Fish and shell fish form an important part of the human diet, both of the poor and of the wealthy. The Northeast region of India is known for its vast natural resources and a cauldron of different people and cultures. The Northeast India with various ethnic groups (about 166) offers a tremendous opportunity for ethnological studies especially on processing and preparation of smoked and fermented fish products which are inseparable and important part of the food consumed by these groups and play a significant role in their traditional life style. The ethnic people of this region consume these cured fish products as a part of their daily diet and also there are traditional beliefs regarding their health beneficial effect. The region is bestowed with many fermented fish products like *Shidal*, *Ngari*, *Hentaak*, *Lona ilish*, *Tungtap*, *Numsing* etc. along with traditionally processed smoked fish products like *Nga-mu-leirou*, *Ukabi-leirou*, *Khazing-ayiba*, *Kharang*, *Khyrwong* etc. Though Northeast India is very rich in its food culture, but it differs vastly from rest of the country in its taste as well as flavours. Several studies revealed their significance as 'health food' due to their antioxidative and probiotic potential. The broad objective of this study was to investigate different traditionally processed fish products available in the region since time immemorial for their documentation. Moreover, an overview of different value added fish products utilizing low priced fish in the context of NE India has also been furnished.

Introduction

Fish makes a vital contribution to the survival and health of a significant portion of the world's population. Fish is especially important in the developing world and plays a major role in human nutrition. Fish and shell fish form an important part of the human diet, both of the poor and of the wealthy. Compared to meat products, which are viewed as unsafe due to incidences of diseases like mad cow disease, bird flu etc.; good quality fish is an extremely safe. Fish is organic and is harvested from both wild as well as from farm. Fish have always been important to man. Man has always eaten fish. For thousands of years, fish has been an important part of the human diet. The ancient Assyrians, Romans and Chinese were famous for their fish farming (Beddows, 1985). In developing countries fish is still very much an essential food and a main source of protein. During the past decades per capita consumption of fish has gone up globally.

From nutritional point of view, fish is the balanced diet one can easily think of, when consumed alongwith cereals. These are richest source of essential amino acids which are required for overall growth of a person. Besides amino acids, fish contains number of fatty acids of immense nutritional value which could help to reduce the risk from cardio-vascular diseases. Fish is soft, easy to cook and more easily digested than meat so even young children can be fed fish, contributing to improved nutrient intake. Fish can also be used as complementary foods especially in paste or powder form. These products can be used to enrich the maize and cassava based porridges that are normally consumed by young children in rural communities. Often referred to as "rich food for poor people," fish provides essential nourishment, especially quality proteins, fats, vitamins and minerals. For those involved in fisheries, aquaculture and fish trade, fish is a source of income. India produces about 6.57 million metric tons fish every year. The inland-sector, which has a growth rate of 6 per cent, contributes around 55 per cent of it. Recently, researchers all over the world have repeatedly

emphasized the beneficial effect of eating fish, after conduction of systematic research for many years.

According to FAO recent estimates (FAO, 2014), fisheries and aquaculture provide livelihood security and economic benefits for an estimated 55 million people engaged in the primary sector and for an estimated 660-820 million people forming 10 – 12% of the world's population in the dependent sectors. Recently, researchers all over the world have repeatedly emphasized the beneficial effect of eating fish, after conduction of systematic research for many years. The whole story began following the discovery that coronary heart disease, while being one of the biggest killers in the world, is practically unknown among the Eskimos. The investigations found that their diet is mostly fish based and is rich in long chain ω-3 (*omega*-3) polyunsaturated fatty acids. Eskimos also have a reduced tendency to blood clotting and longer bleeding times compared to other people. Medical researchers carried out detailed investigations and showed that men who ate fish once or twice per week were protected against coronary heart disease. An increase in fish oils in the diet results in a marked reduction in blood cholesterol and triglyceride levels and also thrombosis problem.

Fish preservation is a very important aspect of the fisheries. Normally the fish farms or other fish capturing sites are located far off from the market place and there is chance of fish decomposition and the uncertainties of their sale in market. When the fishes are caught in numbers, greater than the amount of consumption, their preservation becomes a necessity for their future use. Preservation and processing therefore become a very important part of commercial fisheries. It is done in such a manner that the fishes remain fresh for a long time, with a minimum loss of flavour, taste, odour, nutritive value and the digestibility of their flesh. There are different ways of preserving fish which includes traditional methods such as simple sundrying, salting, marinading, smoking, fermentation to modern technologies like refrigeration, freezing, canning etc.

Nutritional significance of fish

The taste, flavour and nutritional value of fish vary considerably from species to species and even among the same species individual variations can be observed. This is due to the fact that the properties of fish – culinary, physical or nutritional – depend on its biochemical composition and the biochemical composition is not the same for all species. The basic constituents that make up the fish tissues are the same as those found in other animal tissues. Water, protein, fat (or lipid) and minerals are the principal constituents. These four constituents together form about 95 – 98% of the total weight of the tissue. Carbohydrate is not a major component, especially in the muscle tissue. A variety of many other minor constituents like water soluble vitamins, free amino acids and nucleotides are also present in fish. Even though these are quantitatively less significant, each one has specific biological functions and the absence of these will lead to metabolic and physiological disorders. Conditions like genetic characteristics,

Principal constituents (%) of fish muscle

Constituent	Min	Normal range	Max
Protein	6	16 – 21	28
Lipid	0.1	0.2 –25	67
Carbohydrate		<0.5	
Minerals	0.4	1.2 –1.5	
Water	28	66 – 81	90

Human disorders reported / prevented by n-3 PUFAs

- High cholesterol
- High blood pressure
- Heart diseases
- **Attention deficit/hyperactivity disorder (ADHD)**
- Asthma
- **Colon cancer**
- Rheumatoid arthritis
- Diabetes
- Osteoporosis
- **Prostate cancer**
- **Inflammatory bowel disease (IBD)**
- **Menstrual pain**
- **Breast cancer**
- **Skin disorders**

biological status in the life cycle, feeding habits, environmental conditions, etc. are the important parameters determining the chemical composition.

Fish contains protein of high biological value, essential minerals, vitamins and fats. It has been reported that 85% to 95% of the fish protein is assimilable. The chemical score or amino acid score compares a food's amino acid pattern to that of whole egg protein. The protein efficiency ratio (PER) , another measure of protein quality, is around 3.5 for fish, which is much higher than beef (2.3) and milk (2.5) and close to that of egg (3.92).

Recommendations of the American Heart Association (AHA) for *Omega*-3 Fatty Acid Intake

Population	Recommendation
Patients without documented coronary heart	Eat a variety of (preferably fatty) fish at least twice a week. Include oils and foods rich in alpha-linolenic acid

Fish is a good dietary source of taurine, a non-protein amino acid with multiple functions like neurotransmission in the brain, stabilization of cell membrane and in the transport of ions such as sodium, potassium, calcium and magnesium. Apart from this, fish protein has some unique nutritional characteristics. It is now established that fish protein behaves as a hypocholesterolemic agent, probably because of the characteristic amino acid composition. Another recent finding is that fish protein is a strong cardio protective agent and can control the symptoms of experimentally induced myocardial infarction in albino rats. It protects the antioxidant system and thus minimizes the chances of tissue damage caused by oxidative stress. It has also been reported recently that fish protein have a clear protective effect in diabetic renal diseases.

Fish and shellfish have high levels of poly-unsaturated fatty acids (PUFA) among which arachidonic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are the major components (Sikorski *et al*., 1990). Most of the PUFA from fish oil belong to the *omega*-3 groups, which tend to lower blood cholesterol by depressing low density lipoprotein (LDL) concentration. *Omega*-3 fatty acids appear to also reduce levels of plasma triglyceride, in particular very low density lipoprotein (VLDL). EPA is believed to play important roles in maintaining the health of heart and circulatory system, whereas DHA is involved in the functioning of brain, nerves etc. Since these acids cannot be synthesized in the human body to the required extent, it is essential that adequate quantities are supplied through food. Fish and other marine products are the best sources for these acids.

However, due to the high levels of long chain PUFAs, fish products are susceptible to oxidation. Oxidation of lipids is associated with a decrease in triacylglycerols and phospholipids and an increase in free fatty acids and often results in a product with off flavours (rancid) which may not be appealing to many consumers. Fatty fish have high levels of polyunsaturated fatty acids, especially the 2-3 fatty acids EPA and DHA, which are very susceptible to rancidity.

Fish is a good source of almost all the minerals present in seawater and the value range from 0.4 to 1.5%. The minerals present in fish include iron, calcium, zinc, iodine (from marine fish), phosphorus, selenium and fluorine. All the vitamins necessary for good health in humans and domestic animals are present to some extent in fish, but the amounts vary widely from species to species, and throughout the year. Fat soluble vitamins A, D, E and K are present in fish in varying amounts, often in higher concentrations than in land animals. Fish liver, eggs, milt and skin are good sources of B_1, riboflavin, pyridoxine, folic acid, biotin and B_{12}.

The major factors that affect the nutritive value of fish products are related to how fish is handled, processed or preserved, and stored. Traditional practices such as exposing fish for long periods to weather elements coupled with traditional methods of preservation (hot smoking, sun-drying, and deep frying) and poor storage are subjecting fish to different kinds of degradation. Because of the high unsaturated fatty acid content of fish, free radical

oxidation is a common phenomenon in all types of fish products (fresh or processed) that are exposed to air.

Fisheries is fast emerging as a priority area in the national economy of India, the main aims being increase of production, improving export earnings, providing more and better animal protein to the weaker sections and expanding employment opportunities especially among the rural poor and women. Fish is the ultimate answer to the problem of protein calorie malnutrition in countries like India, where aquaculture is also developing fast. Fish is thus a product that needs proper handling and processing in order to preserve nutrients and its functional components that promote good health.

Handling of fish for marketing

In live condition

Fish is a very perishable food commodity that requires proper handling and preservation to increase its shelf life and retain its quality and nutritional attributes. The first obvious way to avoid spoilage and loss of quality is to keep caught fish alive until cooking and consumption. Handling of live carp for trade and use has been practiced in China for more than three thousand years. Today, keeping fish alive for eventual consumption is a common fish-handling practice worldwide. To do so, fish are first conditioned in a container with clean water, while the damaged, sick and dead fish are removed. Fish are starved and, if possible, water temperature is lowered in order to reduce metabolic rates and make fish less active. Low metabolic rates decrease the fouling of water with ammonia, nitrite and carbon dioxide that are toxic to fish and impair their ability to extract oxygen from water.

A large number of fish species are usually kept alive in holding basins, floating cages, wells and fish yards. Holding basins, normally associated with fish culture companies, can be equipped with oxygen control, water filtering and circulation and temperature control. Simpler methods are also used. For instance, large palm woven baskets act as floating cages in rivers (China) or simple fish yards are constructed in a river's backwater (South America). Also, the transportation of live fish ranges from very sophisticated systems installed on trucks that regulate temperature, filter and recycle water and add oxygen, to very simple artisanal systems of transporting fish in plastic bags with an atmosphere supersaturated with oxygen.

Handling of dead fish

For dead fish, handling operations after capture are: transferring catch from gear to vessel, holding of catch before handling, sorting/grading, bleeding/gutting/washing, chilling, chilled storage, unloading. These operations can be performed in several ways, from manual methods to fully automated operations. The number of operations and the order in which they are performed depend on the fish species, the gear used, vessel size, duration of the voyage and the market to be supplied.

It is crucial to provide a continuous flow in handling and to avoid any accumulation of unchilled fish, thereby bringing the important time-temperature phase under complete control. It is also essential to improve working conditions onboard fishing vessels by eliminating those catch-handling procedures that cause physical strain and fatigue to fishers. Nowadays, this is possible in industrial fisheries because of equipment and handling procedures designed to eliminate heavy lifting, unsuitable working positions and rough handling of fish.

Different fish preservation techniques

Many different techniques have been used to preserve fish quality and to increase their shelf life. Actually the method of fish preservation varies from community to community and depends on the food habits of the people. In European countries frozen fish are mostly preferred whereas dried, smoked and fermented products are the choice of preservation in Southeast Asian countries. But all the preservation techniques are primarily designed to inhibit or reduce the metabolic changes that lead to fish spoilage by controlling specific parameters of the fish and/or its environment besides taking due care on the organoleptic characteristics. These techniques can be classified as follows:

***Techniques based on temperature control*:** These encompass a wide array of technologies used to decrease the fish temperature to levels where metabolic activities - catalyzed by autolytic or microbial enzymes - are reduced or completely stopped. This is possible by refrigeration or freezing where the fish temperature is reduced, respectively, to approximately 0 °C or < - 18°C. Fish refrigeration can use cool air circulating around the fish (mechanical refrigeration) or icing. Icing is the oldest method of preserving fish freshness. Currently, it is widely used thanks to mechanical refrigeration, which makes ice readily and cheaply available. In addition, ice keeps fish moist, has a large cooling capacity, is safe, is a portable cooling method that can be easily stored, transported and used by distributing it uniformly around fish. Ice can be produced in different shapes - the most commonly used to cool fish are flake, plate, tube and block. Block ice is crushed to chill fish. Chilled or frozen fish products require additional cooling in cold store to avoid an increase in temperature.

***Techniques based on the control of water activity*:** Water activity (a_w) is a parameter that measures the availability of water in fish flesh. It is expressed as the ratio of water vapour pressure in fish/vapour pressure of pure water at the same temperature and pressure. A_w varies from 0 to 1. Water is necessary for microbial and enzymatic reactions and several preservation techniques have been developed to tie up this water (or remove it) and thus reduce a_w. These include drying, salting, smoking, freeze-drying, the use of water binding humectants and a combination of these. Some of these techniques, such as drying, salting and hot smoking, have been used for thousands of years. They can be implemented very simply, e.g. by salting, solar drying, or using fully automated equipment with temperature control, relative humidity, etc.

***Techniques based on the fermentation of fish*:** Fish fermentation has been a method of preservation to develop suitable physicochemical characteristics responsible for favourable sensory properties, still enjoys popularity in many developing and underdeveloped countries owing to simplicity of preparation and low cost of processing. The fermented fish products find important place in the dietary lists of the people in Southeast Asian countries. Fish fermentation may be with or without salt and takes place in partial anaerobic to completely anaerobic condition in specially designed container which may either be made of mud, wood or tin coated iron.

***Techniques based on the physical control of microbial loads, its chemical and enzymatic activity*:** These physical methods use heat (cooking, blanching, pasteurizing, sterilizing), ionizing irradiation (for pasteurization or sterilization) or microwave heating. Cooking or pasteurizing are processes that do not allow complete inactivation of microorganisms and thus often need to be combined with refrigeration to preserve fish products and increase their shelf life. This is not the case of sterilised products and which are stable at ambient temperatures (< 40°C). These require packaging in metal cans or retortable pouches before the heat treatment, thus the term "canning".

***Techniques based on the chemical control of microbial activity and loads*:** These techniques are designed to add anti-microbial agents or decrease the fish muscle pH to levels that are inhibitory to microbial growth and proliferation. Most bacteria stop multiplying at pH < 4.5. The decrease of pH is obtained by fermentation, marinades or by adding acids (acetic, citric, lactic, etc.) to fish products.

Principal method of fish preservation in the Northeast India

The principal method of fish preservation in the Northeast India (NEI) is fermentation of fish, has been in practice since time immemorial followed by drying and smoking (Majumdar, 2005). Such fish fermentation technique prevalent in NEI is unique in India and surely claims a 'Geographical Indicator'. The reason of such diversified technique of fish preservation lies in the history of NEI.

The North Eastern Region of India is known for its vast natural resources and a cauldron of different people and cultures, lie deep in the lap of easternmost Himalayan hills in North-Eastern part of India, connected to rest of India by merely 20 km of wide land. The region comprises of States like Arunachal Pradesh, Nagaland, Manipur, Tripura, Mizoram, Meghalaya, Assam and Sikkim. The North-East India shares over 2,000 km of border with Bhutan, China, Myanmar and Bangladesh. Its total is 2,55,168 sq km with population of 40 million (as per 2010 census), of which the Brahmaputra valley in Assam alone houses almost half of its population. People of all religions like Hinduism, Islam, Buddhism and Christianity live here. The NEI is home to varied number of tribal groups (almost 166). Each tribe has their own distinct culture, which gives them a unique cultural identity. Numerous art forms and festivals of the region are intrinsic part of its rich culture and tradition. Though North-East India is very rich in its food culture, but it differs vastly from rest of the country in its taste as well as flavours. Normally, inhabitants of the region are non-vegetarian, and fond of spice. North East Indian tribes can be largely associated with the ethnic groups of Indo Mongoloids, Tibeto-Burmese and proto Austrioloids which represent the Asio-Austric culture on Indian hilly regions. The trends of these ethnic groups are visible in the looks as well as the traditions which are followed by these communities. They provide a cultural bridge between India on one side and South-East Asia, China and Inner Asia and Burma on the other by ethnic and linguistic angles. Their existence can be traced back to the pre-historic times. The region is a treasure on indigenous knowledge systems pertaining to agriculture, medicine, food and natural resources management. Different fermented and non-fermented foods are used in various combinations with traditional vegetables to meet the food and nutritional security. The traditional foods consumed by tribes of NEI are intimately connected to virtually all aspects of their socio-cultural, spiritual life and health.

The fish fermentation technology in the NEI states evolved by compulsion of people (Majumdar, 2005). The Northeastern sector of India, being the highest rainfall area of the world, does not provide a congenial environment for simple sun drying of fish. People used to preserve fish for use in lean period by drying under sun. Hence, such drying used to be prolonged due to high humid atmosphere and frequent rainfall particularly during the peak fishing seasons (i.e. from May to September). Northeast, being abundant in low lying areas where accumulation of water during rainy season offers an ideal habitat for the breeding of weed fishes such as *Puntius* spp., 'Darkina' (*Esomus danricus*), 'Mola' (*Amblypharyngodon mola*). The clever fishermen, therefore, was in search of a method through which they could preserve the heavy catches of such less valued weed fishes for consumption and sale in the dry seasons (November to April) when there was scarcity of raw fresh fish in the market. Moreover, due to non-availability of ice and good road communications, these perishable produce could not have been transported to the distant markets where they could get a higher price which they never used to earn in the village markets. It is fact that the tastes and food

habits of the rice-eater prefers to eat his rather tasteless rice mixed with little morsels of products bearing strong flavours. In this situation, the fermented fish could become ideal to cater their needs.

Fermentation technology in NEI has adapted itself to social demands. Most of the traditional food fermentation industries are rural, seasonal, labor intensive, informal, and capital deficient. Commonly, fermented foods are sold and consumed in the areas where they are produced. The methods of processing were developed in homes and improvements were based on the observations of the practitioners. Fermentation processes are normally handed down from generation to generation. There is little interest in knowing the role of microorganisms and the physical and chemical changes that occur in the products. What is recognized are changes in colour, odour, and taste that result from modifications of the process or variations in the ingredients or conditions. Most processes are conducted on a trial-and-error basis with little quality control. Product quality primarily depends on the experience of the processor.

Northeast region is bestowed with many fermented fish products such as shidal, ngari, hentaak, lona ilish, tungtap etc. (Majumdar et al., 2015a). Fermented fish contributes a regular menu especially in the diets of tribal people. Unlike salt fermented fish products of Southeast Asia, the salt-free fermented fish products of the Northeast indicates the fact that the technology of salt-free fermentation originated long before the men started using salt (sodium chloride). Later on salt was used for fermentation as it was observed in case of salt fermented hilsa (lona ilish).Preparation of such fermented fish products is simple but most of the critical steps are optimized by experiences for getting a yield of different qualities.

Popular fermented fish products of Northeast India

Shidal: *Shidal* is a salt-free fermented fish product indigenous to the Northeast sector of India. It is popularly called as '*seedal'*, '*sepaa'*, '*hidal'*, '*verma'* and '*shidal'* in Tripura, Assam, Mizoram, Arunachal Pradesh and Nagaland. Especially Assam and Tripura is the major producer of *shidal* amongst the NEI states. The technology is very old and originated in the erstwhile undivided India (now Bangladesh) and believed to came into existence at least before the British Era in North eastern states of India, i.e., before 1824. *Shidal* is exclusively prepared from *Puntius* sp. (generally *Puntius sophore*) which is popularly known as *Punti shidal* (Majumdar et al., 2015b). The product is very much popular due to its strong flavour. The typical strong flavour is due to break down of fish protein and lipid, which produce some peptides, amino acids, fatty acids, indole, skatole etc. producing a strong characteristic odour of *shidal*. The appearance of the product is solid, bilaterally compressed and pasty and shape of the fish remains almost unchanged except little disintegration near belly and caudal portion. The colour of best quality product is dull white that gradually becomes slight brownish to deep brownish on continuous exposure to air. Presently, the production of *shidal* is confined to particular districts of the states of Assam (Nagaon, Dhubri, Goalpara and Kachar districts), Manipur (Imphal city) and Tripura (West Tripura district). Due to local non-availability and high price of dry punti fish, traditional *shidal* producers tried to make *shidal*


Puntishidal


Phasashidal

with other varieties of fish. It was found that phasa fish (*Setipinna phasa*) could be used as an alternative to the punti fish with reduced cost of production in comparison to *Punti shidal*. In Manipur it is known as *Thum-thakpi*, *Thumnga*, *Ngari*, *Samudrangari* etc. whereas, in Tripura and Assam it is popularly known as *Telesech*, *Baspati*, *Phasa shidal* etc.

In traditional practice, fermentation takes place in earthen narrow mouth hundies, locally known as '*matkas'*. Generally older *matkas* are used by the traditional *shidal* processors as it provides very good air sealability and gives better quality end product. In traditional system such *matkas* are smeared with oil. *Matka* is made usable by repeated oil smearing followed by sun drying for several times. Fish oil is mainly used for smearing as fish oil gives characteristic flavour also. But fish oil is not available in adequate quantity for large number of *matkas*. *Matka* is fully saturated with oil because oil will help to prevent the entry of very minute foreign materials from outside to inside the *matka* and if a *matka* is fully saturated with oil it will not absorb water from the fish when fishes will be tightly packed inside. Due to addition of extra oil and use of semi fatty raw material fish, rate of lipid oxidation is high in such products besides high total volatile basic nitrogenous compounds. *Matka* filled with partially wet dry punti/phasa fish is covered with a paste made from crushed dry fish with little oil. This paste (cover paste) seems to form a good medium for growth of microbes and probably plays the major role for initiating the fermentation process. Filled *matka* is finally sealed by thick mud clay to prevent entry of air/moisture inside the *matka*and alsoto protect the cover paste from flies and maggots. The *matkas* are left for fermentation at room temperature for 3-5 months.

***Ngari*:** *Ngari* is a popular fermented fish product of Manipur which is prepared by using sundried salt-free punti fish (*Puntius sophore*), locally known as *Phoubu* usually imported from Brahmaputra valley of Assam and Bangladesh (Majumdar et al., 2015a). The method of production is almost similar to that of *shidal*. The only difference is that, unlike *shidal*, water soaked and partially dried fish are subjected to heavy pressure by legs using gunny bags to remove excess water by breaking the heads and bones. The oil released from head during pressing is believed to cause initiating fermentation. The resultant fish of somewhat paste like consistency is then filled in the previously oil processed *matka*. After primary sealing with cover paste made from crushed dry fish, final sealing is given by mud and cow-dung slurry. The filled and sealed *matka* is then left at dark undisturbed for 6 to 12 months. Considering the importance of *ngari* to the people of Manipur, recently sun dried *Setipinna phasa* is introduced as raw material for its preparation. *Ngari* is consumed as a daily compulsory side dish called *Ironba* (mixed with potatoes, chillies etc.) with cooked rice by people of all communities of Manipur.

***Hentaak*:** It is an indigenous fermented fish paste product of Manipur prepared from dry fish *Puntius* spp. *Amblypharyngodan mola*, *Esomus danricus* etc. along with vegetable like *Colocasia* spp. (Majumdar et al., 2015a). The principal aim behind the production of *Hentaak* is to preserve the animal protein along with vegetable ingredients for a longer duration without any spoilage. *Hentaak* is consumed as curry as well as a condiment with boiled rice. The dried fish of any variety is washed thoroughly and allowed to dry completely by

exposing them under sun till the fish becomes easily crumble. The petioles of aroid plants is finely chopped, washed thoroughly and dried in the sun for about an hour. The dried vegetable and powder of dried fish are taken at 1:1 ratio and made to a homogenous paste in a grinder. The texture of the paste is most important for its quality and shelf-life. Optimum texture quality can be achieved by adding adequate quantity of vegetable component or fish powder. The texture becomes soft if vegetable component is more and hard when fish powder is more. Small balls of size not more than an egg are made from this paste which are kept in an earthen container in air tight condition and allowed to undergo fermentation for four days.

After four days, the balls are taken out and kneaded uniformly and again transformed into small balls as done earlier. These balls are again kept for another six days in the same container in air tight condition. Again, after six days, the balls are taken out of the container and kneaded well with addition of little quantity of mustard oil. Further, small balls are made out of the paste and stored in the same container in air tight condition for ten days. If the texture is too soft, a little quantity of finely ground fish powder is added to control the excess moisture or softness of the product. In case the texture is too hard, a little quantity of onion is added to it and again ground and compacted as a whole. In this way, the taste of the final product can be enhanced. After this stage of fermentation, the product in the form of small balls are wrapped with clean banana leaf and put in the earthen container which is sealed air tight with a paste made from clay and raw cow dung at 1:1 ratio. After a storage period of six months the product is ready for human consumption.

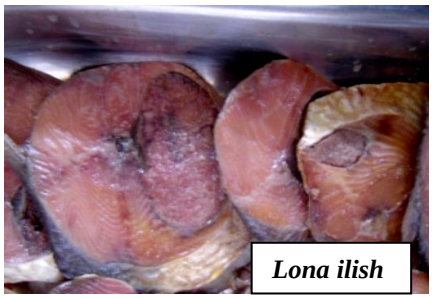
Tungtap: It is similar fermented traditional fish paste popular among the *Khasia* tribes of Meghalaya (personal communication). The raw fishes of *Puntius* sp. locally known as *punthia* are eviscerated, sun-dried and processed with local species. *Tungtap* has been reported to be good source of protein (40.6%). Dry fish (*Danio* spp.) is mixed with salt, kept in an earthen pot and fermented for 4-7 days and consumed as a pickle.

***Numsing*:** It is an ethnic fish product prepared by *Mising* tribes of Upper Assam region (personal communication). It is prepared from flame dried and smoked small economic fish species like *puntius*, *mola*, *channa*, *tengra* etc. Dried fishes are mixed with spices and then grind the mixture in a traditional huller. Stuff the bamboo container with the mixture and seal the container with the fern leaves, rice straws and the final layer with clay. Then ferment it with intermittent heating and keeping it near a fire place for about thirty days. The final product *Numsing* can be store in bamboo container or in glass bottle. It is a good source of both protein and carbohydrate. It is consume after steam cooking or after preparing some vegetable curry.

***Dang-pui-thu*:** *Dang-pui-thu* is prepared from small prawn, crab and fish species. Small fish and prawns are dried over bamboo rack under sun for 4-5 hours and ground to paste (personal communication). These mixed species used to ferment in an earthen *matka* for 2-4 months. The indigenous tribes of South Mizoram region used to prepare this product in their household. The

Dang-pui-thu

product is round shaped, reddish-brown in color and having very strong smell.



Lona ilish

***Lona ilish*:** *Lona ilish* is a salt fermented fish product, prepared exclusively from Indian shad (*Tenualosa ilisha*), a high fat fish (fat content of adult *hilsa* ranges from 14-25%) (Majumdar *et al*., 2006). The product is sliced *hilsa*, about 1.50 to 2.00 cm in thickness. A typical *lona ilish* has a uniform pink colour with a glossy appearance immediately after taking the product out of the brine. The texture remains firm and the flesh does not easily separate from its bone. It has a characteristic strong aroma mixed with some sweet, fruity and acidic notes along with some saltiness.

The fish (*Tenualosa ilisha*) after washing are de-scaled and tail portion and head is removed leaving gut inside. The fish are cut diagonally in such a way that the steak/chunk has more flesh exposed than that or the skin. The thickness of the steaks is generally 1.5 to 2.0 cm. Each of the fish steak is rolled thoroughly in salt (fish to salt ratio is 4:1) and kept in a bamboo made basket layer after layer with flesh side down. Salt is sprinkled between each layer and above the top layer. The filled basket is covered with black polythene sheet so as to avoid entry of light. The baskets are stored in a dark place. The self-brine formed is allowed to drain. In dry salted condition, fish steaks are kept for 48 hours. A considerable amount of moisture content of fish is reduced during this process and colour of the flesh becomes dull white and texture becomes somewhat tough. The salt cured *hilsa* steaks are then packed in a container. The containers used for this fermented product are the empty tin made containers of cooking oil. Packing of cured hilsa is done layer after layer and compacted uniformly by hand after putting each layer till the fish layer reaches at least 2-3 cm below the top. The salted *hilsa* steaks are shaded well before packing to remove adhering salt. Then cold saturated brine is poured slowly in the container over the fish to fill the voids between the steaks and maintain a level of brine about 2-3 cm above the fish. Saturated brine is prepared and boiled properly one day before packing of *hilsa* steaks and cooled overnight. All the containers are stacked in one dark room and left undisturbed for 4 to 6 months for fermentation. If the fish is exposed to air and light for few hours the pink red colour changes to greyish black which is not acceptable.

Smoked fish products

Smoking is a curing method where fish or other food items are smoked by burning woods or any other combustible items. This method of preservation involves removal of moisture content by drying and reduction of microorganisms by the deposition of smoke constituents over the fish. The process imparts a characteristic golden brown colour and smoky odour to fish. Smoked fish products are mostly popular in Manipur state and to lesser extent in certain tribes of Meghalaya, Nagaland and Mizoram states of NE India. Though there are several reports on smoke curing of fish in India and abroad, the smoking of fish in Manipur is unique in nature. The process may use unsalted fish or various salt additions giving salt concentration in the final products ranging from less 2% to over 20%. Some ethnic smoked fish products which are popular and available in the markets of NEI are as follows:

***Sukati Machh*:** The product is a powder of smoked fish and popular in some communities (*Hazarika*, *Bora*, *Kalita*, *Rajbangshi*, *Mohanta* etc.) of Assam State (personal communication). Fish soup is made from this powdered product by adding chilli and garlic. There is a belief prevalent amongst the users that this product is helpful for prevention of malaria. In this process fish is preserved in powder form by the combined preservative effect

of salt and smoke generated from burning of wood. Any variety of fresh trash fish are dressed by removing scales and viscera and washed thoroughly with good quality water. The cleaned fish are then immersed in brine (6-10% solution of sodium chloride) for 10 to 15 minutes. The fish are removed from the brine and dried in the sunlight for about 30 minutes. This partially dried fish are then placed over a wooden sieve. The sieve with fish is kept over a fire so that fish are exposed to smoke and heat produced by the burning wood. After 4 to 5 hours the fish are turned upside down so that both sides of fish are exposed to smoke. After complete drying, the smoked fish are ground with the help of a grinder or *Gaiyl-Chekai* (a traditional, wooden and manually operated grinder) to a powdery form. This fish powder is then stored in air tight container and kept in a dry place. The product has a long shelf-life.

***Smoked fish products of Manipur*:** Amongst the NE states, Manipur is famous for different variety of smoked fish. *Ngamu-leirou* (smoked *channa* fish), *Ukabi-leirou* (smoked *Anabus* fish), *Nga-phak* (smoked common carp in butterfly style), *Pengba-ayaiba* (smoked *Pengba*), *Ngapai-ayiba* (smoked *Notopterus* fish), *Khazing-ayiba* (smoked prawn) etc. (personal communication). These products are traditionally prepared by the tribes of Manipur in their household. The traditional process adopted in Manipur is different from the smoking adopted world over.

Pengba-ayaiba

Ngamu-leirou

Smoked *Glossogobius* sp.

Smoked *A. mola*

The fishes (salted/unsalted) after washing are spread over a wire mesh tray and then exposed to flame briefly to burn the skin. This is repeated by turning the fishes upside down till the characteristic golden brown colour develops. Fishes are smoked by exposing to smoke generated from burning wood or saw dust and paddy husk from a distance of 30 cm below for 2 to 3 hrs at 70 to 80°C. The smoked products are then spread on a bamboo mat and dried under sunlight so as to reduce moisture content before storing. In case of larger size fishes, these are split open along the vertebral column and then smoked. The end product is packed in split bamboo baskets and the baskets are generally hung from above the chimney in traditional household to keep them dried. The shelf life of such products ranged from 4 to 5 months at normal temperature.

***Kharang* and *Khyrwong / KhaPyndong*:** *Kharang* and *Khyrwong/KhaPyndong* are very age old traditional technology of processing fish and are still practiced by the villagers of Umladkur and Thangbuli villages of Jaintia hills district of Meghalaya (personal communication). These are indigenous smoked fish products and several dishes like curry, chutney etc. are prepared out of these products. Usually, the fish of bigger variety like Chocolate Mahseer (*Acrossocheilus hexagonalepis*), Rohu, Mrigal, Grass carp etc. are preferably used for production of *Kharang* and *Khyrwong / Khapyndong*. A special type of small hut or smoke house is required with muddy floor, grass covered roof and a traditional furnace in the centre of the room. Wooden frames are fitted surrounding the furnace in such a way that flame can flow through the centre of the frame. Fish are first washed properly and only viscera are removed by cutting the belly upside down. When bigger fish of size range 500g to 1.0 kg above is used, the product is known as *Kharang* and in case of smaller size (less than 500g)

fish, the product is called as *Khyrwong / Khapyndong*. Dressed fish are washed thoroughly with plenty of water, one fish in case of *Kharang* and two fish at a time in case of *Khyrwong / Khapyndong* are pierced by bamboo sticks. The bamboo stick is pushed through the mouth of the fish through the belly up to the caudal peduncle region. Only 1-2 inch portion of the stick remains protruded outside the mouth cavity to facilitate keeping the fish in the wooden frame during smoking. The fishes are arranged in the wooden frame and smoking process starts by burning wood in the furnace. Bigger fish (*Kharang*) are arranged near the flame. Fish are placed with upside down in such a way that the head and belly dries up first, and then gradually rolled-over/turned in the frame by holding the protruded bamboo sticks for uniform smoking and drying until the product turns into brown colour. The product is now ready for marketing and different items are traditionally prepared from this smoked fish, such as soup, curry, chutney, fish balls etc.

Processing of fish for value added products

In addition to preservation, fish can be processed into a wide array of products to increase their economic value and allow the producer to reap the full benefits of their aquatic resources. Value addition means any additional activity such as addition of ingredients or processes (icing, freezing, drying, smoking etc.) that make them more attractive to the buyer and finally change the nature of a product thus adding to its value at the time of sale. Value can be added to fish and fishery products ranging from live fish and shell fish to ready to serve convenience products according to the requirement of different markets. Besides, value addition also make the fish more convenient and ready to use, with enhanced appeal and attraction. In addition, value processes generate further employment and hard currency earnings. This is more important nowadays because of societal changes that have led to the development of outdoor catering, convenience products and food services requiring fish products ready to eat or requiring little preparation before serving. However, despite the availability of technology, careful consideration should be given to the economic feasibility aspects, including distribution, marketing, quality assurance and trade barriers, before embarking on a value addition fish process.

In the Northeast, more than ninety eight percent of the population is fish eater. NEI is a good market of fish and fishery products. The people have become more selective in their food choices and such preferences are the result of changes in work cultures and life styles, availability of disposable income and lack of leisure for house hold work. Preparation and marketing of value added fish products can play a significant role in the income generation of unemployed youth. Unemployed rural women can improve their socio-economic condition by involving themselves in the production and marketing of value added fish products. At present there are number of government financing agencies (DRDA, FFDA etc.) besides nationalized banks those who are ready to finance such commercial ventures. There are number of Self-Help Groups (S.H.Gs) existing in the NEI States, some of them may be encouraged for production and marketing of value added fish products.Recently, food processing and value addition is becoming the focusing point of the Government of India. The following value added fish products have gained popularity in the Indian markets:

- Fish steak
- Fish fillet
- Fish soup powder
- Fish pickle
- Prawn pickle
- Fish cutlet
- Fish ball
- Fish finger
- Fish sandwich
- Fish momo
- Fish papad
- Fish noodles
- Fish samosa
- Fish pakora
- Fish burger

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- Fish paste products like, Kamaboko, Sausages, Surimietc

Some value added fish products in the context of Northeast

Usually, the fishes which are less preferred and fetch comparatively low price in fresh condition, viz. silver carp, grass carp, big head carp, pangas etc. are preferentially utilized for preparation of value added fish products (Su. Some value added fish products which are very easy to prepare are discussed here.


Fish Fingers

***Fish fingers*:** The mince is frozen in the form of rectangular slabs. The slabs are sawn into thin fingers and battered and breaded. They are then flash fried for 20 seconds. Alternately, fish fingers are made out of frozen compact slabs of fish fillets also.

***Fish cutlets*:** Fish cutlets are prepared using cooked fish mince, which is mixed with cooked potato, fried onion and species etc. It is then formed into the desired shape, each weighing approx. 40 g. The formed cutlets are battered, breaded and flash fried for 20 seconds.


Fish Cutlets

***Fish balls*:** Fish balls are prepared using minced fish mixed with cornstarch salt and spices and formed into balls, 2-3 cm in diameter and cooked in boiling brine for 8-10 minutes. The balls can be further processed as a coated product by pre-dusting, battering and breading or as a heat processed product in a suitable fluid medium.


Fish Balls

***Fish sausage*:**Fish sausage is an analogue of sausage made from pork. The main ingredient is surimi or ground fish meat. The surimi is mixed with salt (3-4%), sugar (2-3%), sodium glutamate (0.3%) starch, and soy protein in a silent cutter. At the end of mixing, lard or shortening (5-10%), polyphosphate (0.2-0.3%) and flavourings are added and the minced meat is placed in a casing tube made from vinylidine chloride. Stuffing is done by an automatic screw stuffer. The casing tube is closed by metal rings. The tube is heated in hot water at 85-90°C for 40-60 min. After heating, it is cooled down slowly to avoid shrinking of the tube and then stored at refrigerated temperature.


Fish Sausage

Fish pickle / prawn pickle: Any variety of medium or large sized fish preferably with less bone can be used for preparation of fish pickle. Small variety of fish such as ‘aonaiya’, ‘maka’, ‘gutum’ etc. can also be used. Although, at present prawn is costly in NE states, but medium size prawn can be used for preparation of prawn pickle. Pickle


Fish Pickle

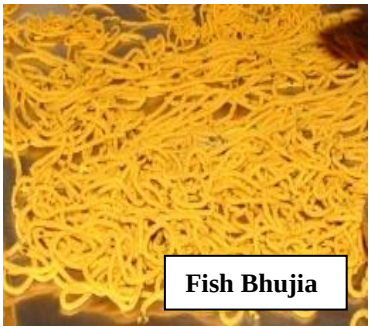
can be packed in poly-pouch or glass container and shelf-life is about 5-6 months at room temperature.

***Fish samosa / Fish pakora/Fish sandwich*:** Usually boiled fish meat from any variety of fish is used. These fetch a good demand when served with tomato sauce and salad.

More value added fish product

Training of preparation of smoked/fermented fish products/value added fish products

Dept. of Fish Processing Technology, College of Fisheries (CAU), Lembucherra, Tripura organize short-term training programmes for line department personnel and unemployed youths (sponsored programmes) to develop skill and entrepreneurship in this field. Contact details for any technical queries and training: Dr. R. K. Majumdar, Head of the Dept. (FPTE), Mobile:+91-9862441057, e-mail: drrkmcof@gmail.com



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Two specialized products developed in College of Fisheries (CAU), Lembucherra, Tripura

***Extruded fish based snacks*:** Prepared from a blend of fish with rice/corn/soya etc. through the process of extrusion. Very popular ready to eat snacks. The product is nutritionally superior than the available snacks like 'Kurkure' etc. extruded products because it contains fish proteins and lipids in addition to simply cereals.

***Shelf-stable 'Ready to serve' fish/prawn curry in pouch*:** 'Ready to serve' fish/prawn/ traditional fermented fish curry as per Northeast Indian style has been developed and ready to



launch in the market. Shelf –life of such product at room temperature is more than one year.



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Development of Small scale fish Producers in NE Region States: Role of low cost Processing and Packaging Technologies

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Abstract

The need for Processing and Packaging of freshwater fish and technologies available with ICAR-CIFT in chilling of fish, vacuum packaging of fish, Modified Atmospheric Packaging (MAP), Active Packaging, Sous-vide processed products, Frozen fish products, development of Coated Fish Products, Mince, Surimi and related products, Retort Pouch Processing, Cured Dried & Smoked fish products were given brief account. CIFT has developed different models of solar driers for drying of fish and community fish smoking kilns popularly known as COFISKI for smoke curing of fish. Different models of COFISKI were installed in all 8 NE Region States. CIFT has worked on the production of extruded products by incorporating fish mince with cereal flours. CIFT also developed technologies such as absorbable surgical sutures with gut of carps, isinglass with airbladders of fish give fish maws for producing pure fish collagens that find application in producing artificial skin after impregnation with haemostatic agents like chitosan. These membranes find use in treatment of burns and in dentistry. Post harvest handling & prospects for value addition of Pangasius namely the reason why Pangasius is preferred, gutted fish, Steaks and fillets were given brief account. In *toto* in this paper, technologies available for proper processing and packaging of fish, equipment required to start fish processing facility and business and planning for development of entrepreneurial skills among small scale fish producers of NE Region States was given in nutshell

Introduction

Fisheries sector plays a focal role in the economy of the country apart from acting as a sole source of employment for millions of people. In India, fisheries sector has evolved from a subsistence traditional activity to a well-organized commercial and diversified enterprise. According to FAO, out of 38 million fishermen population nearly 69% are classified as small-scale fish farmers. In India, around 70, 90, 95 and 100% of fishermen in marine fisheries, shrimp aquaculture, coastal aquaculture and inland aquaculture belongs to small-scale fishermen community. Although the small-scale fish farmers constitute a major percentage of fisher population, their economic status is still not very good. This observation holds valid for NE Region fishers too. There are many reasons for this condition that included post-harvest quality losses due to poor infrastructure and lack of storage and transportation, involvement of multiple middlemen in the trade and poor adoption of various preservation methodologies. Adopting good handling practices and applying low cost processing and packaging solutions by fisher population can lead to better profit realization. At present, small-scale fishers involve in processing activities such as open sun drying and curing in very small scale units. Nearly 100% of fish caught by small-scale fishers are sold to various agents without any further processing. There is a growing demand for variety of fish products from distant markets due to their health benefits. There are many ways to increase the margin of profitability by small-scale fishers. The first and foremost important task is to maintain proper quality of harvested catch employing ice and storing fish in good storage facilities which minimized the post-harvest loss as well pressure on the fishing activity. The landing centre should have minimum facilities like clean water, sufficient ice, refrigerated vehicles and manpower for hygienic handling. By adopting these simple low cost icing practices, the keeping quality of fish can be extended to 10 – 17 days depending on the fish species. The traditional unhygienic drying practices can be minimized by adopting drying on the platform made of locally available materials which minimized the cost. Apart from these, solar drying

with or without energy back-up can be adopted which improves the quality. There is also a great demand for diversified ready to serve and ready-to-eat products in both domestic and export markets. Fish and shell fishes in live, fresh chilled, whole cleaned, fillets steaks, battered and breaded products, variety of dried products, smoked fish, fish sausage and traditional products are the range of low cost processing methods which can be readily adopted by small-scale fishers of NE Region States (Ravishankar, 2015).

Why Processing and Packaging:

Attractive packaging and advertising are also important which determine the success of any diversified new product. Technology developments in fish processing offer scope for innovation, increase in productivity, increase in shelf life, improve food safety and reduce waste during processing operations. A large number of value added and diversified products for export and internal market based on fish, shrimp, lobster, squid, cuttlefish, bivalves etc. have been developed. Fishery by-products with industrial & nutraceutical applications command premium prices. Attention to be given for inland resources & aquaculture for increasing fish production as marine catches are dwindling. Freshwater fishes at present are mostly consumed in fresh condition. Increased production will naturally necessitate better and cost effective technologies for the preservation and processing. There is very good scope for developing modern post-harvest technologies for inland fish.

1. Chilling of fish:

Chilled fish products viz., whole fish , gutted fish, steaks, condiment incorporated ready to cook items etc. have great demand in the urban markets .However these products have to be prepared from prime quality raw materials and the shelf life is very limited.

Up to 35% yield of high value products can be expected from fish processed within 5 days of storage in ice, after which a progressive decrease in the utility was observed with increase in storage days.

Fig1: Fish and Prawns in chilled condition

2. Vacuum Packaging of Fish

I. Vacuum packaging is used for extending the shelf life of fish and Shell fishes in chilled storage condition

II. This reduces the oxygen content in the package there by reduces the oxidative changes as well as the growth of aerobic microorganisms.

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Vacuum Packaging of Fish Products

3. Modified Atmospheric Packaging (MAP):

I. Modified atmospheric packaging is a process by which the shelf life of fish is increased by enclosing it in an altered atmosphere such that it slows down the degradation by microorganisms and development of oxidative rancidity

II. In practice fish/fish products are packed in an atmosphere of carbon dioxide and other gases like oxygen and nitrogen

III. MAP chilled fish is an attractive proposition both to the retailer and to the consumer

IV. MAP chilled fish has an extended shelf life of 10 days or more depending on the species.

Modified Atmospheric Packaging of fish fillets

4. Active Packaging

I. Incorporation of certain additives into packaging systems to alter the packaging atmosphere and to maintain it throughout the storage period with the aim of maintaining or extending product quality and shelf-life .

II. Scavenging systems (O_2, CO_2, H_2O, ethylene, taints)

III. Releasing systems (CO_2, H_2O, antimicrobials, antioxidants)

Active Packaging of fish

5. Sous-vide processed products

I. *Sous vide* (meaning, 'under vacuum') cooking is defined as cooking of raw materials under controlled conditions of temperature and time inside heat-stable pouches under vacuum, followed by rapid chilling.

II. *Sous vide* processing improves quality and shelf life fish products compared to air pack & vacuum packs.

Sous-vide processed products

6. Frozen fish products

I. Many varieties of fresh water fishes like rainbow trout, pangasius, shell fishes, catla, rohu, tilapia fillets can be frozen for domestic market and export to developed countries in block frozen and IQF forms.

II. Individually quick frozen (IQF) products fetch better price than conventional block frozen products. However, for the production of IQF products raw-materials of very high quality needs to be used.

III. The products have to be packed in attractive moisture-proof containers and stored at -30°C or below without fluctuation in storage temperature.

IV. Thermoform moulded trays have become accepted containers for IQF products in western countries.

Frozen fish products

7. Coated Fish Products

I. Coated products are also known as battered & breaded products. The process of coating with batter and breadcrumbs increases the bulk of the product thereby reducing the cost element.

II. As a convention 50% fish portion is expected in any coated product. Fish fingers, fish portions, fish cakes etc. are the staple breaded seafood lines, while breaded shrimp, lobster, oyster, scallops etc. cater to a luxury market and are widely used in restaurant trade.

III. The production of battered and breaded fish products in most cases involves seven steps- portioning/forming, pre-dusting, battering, breading, pre-frying, freezing and, packaging and cold storage.

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Coated Fish Products

8. Mince, surimi and related products

I. Though the preparation of minced fish from fresh water fishes is not a problem the preparation of surimi poses many problems.

II. The wash water temperature, rate of agitation and number of washing cycles have to be carefully monitored to get a good quality surimi.

III. Characteristic muddy flavour of the meat could be minimized by employing a leaching technique of low volume exchange of chilled water.

IV.

Mince, surimi and related products

Rohu curry in TFS cans

Smoked trout steaks in TFS cans

9. Retort Pouch Processing

I. Retortable flexible containers are laminate structures that are thermally processed like a can, are shelf stable and have the convenience of keeping at room temperature for a period of more than one year without refrigeration.

II. The most common form of pouch consists of a 3 ply laminated material. Generally it is polyester / aluminium foil / cast polypropylene.

III. The flexible pouches manufactured indigenously employing the configuration recommended by CIFT has opened the way for commercialization of fish curry in retortable pouches.

Fish curry in retortable pouches

10. Cured Dried & Smoked Fish Products

I. More than 10,000 tons of smoked fish produced from miscellaneous varieties of inland fishes are sold in NEH regions. More than this quantity is processed by salting & drying.

II. However the quality of the products in market is very poor.

III. CIFT has developed different models of low cost dryers, solar dryers with backup systems suitable for inland regions for the production of quality dry fish.

IV. The Institute has developed Community fish smoking kilns for hygienic preparation of smoked fish which have been installed in NEH states.

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Solar Fish Drier

Solar dryer with alternate energy backup is designed and developed to dry fish, fish products and other agro-products

A 250kg capacity solar fish dryer with LPG alternate back up heating system was installed and commissioned at ICAR Research Complex for NEH Region at Imphal

Designed and developed a Renewable Energy Solar Biomass Hybrid Dryer for eco-friendly and hygienic drying and preservation of fish and agricultural produce

While developing the technologies base was synthesis wherein research leads to the creation of something as compared to research that is analysis of a phenomenon or how something works. In this particular presentation it refers to design, fabrication and installation of different models of "community fish smoking kilns" popularly known as COFISKI for production better quality smoke cured fish, with longer shelf life catering the animal protein requirements of people residing in hinterlands of NE Region states at an

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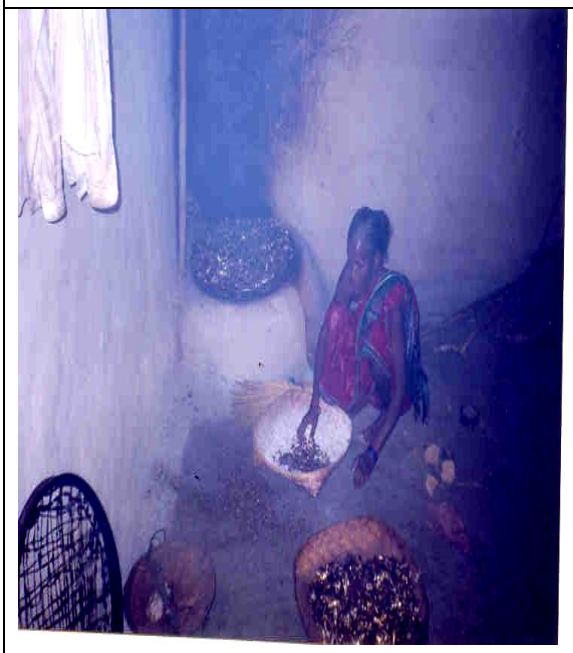
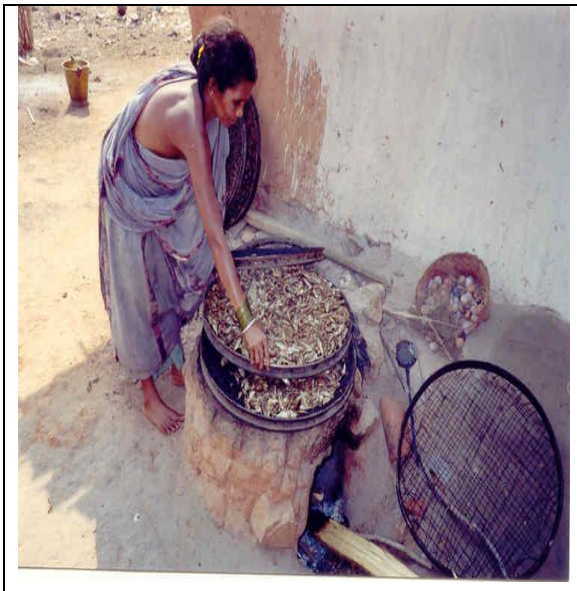
affordable rate especially for economically under-privileged groups, generating sustainable income to the small scale fishers. Different models of COFISKI were designed taking into consideration of ergonomics of the women fishers, free from health hazards while in operation, eco-friendly green kilns that utilize less energy for processing of smoke cured fish (Prasad, 2014)

Comparison of traditional and scientific smoke curing of fish	
	
Hazardous conditions in traditional fish smoke curing of fish	**Smoke cured fish from COFISKI**
Comparison of Quality of Smoke curing of Fish by Traditional & scientific hygienic-conditions	



Traditional smoke curing of fish

Smoke cured fish from COFISKI

Fig. 4.5: A COFISKI ready for inauguration in Komlakhong (Imphal, Manipur)

Fig. 4.6: A Domestic Fish Smoking Kiln (DOFISKI) with fish for smoking

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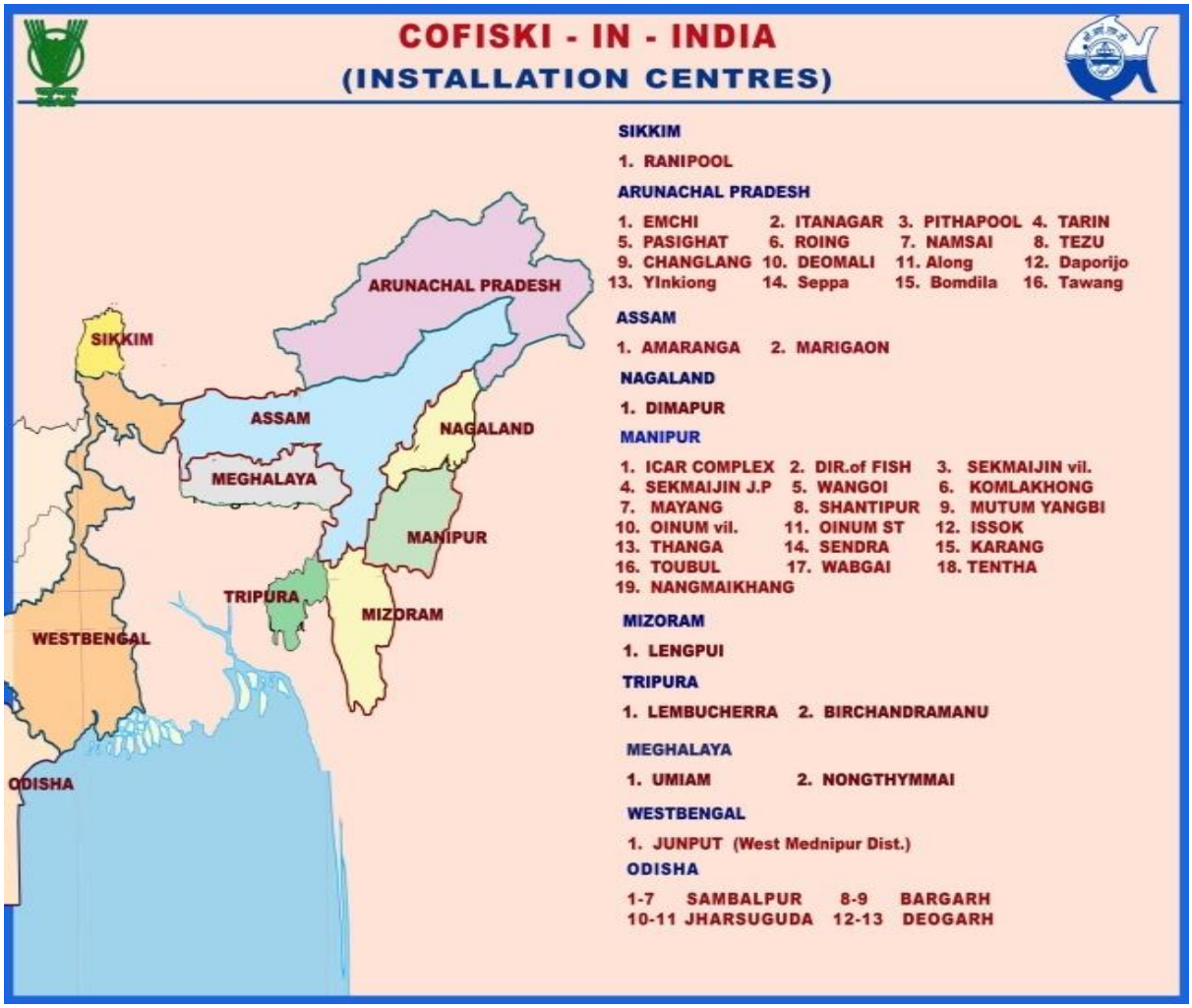
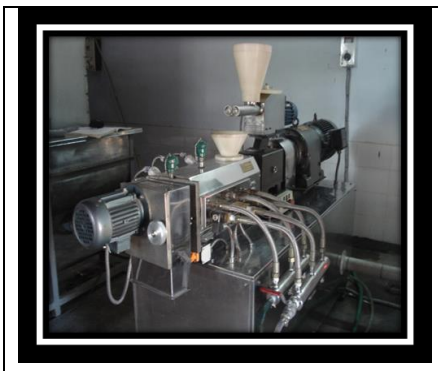


11. Fish mince based Extruded Products

I. CIFT has worked on the production of extruded products by incorporating fish mince with cereal flours.

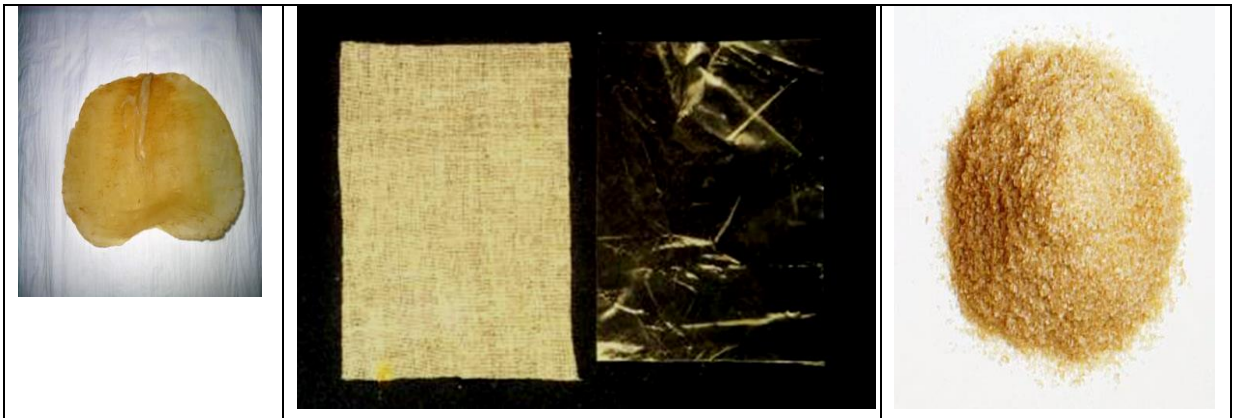
II. The fish mince is mixed with cereal flours, spices and vegetable oil and extruded using a twin-screw extruded. The product obtained is finally coated with spice mix to provide a delicious snack that has been christened as “Fish Kure”.



Fish mince based Extruded Products

12. Byproducts

I. Gut of carps can be used to produce absorbable surgical sutures
II. Airbladders of fish give fish maws for producing isinglass
III. Pure fish collagens find application in producing artificial skin after impregnation with haemostatic agents like chitosan.
IV. These membranes find use in treatment of burns and in dentistry.



Fish Byproducts

13. Gelatin from Carp Skin

I. Gelatins from the skins carps were found to have a mild but easily perceivable odour, had a snowy white appearance and were light-textured.
II. Gelatin was extracted from the skin of fresh water by pretreatment with mild alkali and acid solutions followed by extraction with water at 50-60 0 C.
III. The maximum yield of Gelatin was observed for Rohu (12.9%) followed by Common carp (12%) and Grass carp (10.5%) skins.

Gelatin from Carp Skin

Post harvest handling & prospects for value addition of Pangasius:

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Why Pangasius?

I. Pangasius is widely cultured in the inland fish culture sector of India, particularly in the state of Andhra Pradesh
II. Frozen catfish fillets popularly known as “Basa” form the mainstay of export of fishery products from Vietnam to U.S and Europe.
III. In Andhra Pradesh and at present about 32,000 Ha is under Pangasius culture mainly in the districts of Krishna, West Godavari, East Godavari, Guntur and Nellore.
IV. The fish has a remarkable growth rate (almost one Kg in 90 days) which makes it a preferred candidate for culture.
V. Pangasius meat has high nutritional qualities and excellent sensory properties.
VI. The fish can easily be filleted due to the absence of intramuscular pin bones.

Pangasius fillets are preferred choice for a wide range of products due to:

- Tender flesh
- Sweet taste
- Absence of fishy odour
- No spines
- No small bones
- No skin
- Delicate flavour
- Firm texture when cooked

- The shelf life of Pangasius is influenced by preservation and handling practices.
- Care has to be taken to avoid cut or bruises on the surface of fish during handling.
- To reduce the bacterial spoilage, fish should be washed and iced immediately after harvesting.
- The bigger sized samples (5Kg up) contain significant quantity of subcutaneous fat and high collagen content in the meat.
- Medium sized specimens (2Kg) are found to be suitable for product development.
- For better preservation, the fish should be gutted; gills removed, washed thoroughly and packed in ice.
- Bleeding the fish immediately after the catch significantly improved the quality and colour of meat.

Gutted fish

- Shelf life of the fish can be extended by gutting and evisceration.
- Studies conducted at CIFT have shown that gutted fish remained in acceptable condition up to 24 days in ice.
- Sensory evaluation revealed that gutted fish retained high quality compared to whole fish at the same conditions of storage.

Steaks and fillets

- The most common form of ready to cook product of fish is steaks and fillets.
- The whole fish has to be gutted and the gutted fish can be cut into steaks of 1-2 cm thickness.
- Fillets are prepared as skin on and skinless from the whole fish.

  Studies carried out in CIFT have shown that Pangasius steaks had a shelf life of 14 to17 days in chilled conditions.

Steaks and fillets

Smoked portions

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- Fish portions cold blanched in 10% brine and hot smoked at 60^0 C for two hrs.
- Shelf life - 4 weeks in chilled storage

Fish Orbs

- Fish mince was thoroughly mixed with salt, corn starch and spices.
- It was made into orbs of 2-3 cm in diameter and cooked in boiling water for 5-10 minutes.
- The cooked orb after cooling were battered & breaded and flash fried
- Shelf life – 2 weeks in chilled storage

Fish fingers

- Prepared from the skinless fillets / portions of meat
- The meat cut in the size of 8 X 2 X ¾ cm are cold blanched in 2% salt solution for 10 minutes, drained and coated with batter and breadcrumbs
- Shelf life – 2 weeks in chilled storage

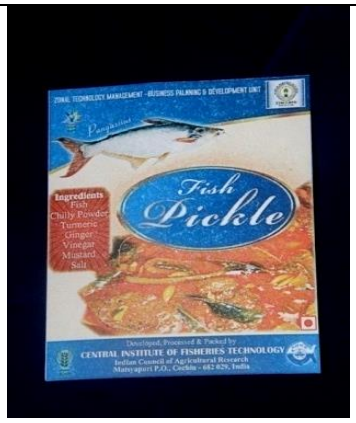
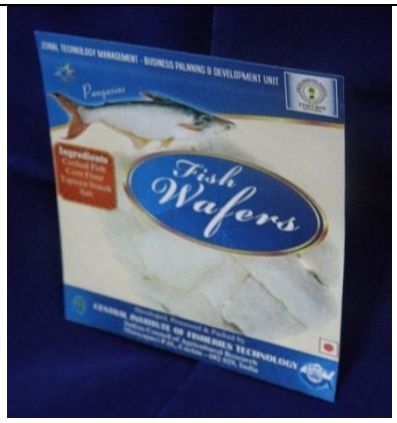
Smoked portions

Fish Orbs

Fish Fingers

Fish pickle

- Fish meat is cut in to small pieces and mixed with 3% salt and sun dried for two hours.
- The semidried meat pieces are then deep fried in gingelly oil and mixed with other fried ingredients.
- After cooling, sufficient quantity of vinegar is added, salt adjusted and kept at least for two days for proper mixing of ingredients and adjustment of pH.
- The pickle is then packed in airtight containers / stand-in pouches for consumer use. Besides the above mentioned products, a variety of other value added items can be prepared from the species viz., ready to eat products like fish curry in retort pouches, canned products, frozen curry in tray packs etc. For products like cutlets and wafers, the meat attached to the filleting frames can be separated after cooking and can be utilized.

		
Fish products developed at CIFT		

Machinery employed in processing of freshwater fish: The machinary used in fish processing, their,capacity, cost and representative figures are prtovided in Table 1.

Table 1. Machinery employed in processing of freshwater fish

S.No	Description of the item	Generl use	Cost in rupees	Representative picture
1	Fish Scaling machine	Hand Held Machine Ideal for Carps	100,000	
2	Fish Filleting machine	Capacity-60 fish/minute	500,000	

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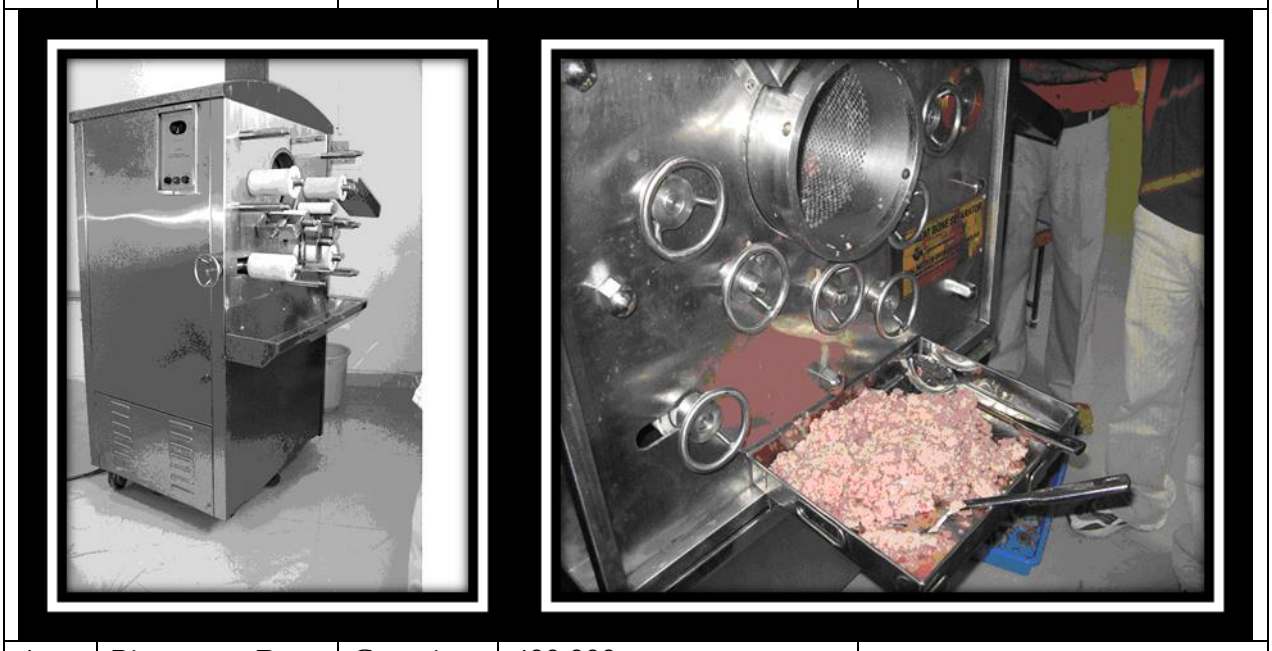
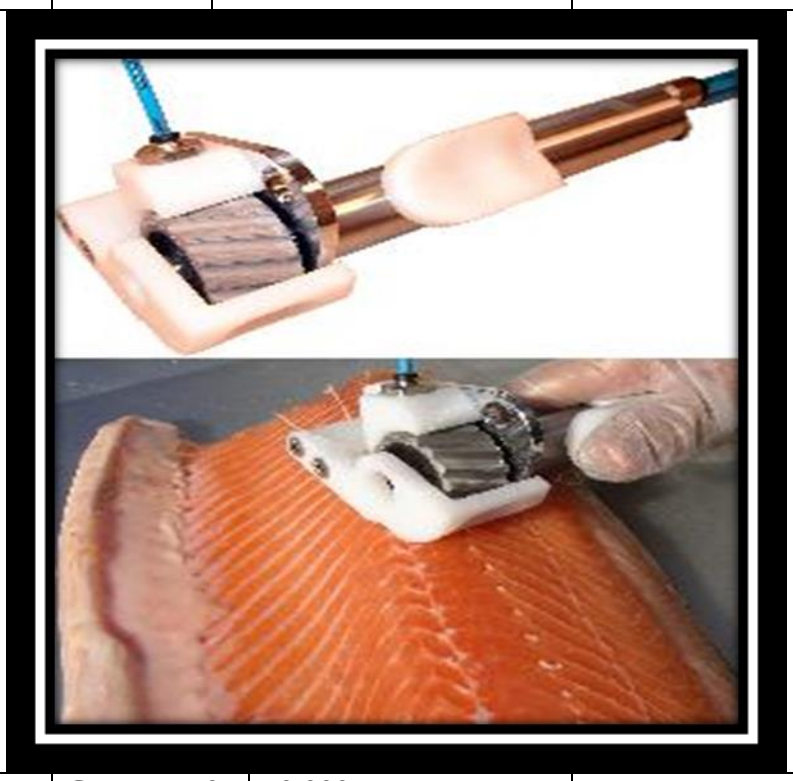
3	Meat bone separator	Capacity: 100 kg/hr	300,000 to 400,000	
				
4	Pin Bone Remover	Capacity: 10-12 fillets/mi	400,000	

		nute		
				
5	Meat mincer	Capacity:100kg/hr	50,000	
				

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6	Meat dicer	Capacity: 100kg/hr	75,000/-	
7	Bowl chopper	Capacity: 300 Kg/hr Volume: 30 L	100,000	
8	Battering and Breading machine	Capacity: 10 kg flour Volume: 30 L	500,000 to 700,000	
9	Forming machine	Capacity: 200 pcs/min Volume: 30 L	200,000	

10	Automatic Orb Forming Machine	Capacity: 230 orbs/minute Volume: 30 L	170,000	
11	Sausage stuffing machine	Capacity: 300 kg/hr	85,000	
12	Air blast Freezer	Capacity: 100 kg	800,000	

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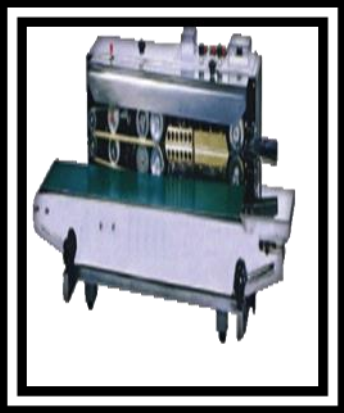
13	Band Saw	Cutting thickness: 4-180 mm	100,000	
14	Fish smoker	Capacity: 100 kg/batch	500,000 to 800,000	
15	Vacuum packaging machine	Sealing Length: 400 mm Seal width: 10 mm Sealing speed: 4 Pcs/min	80,000	
16	Gas Griddle	Temperature range: 50-300 °C	50,000	

17	Eletic Frier	Temperature Range: 50-200°C	45,000	
18	Gas Stove & Oven	Capacity: 10 kg flour Volume: 30 L	40,000	
19	Film Sealing Machine	Seal width: 6-15 mm Temperature range: 0-300°C	100,000	

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20	Flake ice machine	Capacity: 100 kg/day	500,000	
21	Mixer	Capacity: 10 kg flour Volume: 30 L	100,000	
22	Cold Store	Capacity: 10 tons	10,00,000	

Zonal Technology Management – Business Planning & Development unit:

I. The ZTM-BPD Unit is a business incubation drive designed for the Indian agricultural sector to promote agripreneurs with the help of the vast R&D facilities and knowledge available with ICAR.

II. In south zone, this unit is at the Central institute of Fisheries Technology, Cochin.

Objectives

A. Commercializing technologies developed at CIFT and member institutes.

B. Helping entrepreneurs to commercialize business ideas utilizing the R&D back up of the institutes, with special emphasis to women entrepreneurs.

C. Providing pilot level production facilities in fisheries to entrepreneurs for test marketing.

D. Imparting training for creating prospective entrepreneurs and value added manpower.

E. Creating technology-clinics to help existing businesses**.**

Process of Business Incubation

- Direct incubation of entrepreneurs in the first phase at CIFT
- Virtual incubation of off campus first generation entrepreneurs; and established entrepreneurs who want to start new enterprises or increase efficiency of existing ventures
- Virtual incubation of micro business ventures in a corporate environment with special emphasis to marginal farmers.

Services Offered:

I. Market Research
II. Net Working
III. Training
IV. Membership
V. Business Plan
VI. Seed Capital
VII. Market Testing

Conclusion:

All in all in this paper, technologies available for proper processing and packaging of fish, equipment required to start fish processing facility and business and planning for development of entrepreneurial skills among small scale fish producers of NE Region States was given in nutshell. ICAR-CIFT is actively and pragmatically involved in all eight NE Region States for the last one and half decades. What is in anvil further is establishment of Mini-Fish Processing Facilities and the three states have already been identified and the work is in progress. There are so many other programs too that are chalked out for all NE Region states.

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Hill Fishery Aquaculture and Conservation of golden mahseer through Angling tourism

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Abstract

The diverse habitats of north east region harbor more than 35 percent of the total freshwater fishes of India. Moreover, the hill fishery resources of the region are still not explored properly. As such, the region's hill fisheries resources are not developing as per the rest of the country which needs to be understood before the degradation to threshold limit. Lack of scientific interventions, virgin and terrible topography, shortage of skilled human resources etc. are attributed for this. The hill fishery resources are declining rapidly with the growing time due to habitat loss, alteration, siltation, and deforestation, prevention of natural river flow, and climate change couple with lack of scientific technological intervention. Keeping all these in view, some candidate species suitable for hill fishery aqua culture is suggested. The first successful breeding of Silghoria (Labeo pangusia) and Nepura (Labeo dero) are also highlighted is the present communication. The efforts of establishing the first ever flow through golden mahseer hatchery and brood bank for entire northern India for propagation of mahseer has also been discussed. At last, angling tourism as a conservation tool for the sport fish, golden mahseer has been explored with experiences from North East and measures to develop the sector has been proposed.

Key words: Hill fishery, golden mahseer, angling, candidate species, flow though hatchery.

Introduction

North East Region of India comprise of eight states with an approximate geographical area of 2.55 lakh sq. km which is about 7.76 percent of India's total landmass with diversified natural resources. This region falls under part of Eastern Himalayan zone characterized by varied agro climatic and geographical speciation in terms of topography, temperature, rainfall and soil. All types of physical formations from alluvial plains to tableland, low hills to high mountains and fertile valleys are found in this zone. The altitudinal differences coupled with physiographical conditions, the climatic variations and rainfall have segregated into tropical, subtropical and temperate areas of the region. The eco climatic condition of the region varies from sub-tropical evergreen region to the subzero alpine condition with huge diversified plants and animal aboding this region making it one of the seventeenth biodiversity hotspots in the world. The different topographical conditions ranging from flood plains of Brahmaputra and Barak valley in Assam, the upland flats of Manipur valley, rest of the region mainly comprises of hills and mountains which forms more than 65 percent of its territory.

This region has more than 35 percent of nation's total freshwater including glacial streams, rivers, beels and reservoirs. The eco climatic zone in this region of fresh water fisheries ranges from warm water drainage system to subzero temperate condition. This results vast and varied fisheries resource abounds in the form of rivers, lakes, wetlands, reservoirs and vast flood plains giving the scope for a huge diversity of fish germplasm. The hill fisheries resources and cold water fisheries are mostly concentrated in the rivers, lakes, reservoirs in the uplands of Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Mizoram, Sikkim, foothills of Assam and parts of Tripura. The major notable rivers (56 in numbers) run 62289

ha and low lying paddy cum fish culture system 2780 ha up to 20050 kms, reservoirs 23792 ha, lakes and swamps 143740 ha, ponds and mini barrages. The riverine fishery plays the crucial role as it harbors most of the natural fish species thriving in the region.

This region possesses about 33.75 percent of total fresh water fishes of India (Borah and Bania, 2014). Among the 2844 number of fish species of India availability of 296 fish species belonging to 110 genera under 35 families are reported from North East India (Vishwanath et al., 2007) reported. Assam being the center, possesses largest number of fish species (216) (Bhattacharyya et al., 2001), followed by Arunachal Pradesh (213) (Bagra et al, 2009), Meghalaya (165), Tripura (134), Manipur (121), Nagaland (68), Mizoram (48) and Sikkim (38) species has been identified so far.

Some potential candidate species for hill aquaculture

A good number of fishes are available in the hill aqua resources. Still depending upon the demand and considering the suitability for production purpose, some of species has been suggested for commercial culture which is expected to cover the market very easily with high return. This are-

Labeo pangusia

The high valued minor carp, Labeo pangusia (Hamilton) locally known as Silghoria belongs to the cyprinidae group with a wide distribution in the entire Himalayan region (India, Pakistan, Nepal, Bangladesh and Myanmar). This species commonly known as the rohu of the hilly region prefers the deeper pools of upland rivers and streams with sand and boulder type bed as that of mahseer. The fish grows fairly big size (about 65cm) and highly tasty. Because of this the fish is highly preferred and rampantly caught which ultimately results with the depletion of this species in the wild stock. IUCN has categorized this endemic species as near threatened which calls for much conservation effort to sustain in its natural abode.

The species attains table size (approx. 25cm) by the end of first year of age (Biswas, 1982). The maturity of L. pangusia starts from April onwards. Both the male and female attains maturity at 2nd year of life at 25-30cm length (Biswas, 2010). Spawning is reported from last part of May with the onset of monsoon rain which extends up to August. As far as feeding habit is concerned, it is detriphagus in nature and hence mostly depends on the periphyton and detritus of the river bed.

The culture of *L. pangusia* in the upland ponds of Assam and North East as well is not common due to lack of seedlings. As such, a trial has been carried out at Nameri Eco Camp, Patasali, Tezpur, Assam under the leadership of the author to breed the fish in captivity with synthetic hormones with the brood stock collected from River Subansiri and reared for couple of years in well aerated controlled ponds. The trial is successful in July, 2015 with production of more than 4 lakh spawns which created the record for 1st time successful breeding of the endemic species.

Labeo dero

The cyprinid, Labeo dero (Hamilton) or Bangana dero (Hamilton), another candidate species for culture fishery is highly priced as food fish. It has wide distribution in River Brahmaputra and its tributaries, Himalayan foot hills in India, Nepal, and China even in Bangladesh. Labeo dero is an important food and game fish. This minor carp of north eastern India is characterized by the presence of a groove along the snout, the snout being often covered by pores; the anterior dorsal convexity changes gradually to a concave profile, giving it an elegant slender appearance (Vishwanath, 2010). Its flesh is well flavored and highly esteemed as food. It attains a length of about 75 cm and can readily be caught with cast-nets.

Data on reproduction biology of *Labeo dero* is very rare due lack of study. The species prefers to inhabit in torrential hill-streams in shallow waters. Adults are reported to migrate to warmer regions of lakes and streams during winter. Since the fish is a torrential hill stream species, rapid decline in these habitats, dams and other human activities are the possible threats. IUCN has categorized this species as least concerned. Still, investigation is needed to determine whether or not this species is experiencing a decline, or is undergoing natural population fluctuations.

The first report of captive breeding of this species in Assam too is by the author at the fish farm of Nameri Eco Camp, Tezpur. The first successful breeding was in the first part of July, 2015 which opens up the hope for restoration of the species in its habitat through commercial cultivation of the same in upland ponds.

Semiplotus semiplotus

The Assamese king fish (Raja mach), *Semiplotus semiplotus* belongs to cyprinidae family which is highly restricted to the Brahmaputra drainage in Nepal and North East India. It is mandatory to mention that this prized vulnerable species of eastern Himalaya is endemic to the region. This vulnerable species groups up to the maximum length of 20cm. The species prefers the habitat with well vegetation, adequate covers and refuges with boulder substratum where water temperature varies from 14.27 to 25.78oC and possesses adequate dissolved oxygen. Semiplotus is herbivorous in nature and prefers plankton. Sexes can be identified with morphological observation. The length of firth maturity varies from 151-160mm in case of male whereas 146.22-151.51mm in case of female (Bagra, 2012).

Tor putitora

The cyprinid, Golden Mahseer (*Tor putitora*) is the most demanded sport fish among all groups of anglers. The species is distributed all along the Himalayas, Assam, J&K, Sikkim, Uttarakhand, H.P., Afghanistan, Bangladesh, China, Myanmar, Nepal and Pakistan. This species has an oblong compressed body covered with large cycloid scales having golden orange tinge. Body greenish dorsally, light pink laterally, silvery white ventrally. Tip of caudal fin is orange in colour. The fish remains omnivorous during larval stage, carnivorous during juvenile stage and herbivorous during adult stage. It mainly feeds on filamentous algae, insect larvae, small molluscs and algal coatings of rocks.

Males grow faster than females in first year and in subsequent years they grow same. In natural condition the fish attains 2.75m in length and 54 kg in weight. The male matures after 2 years whereas the female matures after 3 years of life. As far as breeding is concerned, it breeds basically in riverine condition. But reports have been available for breeding in captivity under pond condition if provided the facility of flow through system. It breeds three times in a year (January to February, May to June and July to October). Fecundity very low, ranges from 3500-8900 nos. ova/kg body weight. Eggs are lemon yellow or brownish golden in colour, 2.5-3.5mm in diameter. It takes 94-136hrs for hatching at 17-24^{0}C.

Neolissochilus hexagonolepis

Another member of the Cyprinid group, *Neolissochilus hexagonolepis* or chocolate mahseer is an important food fish and sport fish as well. It inhabits in streams with fast flowing water mostly in high gradient and low gradient riffles and pools (Menon, 1991). It prefers rocky and boulder areas with high flow. It is distributed in North eastern part of India including Assam, Manipur (Brahmaputra and Chindwin drainages), and Nagaland, Eastern Himalayas, West Bengal, Nepal, Bangladesh, Myanmar and Malaya Archipelago. IUCN has categorized it as near threatened. Chocolate mahseer is a highly prized and esteemed food fish, which can be regarded as a candidate species for hill aquaculture as it breeds in captivity

and reports are available for culture in ponds. The fish grows up to 60cm and weigh around 11kgs. It breeds from April to October with a peak in August to September in pools with running water. The male species is reported to breed at an early size of 9cm.

The species is in threat due to habitat loss, collection of sand and gravels, overexploitation, deforestation and upcoming dams as well. For all these the prized species is in declining in its population. Propagation of the species and ranching in the wild habitat can only enhance the wild population of Chocolate mahseer.

Factors contributing for degradation of hill fisheries

At the present day context, all aquatic environments are experiencing severe threats. The hill fishery resources are also not excluded from these threats. The threats could be anthropogenic or natural or in combination of both of these. The major contributory factors can be summarized as – loss of natural breeding ground, overexploitation of resources, unsustainable fishing, degradation of natural habitat as well as alteration, siltation, mining activities, collection of boulder from river, frequent change in courses of river coupled with regulation of river flow through construction of dams and embankments, loss of rivarian vegetation, invasion of exotic species, impact of climate change, high flood etc. These threats need to be redressed at the earliest to restore the hill fisheries for future generation.

Conservation Initiatives

First ever successful breeding of hill stream fish, Silgharia (Labeo pangusia) and Nepura (Labeo dero) in captivity- A case study

An experimental breeding trial of high valued wild hill stream fish commonly known as Silgharia (Labeo pangusia) and Nepura (Labeo dero) were successfully conducted at Nameri Eco Camp by members of ABACA at Golden Mahseer Hatchery of Eco Camp, Sonitpur district of Assam. The breeding programme was successfully carried out under the aegis of the author. The breeding trial commenced from 21st. June 2015 with subcutaneous infusion of gonadotropin injection and modulating the water level of the tank. In the evening of 11th July, 2015, male and female brooders of both the selected species of 2+ -3+ year age group were selected for breeding depending on their breeding readiness. The recorded length of the fishes varies from 35-50 cm and weigh between 1.3-1.8 kg. The brooders were injected with inducing agent Ovatide @ 0.5ml-1ml/kg body-weight in both male and female brooders. After the injection, the injected fishes were kept in breeding hapas overnight for their courtship and mating. In next day early morning hours i.e. on 12th of July, 2015, fertilized eggs of Labeo dero and Labeo pangusia were striped of the eggs which were mixed with milk of the male fish for the fertilization on breeding trays. Fertilized eggs were than kept in the breeding hapas. The breeding hapas were installed in the cemented cisterns of the golden Mahseer Hatchery brood tank. The fertilized eggs of Labeo dero were transparent white and round in shape. A total of 7, 50,000-8, 00,000 fertilized eggs were recorded during the breeding trial. The water quality parameters recorded during the breeding programme were water temperature: 30oC, pH: 7.5, total hardness: 250-300 ppm, total alkalinity: 200 ppm.

It may be mentioned that this was the first report of breeding of hill stream wild Silgharia and Nepura in artificial condition, reared in cemented brood tank. It may be mentioned that this was a huge step forward towards breeding of wild stocks of different cold water hill fish including Golden Mahseer which missed the flight this time due to vagaries of weather condition.

Establishment of first ever flow through hatchery and brood bank of Golden Mahseer- Initiative of ABACA- A group of Anglers

A group of concerned people had given birth of A(B)ACA in mid-forties of ie 1940 . Since then, the members are hardly working for conservation related issues. Initially, the whole of

north Bank Rivers of Assam were in protection. The promotion of angling was the only means study of river, habitat .fish for conservation. As a part of their conservation effort the first ever flow through hatchery and brood bank of Golden Mahseer was established at Eco Camp, Nameri, Tezpur, Assam under the leadership of Atul Borgohain, Project Director, Golden Mahseer Breeding Project cum Prof and Head, Dept of Extension Education, CVSc, AAU, Khanapara. The project was started in 2009 with partial support from DCFR, Bhimtal. It is a pleasure to mention that more than 50% cost of the project was conceded by the ABACA only. As a result, in 2011 infrastructure development work was started. In the first phase the hatchery unit along with a small cement pond of 35ft x 70ft x 3.5ft size, a laboratory, Chowkider shed (9 ft high, wire fenced) and a Scientist transit camp were commissioned. In second phase, i.e. is in 2012 a comparatively big cemented pond of 25ft x 40ft x 3.5ft size was constructed with flow through system and constant water supply along with a deep bore well capable of supplying 30,000Lt./hour. A 15,000Lt overhead tank has also been constructed for smooth functioning of the Flow through system with sprinkling facility. 2 numbers of aerators have also been installed in the pond to maintain the dissolved oxygen level.

Initially around 300 nos of fingerlings of Golden mahseer collected from the wild habitats of Arunachal Pradesh were stocked in the cemented ponds. Later on addition of around 100 nos of Labeo dero and Labeo pangusia and a few numbers of Chocolate mahseer collected from the wild has been done. Addition has also been made time to time to cover the natural mortality.

The artificial breeding of Tor putitora poses a bigger challenge for the scientist to develop a proper breeding protocol of Golden mahseer in captivity that too rearing them in cement cistern brood tanks. This might require more research strategy and high protein rich natural feed for breeding of Golden Mahseer in captivity. It is mandatory to mention that Dr. S. N. Ogale retired Consultant; Tata Power was the pioneer consultant for the said Mahseer project. Dr. Ogale came to ABACA for the first time in 2006 when he conceived the idea. Since inception, he has been frequently visiting the site and provided the technical guidance.

The system is functioning well. The farm raised brooders are now 40-50 cm in length weighing around 3 kgs. For successful commercial breeding, farm raised brooders are of prime importance as natural collection may result in failure also. The brood stock management protocol of mahseer in upland ponds has already been standardized through the project. Male broods are frequently found in oozing condition.

Conservation of golden Mahseer through angling tourism

World Tourism Organization (WTO) define eco-tourism as “tourism that involves traveling to relatively undisturbed natural areas with specific objects of studying, admiring and enjoying the scenery and it’s wild plants and animals, as well as any existing cultural aspects (both of the past and present) found in the areas”. The essential elements of a successful eco-tourism may be natural environment, optimum numbers of environment friendly visitors, activities not causing serious impact on eco-system and positive involvement of the local community (Borgohain and Bania, 2013a). It differs from mass tourism or resort tourism by having very less impact on the environment and by requiring much less infrastructure development (Borgohain and Bania, 2013b). It not only involves the local community but also ensures sustainable development of the area. Further, it minimizes conflicts between resources of tourism and provide livelihood of the local inhabitants. It should always be taken care that type and scale of tourism development should be compatible with environment and socio-cultural life of the local people. Need not to mention that it brings awareness among the people regarding importance of conservation and preservation of culture and nature as well.

Ecotourism encompasses angling or sport fishing as an important part of it due to its minimum adverse impact on the environment, capacity for retaining the beautiful natural

environment through preserving and protecting the river systems and its surroundings besides helping in the growth of fisheries resources through protection and preservation for its future scope and aspiration of better fishing. When angling tourists reach threatened freshwater ecosystems, where there is a risk of degrading the fishery and landscapes that attracted them, they will definitely think for long-term economic development prospects along with emphasis on reducing biodiversity loss. The emergence of catch and release recreational fishing, it is believed that angling can be legitimately considered a form of ecotourism that contributes positively to conservation, science, and local or regional economic development. With successful angling ecotourism projects, anglers and local populations can become viable constituencies for conservation. It cannot denied that when a fisher get 1000 rupees per hour by showing a fish to the angler rather than selling a kg of fish at 100-00 rupees at the end of the day, he will definitely move towards the conservation which will give him better return in future.

It is widely known that angling or recreational fishing is one of the most popular outdoor activities throughout the world, basically in the developed countries. In the United States, over 34 million people participated in recreational angling and 29.4 million recreational fishing licenses were issued in 2001. The revenues from fishing licenses support fish and wildlife management agencies at all levels of government, and the expenditures from recreational fishing contribute to local and regional economies, especially in regions where fisheries have been preserved in pristine or near-pristine conditions.

Need not to mention that the Golden Mahseer angling is the most fascinating sport fishing in India. It is comparable with Salmon of the west and said to be more thrilling than salmon in its strength and size, as stated by the sport fishermen of the west. All along the foothills of the Himalayan river abounds this particular sport fish which is diminishing in its number and size, gradually due various reasons. Almost in the entire North Eastern Region, most of the North bank rivers which flows southwardly viz. Teesta, Sankush, Aie, Manas, Kameng (Jia Bhoreli), Subansiri, Siang, Dibang and Lohit and their tributaries forms some of the deep gorges and rapids which are the abode of the Golden Mahseer. The south bank rivers flowing northwardly to join the mighty Brahmaputra are- Noa-Dihing, Tirap, Burhi-Dehing, Dhansiri, Kopili, Kulshi and their tributaries forming some of the meandering curves and deep pools with rocky bottoms, making it excellent Mahseer rivers as large numbers of Mahseers are still home to these rivers in the Brahmaputra catchment areas. Numbers of anglers are growing day by day which not only consists of the foreigners but also the domestic ones. The angler's activity gives us the updated report of this particular species, their habitat, changes in their population status and most importantly secures the mahseer from poachers besides providing livelihood support to the local community whom they engage for various activities. As such it not only helps in employment generation but also creates awareness among local people for conservation of the prized species.

Suggestive measures to develop the angling tourism

In-spite of the presence of the vast resources and the potentiality to develop the mahseer angling tourism in North East, the said sector is not developed as expected. As such, analyzing all the circumstances, some suggestive measures are given to develop the angling touring for conservation of mahseer.

- Mapping of the sport fishery rivers
- Awareness campaign among local community residing in the bank of mahseer habitat
- Preparation of check list of sport fishes along with the places and the tour guides
- Policy formation for angling
- Formulation of rules and regulation in regional level
- Development of roadmap to ensuring peoples participation in conservation and angling

- Skill development of the local youth to act as profession tourist guide for angling
- Accessibility of anglers to commute to remote areas
- Flexibility of local administration towards the anglers
- Formation of angling clubs
- Development of platform for promotion of angling

Conclusion

The hill fishery resources constitute the major portion for Indian fisheries which are source for protein as well as livelihood for the hill community. To ensure their livelihood and to protect the rapidly dwindling hill fishery resources, it is of foremost importance to develop the breeding and culture technology of the high valued species. At the same time, to minimize the pressure on the natural hill fishery resources, the capture fishery need to be switched over to culture fishery for long term sustainability of resources. Along with the scientists all the other troupe like fish farmers, fisherman, NGOs, anglers, local community and other stakeholders need to join hands to sketch a roadmap for hill fisheries development in general and mahseer fishery development in particular for the grater cause of conservation of Indian fisheries.

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Jasingfaa aqua Tourism Resort – A fledgling but Promising Fishery based eco Tourism venture

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Abstract

The fishery sector has been termed as the sunshine industry keeping in view its acceptability, employability, commercial profitability and overall growth of the fishes. The lives of people are very intimately connected with the fish from the very beginning of the human civilization. People love to see fish, catch fish, and play with fish apart from using fish as a good source of nutrients (Sarma, 2012). Therefore, fish based tourism activities are blooming like anything in the world. On the basis of such activities there is every possibility of fish and fish based tourism to emerge as one of the sectors having generated good numbers of employment opportunities. One of the fish tourism activities (Aqua Tourism) is the angling which is very popular across the world. The anglers of different countries travel widely for this sport which has spawned good numbers of eateries in different such places. In Assam also tourism activities in the guise of such fish sports was not very uncommon nevertheless an organized effort was missing. Mention can, therefore, be made about the Jasingfaa Aqua Tourism Resort of Nagaon that has put forward a very bold step in this regard. The paper will deal largely with the aqua culture, fish experimentation and the tourism activities (business) entangled with this entrepreneurial venture.

Key words: Aqua tourism, entrepreneurship, North East India.

Introduction:

Tourism is the world's fastest growing industry (Goodwin, 1998). According to the World Travel and Tourism Council, international tourism generated about 10% of GDP in 1994 and accounted for over 10% of all consumers spending. The industry is expected to continue to grow at 4-5% per annum in coming years. Tourism as an industry is generally recognized to consist of tourists, transportation, destination-attractions, lodging and food services, and information services (Holland, et al.). There is a great deal of interest in the role of ecotourism for combating the dual problems of conservation and poverty alleviation in rural areas of developing countries. Tourism is of great interest at a national level for developing countries for four main economic reasons (Brandon, 1996): i) The generation of foreign exchange, ii) The generation of employment, iii) Economic diversification and iv) Regional growth.

Though the tourism could be one of the prime and most alluring industries in the NE Region of our country, its pace of development is, indeed, very slow. The resources for the tourism industry are abundant though remaining unutilized and underutilized. The tourism in Assam and other NE States are centered around mainly on forest and wild lives and thus neglects other potential areas of eco tourism. Such an area is water, fish and fish resources of Assam which is especially of tremendous importance from the perspective of the growth of tourism industry. The huge stress of rivers in Assam and other water bodies are full of local and endemic variety of fishes. But, ironically most of these fish resources are drastically being reduced over last couple of decades due to poor management. It would be worthwhile to give a brief overview of the water and fish resources of Assam.

Assam is the second largest state of the North Eastern Region which has been blessed with vast and varied aquatic resources in the form of riverine, flood plain wetlands, low lying paddy field which supports a sizable variety of freshwater fishes. The North Eastern Region is considered as one of the hot spots of freshwater fish biodiversity in the world (Kottelat and Whitten, 1996). Out of total 806 freshwater fish species available in our country, NE Region

representing 267 species belonging to 114 genera under 38 families and 10 orders which is approximately 33.13% of the total Indian freshwater fishes. However a total of 217 fish species belonging to 104 genera under 37 families and 10 orders have been recorded and reported. It has been reported that drastic reduction in the abundance and distribution range of fishes due to habitat modification, over exploitation and manmade interventions (Sarkar and Poniah, 2000).

Among the eight North Eastern states, Assam has the highest potential fisheries resources. The state is rich in both culture and capture fisheries. Culture fisheries include- ponds, tanks, canals, etc. Capture fisheries comprises- the riverine fisheries (constituted by the mighty Brahmaputra and Barak rivers along with their tributaries), beel fisheries, forest fisheries, swamps, low lying paddy fields, etc. The main capture fisheries resources are constituted by the river Brahmaputra and its tributaries and their associated wetlands. The river Brahmaputra flows from Sodia to Dhubri for a length of 730 km. It has 47 tributaries (29 in north bank and 18 in south bank). The beels of Assam are also rich in aquatic flora and fauna as they are the "store house of organic matter".

Assam has the largest area of ponds among the North Eastern States. Of these, about 6,000 ha have been brought under semi-intensive fish culture. A very congenial environment for fisheries development prevails in the region in general and Assam in particular by way of high demand and price of fish (Sharma and Bhattacharjya, 2012).

The potential of fish and fish industries can be exploited through different ways. One fine example is the tourism activities based on fishery resources. The fish and fish resources can be a strong foundation of fishery based eco tourism industry in Assam. According to Singh et al, the natural water bodies and the suitable ponds available along the picturesque valley, mountains and riverbanks in the NE region could also be utilized for development of Mahseer (an endangered cold water fish species) or trout based sports fishery units with development of infrastructural facilities like parking, restaurants, hotels, transport and quality could be augmented with development of aqua sports. Jasingfaa Aqua Tourism Resort is a fine example of such fish and fishery based eco tourism activities in Assam.

Objectives: The objectives of the paper are –

1. To analyse the aqua tourism activities at Jasingfaa Aqua Tourism Resort
2. To know about the fish experimentation at the resort.

Methodology: The study is based on both the primary and the secondary data.

Primary data collection: Since the secondary data was not sufficient the study gave more emphasis to the primary data for a proper analysis of the situation. The primary data has been collected at different point of time by the authors by doing and observing the field situation. A questionnaire survey was adopted to elicit the required data and information regarding different aspects of the eco tourism activities at the resort. Secondary data for the paper has been collected from various sources like books, news paper articles, leaflets, web sites, etc.

Jasingfaa Aqua Tourism Resort – an overview: The Jasingfaa Aqua (Fish-based) Tourism Project was started on 2nd October, 2010 on the bank of a natural wetland named Mahrul Beel which itself is the home to and visiting and breeding ground of various endemic and migratory birds and attracts lots of bird lovers. The project is 5 km away from the district head quarter of Nagaon. It is comparatively a new and unique concept for the people of the region. Sprawling over a land area of 20 acres, more than 10 acres are covered by water consisting of eleven small tanks. Jasingfaa has converted its small tanks into sports fisheries where visitors can play with the fish and catch them. Angling is the sports here which is

gaining importance and becoming popular across the state and region as one of the prime entertainment activities.

Profile of the resort: Established in the year 2010 the Jasingfaa Aqua Tourism Resort is a spectacular resort that offers harmonious blend of nature and modern comfort. The Resort is sprawling over 20 acres of open land amidst water bodies and has been built in rustic surroundings to provide the visitors an eco-friendly atmosphere. It is, indeed, one of the finest resorts in Assam that the visitors will remember for their lifetime.
Location of the Resort: 4 kilometers towards east from Nagaon town (one and half kilometer away from both the AH1 and NH37), the resort is located right on the bank of a natural wetland named Mahrul, which is a home to and visiting and breeding ground of various endemic and migratory birds. The geographical location of the resort is 260 25' 32.47" North and 920 51' 39.86" East.

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Name: Jasingfaa Aqua Tourism Resort
Address: Mahrul, Dimoruguri, Nagaon, Assam
Year of establishment: 2010
Initial area of the resort: 12 acres
Present area of the resort: 20 acres
No of ponds: 11
No of indigenous fish species: 16
No of ornamental fish species: 5
No of staff: 40
Casual: 8
Permanent: 32
Party zone: 3
Children's' play ground: 1
Angling: Round the year.
Angling competition: Once (The Sunday next to July 10).
No of bird species can be seen at Jasingfaa: A number of (both migratory and endemic).

Tourism Activities and amenities at Jasingfaa:
Jasingfaa Aqua Tourism Resort has been converted into a multi dimensional venture with beautification of the landscape and addition of infrastructure like restaurants, boating, and angling facilities besides annual routine fish production. This agricultural field turn fish farm is now a good source of income for the owner and also a good source of employment of about 40 employees hailing from different parts of the state.
Fishery and fishing is the only important eco tourism activity in the resort. Apart from the angling, the open space along the ponds of the resort, the eatables and the natural beauty of the rustic background of the resort is the resource of Jasingfaa and is sufficient to lure the local tourists (mostly from Nagaon, Guwahati, Tezpur, Golaghat, Jorhat, etc.) as well as national and international tourists. Due to the paucity of publicity it is not the much sought a place among the eco tourists. But, the visitors who visit for the first time is sure to come the next time.

Angling: Angling or sports fishing is one of the most fascinating outdoor physical activities which satisfy diverse taste and pursuits. It is a form of eco-tourism promoting sustainable form of resource use and contributes to environmental conservation. Sport fishing is one of the leading adventure tourism activities across the world and especially in USA and Europe (Borgohain, 2012). Similarly, one can be very enthusiastic about aqua sports like fish angling at Jasingfaa Aqua Tourism Resort and spend hours catching fish there which are open for tourists round the year. The tourists, of course, have to abide by the rules and regulations laid down by the management. There are eleven ponds, covering about 60% of the resort that can offer some of the most excited fishing experience.

A good fish stock has been maintained at different blocks (ponds) of the resort. Some of these fishes (like Grass Carps, Bhangon, Mali, Red Bellied Piranha, etc.) are reared absolutely for the purpose of angling and there is no commercial selling of the big fishes that are easy prey to the anglers. To check the availability of these fishes in all the angling blocks, netting is done sporadically. The world famous priced sport fishes Golden Mahseer is one such variety. But, it is to be remembered that angling, on the Mahseer Brood Bank (the pond where the Mahseer is being reared), is strictly prohibited looking into its IUCN 'endangered' status. Jasingfaa is very keen on conserving this and such other species. Jasingfaa provides the facilities to the anglers according to the rules framed by its management.

The ponds of the Resort: There are eleven different ponds at the resort though all are not opened for angling purposes. Especially angling is not allowed at the brood bank of Mahseer. A brief overview of the ponds has been given below:

Fishes available	Name of the ponds	Size of the ponds
Indian Major, Minor & Exotic carps	Dikorai	2 bigha
Indian Major, Minor Exotic carps along with Golden Mahseer & Pengba	Kolong block	4 bigha
Indian Major, Minor & Exotic carps	Dichang	2.5 bighas
Indian Major, Minor & Exotic carps	Dhonsiri	2.5 bighas
Indigenous fish along	Dudhnoi	
Indian Major, Minor & Exotic carps	Champawati	10 bighas
Mahseer and Semiplotus semiplotus & Pengba	Jiabharali	1 bigha
Indian Major, Minor & Exotic carps	Kameng	7.5 bighas
Spoon	Nursery tank	1 bigha
Wild indigenous fishes	Puthimari	2 bigha
Wild indigenous fishes	Subansiri	2 bigha

North East Angling Competition: Jasingfaa feels blessed and delighted for the fact that from the very beginning, on the auspicious occasion of National Fish Farmers' Day on July 10 each year, it has been organizing an angling competition. The competition, initially, was a state level competition nevertheless looking into the interest of the anglers from other parts of the region the scope of it has been widened to make it a North East level competition. It is pleasing to note that the event is getting overwhelming response across the region and people of all age groups come and join the event each year. Jasingfaa feels proud that it has introduced a new era in the scenario of state eco-tourism.

The first angling competition was held on July 10, 2011 which was a state level competition. 70 anglers from different parts of the state took part in this first ever angling competition at Jasingfaa. Dr Debajit Sarma of DCFR, Bhimtal, Uttarakhand, Dr Dhrub Jyoti Sarma, Fishery Officer, Government of Assam and Mr Kameswar Kalita, DFDO, Nagaon were present in different events of the day. The subsequent competitions were graced by different fishery officials including the Honorable Director, Department of Fisheries, Government of Assam. The number of anglers also swelled in the subsequent competitions. The second competitions

were graced by 75 competitors while the number increased to 78 and 85 in the third and fourth North East Angling Competition. The fifth angling competition has just been completed with the participation of 107 anglers from across different states of the region highest number of participants coming from the state of Nagaland. The increased number of anglers shows the interest on the fish angling.

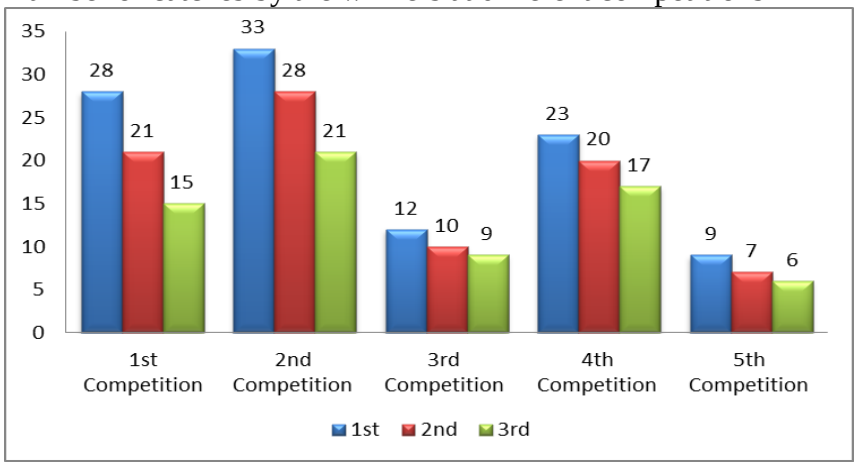
The name of the proud prize getters have been given on the table below:

Details of proud prize getters of 1st All Assam Angling Competition

	1st prize	2nd prize	3rd prize	Prize for big catch	Size of the big catch
1st angling, 10 July, 2011	Sri Ashis Kumar	Sri David Momin	Sri Chittaranjan Guha	Md Moinul Haque	4.2 kgs
Address	Biswanath Chariali	Guwahati	Dhekiajuli	Golaghat	
2nd angling, 10 July, 2012	Sri Dipankar Sen	Sri Shankar Sen	Sri Ashis Kumar	Sri Subhasis Das	3.55 kgs
Address	Nagaon	Guwahati	Biswanath Chariali	Nagaland	
3rd angling, 14 July, 2013	Mr. Pradumna Bora	Mr. Amar Biswas	Mr. Biplab Chakraborty	Md. Altaf Hussain	2.00 Kg.
Address	Golaghat	Nagaon	Nagaland	Golaghat	
4th angling, 13 July, 2014	Mr Prahlad Mazumdar	Mr Rajib Sarma	Mr Dilip Kumar Bhuyan	Mr Rajib Sarma	3.75 Kg.
Address	Kaliabor, Nagaon	Nagaon	Gorajan, Nagaon	Nagaon	
5th Angling, 12 july, 2015	Wati Walling	Ajoy Mondol	H. Lawrence	1st Mezang & 2nd Khekaho	3.991 & 3.875 kg.
Address	Nagaland	Nagaon	Nagaland	Nagaland	

Number of catches by the winners: The trend of the number of catches at all the five competitions has been shown with the help of the following diagram. The number of catches, on the basis of which the winners are selected, shows a fluctuating trend.

Number of catches by the winners at different competitions



Angling club: Looking into the interest of the anglers in the ponds of the resort, the management announced opening of an Angling Club during the first angling competition which was held in July, 2011. The members of the club need to enroll their names by paying a fee of Rs 1000/-. The members need not pay the regular angling fee whereas the non

members need to pay a fee of Rs. 50/- (per angle) each time he/she wants to angle in the ponds of the resort. All other rules and regulation applies to both the members and the non members. Initially there were 18 members which grew into 76 in December, 2014.

Fishes of Jasingfaa: The resort is rich in both the indigenous and ornamental fishes. Some of the varieties are: Rohu, Bhakuwa, Mirika, etc. belonging to the Indian Major Carp family and Kuhri, Bhangon, etc. belonging to Indian Minor Carp family. The important ornamental fishes are: Koi Carp, Red Spotted Swan King, Swiper or Crocodile fish, Red Belly Piranha, etc. Most of the indigenous varieties of fishes are found at Jasingfaa for which there are three separate ponds.

It is worth noting here that Nagaon is a big production center of fish seedling which is being supplied to different districts of the state and especially the districts of upper Assam. Jasingfaa feels privileged that it supplies a large number of brooders of Rohu, Catla, Bhangon, Mirika, Kurhi, Grass Carp, Silvar Carp, etc. to different hatcheries of the district so as to produce quality seedling for the entire fish markets of the state. The following table shows the sale proceeds of the fish (including brooders) by the Jasingfaa Aqua Tourism Resort for last four years:

Sale proceeds of fishes at Jasingfaa

Year	Name of the fish	Total (Lakh Rs.)
2011	Indian Major, minor and indigenous fishes.	2.65
2012		2.85
2013		4.30
2014		5.10
2015, June		4.00

Source: Primary survey at the Jasingfaa Aqua Tourism Resort

Result and discussion:

Experiment on Golden Mahseer: It is also of great pleasure that a good numbers of experimentation on fish is also going on at Jasingfaa Aqua Tourism Resort. Mention may be made of the king of game fish, i.e., Golden Mahseer (Tor Putitora) courtesy to the Directorate of Cold Water Fisheries and Research, Bhimtal, Nainital. Golden Mahseer are large cyprinids, inhabiting the clear, pristine and fast flowing waters of Asia, from the cool waters of Himalayan streams to the tropical rivers of South Asian jungles. They are highly sought after fish, valued for their excellent taste, ornamental beauty and fighting skills. Mahseer, the big-scaled carp attracts the anglers as well as naturalists from all over the world. Mahseer in the Indian subcontinent described as the King of Indian Aquatic Systems encounters in the tor zone (600 - 1200) of the glacier-fed Himalayan Rivers with much more extended distribution to the lower reaches in the peninsular Indian rivers (Sarma and Akhtar, 2014). In India however, it is found in Assam, Bihar, Darjeeling, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Nagaland, Sikkim, Uttarakhand, Uttar Pradesh and West Bengal. This is assessed as endangered in the IUCN red list and Akhtar, et. al. 2014 and Gurung, attributes factors like introduction of exotics, damming and overfishing for such status. Therefore, the conservation of this fish is very important through ex-situ and in-situ

- **First consignment: 7 July, 2011**
- **Came from: DCFR (ICAR), Bhimtal, Nainital, Uttarakhand.**
- **Total numbers: 2000 nos**
- **Size at the time of introduction: Fri**
- **Habitat (pond) size: 1 acre water area**
- **Ph value: In between 7 – 8**
- **Temperature: $12^0 – 32^0$ C.**
- **Present (2015) size: 1000 – 1700 gms (maximum)**
- **Numbers: 150 nos approx.**

conservation approaches. The experiment at Jasingfaa Aqua Tourism Resort is an ex-situ one and the result indeed is exciting.

Jasingfaa always loves to do new experiment. Golden Mahseer is the result of such an experiment. It is generally said that Golden Mahseer is a cold water fish and believed not to survive at warm water or in a captured condition. Jasingfaa took the challenge and made it possible for Golden Mahseer to survive at warm water and therefore, the popular belief has been nullified. It, therefore, proves that Mahseer can also be reared in our eco-climatic condition. It may open up a new era of fish research if Jasingfaa makes the Mahseer to breed in its ponds. A brief journey of the Mahseer to and at the Jasingfaa Aqua Tourism Resort has been given in the following box. After four years of experimentation and meticulous care, the hard work had paid off and the size of the mahseer at present is in between one kg to one kg seven hundred grams.

Other experiments:

Apart from the Golden Mahseer, Hexasticus Mahseer, Pengba (Osteobrama belengari), the State fish of Manipur and Semiplotus semiplotus (Assamese king Fish) are some other varieties of rare fishes which are being tried here with the help of DCFR and other agencies. Jasingfaa feels proud to announce that the Brood Bank of Semiplotus semiplotus is the first of its kind in the country which has been set up here in collaboration with the DCFR, Bhimtal, Nainital and Rajib Gandhi University, Itanagar, Arunachal Pradesh. Pengba has attained a good health in the ponds here while the other two varieties have been introduced a few months back.

Poly culture: All these fishes are being cultured with other Indian Major and Minor carps. Rohu, Catla, etc. are some of the fishes which are being kept at the Brood Bank of the Mahseer. Special attention is been given to the fishes on the pond where the Mahseer is being reared and therefore, perhaps, all the fishes of the said Brood Bank has attained a good size.

Multi-cuisine restaurant: Jasingfaa provides fully furnished Multi-cuisine restaurant for giving the customers a delicious treatment, elegant dining experience and ideal place for meeting-point. The scenic surroundings at Jasingfaa offer a great ambience all around. It offers a choice of dining options that make the most of the settings and feature a mouth watering array of cuisine and beverages. The fish provided at the restaurant are reared at its own fisheries. It provides Tandoori, Chinese, and Continental along with Assamese and Jasingfaa special dishes to satisfy varied tastes of the valued diners.

Nature conservation at Jasingfaa: Nature is exciting, inspiring, refreshing and constantly changing. It is full of mysteries to be marveled at and beauty to be admired. One of the prime aims of the resort is to generate awareness and conserve nature through creation of a good ambience at the resort where one can acquire some amount of knowledge and sensitivity. For the purpose, Jasingfaa takes privilege to hold Nature Camp each year from its very inception in collaboration with other local, national and international organisations doing their bit to conserve nature. In one such camp the campers (school students) calculated about hundred different species of herbs, shrubs and trees at the resort. Jasingfaa along with the Mahrul beel, therefore, are now abode to thousands of different local birds like Sparrow, Myna, Pond Heron, Night Heron, both Large and Lesser Cormorant, Darter, Whistling Teal, Openbill Stork, Lesser Adjutant, Egret, Drongo, Tree pie, Owl, Munia, Wagtail, Magpie Robin, Bulbul, Parakeet, Oriole, Green Pigeon, Kingfisher, Lapwing, Waterhen and many more. Apart from the birds a number of insects, butterflies, dragonflies, etc. are also found in the resort. Mention may also be made of different tree species, especially local fruit and medicinal plants, numbers of which are reducing drastically in recent times.

Package tour: Jasingfaa also organizes package tour as and when demanded by the tourists. It primarily gives emphasis on the rural tourism apart from wildlife tourism. It maintains a very amicable relationship with the small tea growers (and with their association) and thus gives stress on tea tourism. Tourists can "enjoy the sound of silence" in these tea gardens which is situated along the picturesque foothill of Karbi Anglong. The entire process – from the tea plantation, plucking up to the production of the final products – is demonstrated to the tourists in this package. Apart from this, the resort has a very good linkage with some other grass root level organisations operating in different wildlife sanctuaries across the state where it can bring its tourists into. School and college students also visit the sites for educational purposes.

Trend of tourists: Attracted by its entire ambience, fishes, and scenic beauty and the rustic surroundings a good amount of tourists local, national and international make it a point to visit the resort. The following table shows the influx of tourists into the resort during last three years:

No of tourists	2011	2012	2013	2014
National	72 thousands	78 thousands	82 thousands	90 thousands
International	20	32	38	45

International tourist flows are from different countries like Japan, Dubai, USA, Germany, Bhutan, Italy, Poland, England and Russia. Jasingfaa feels bliss that the number of tourists coming to the resort is also increasing over the years.

It is also worth mentioning that the students and the faculty members of Fishery College, Raha, Nagaon, visit the resort for educative purpose.

Employment: Fisheries is an important sector in India. It provides employment to millions of people and contributes to food security of the country. Apart from generating employment to a large extent the fisheries and aquaculture contribute 1.07 per cent to the national GDP (http://indianfisheries.icsf.net/). The Jasingfaa Aqua Tourism Resort is providing direct employment opportunities to more than 40 persons (read forty families) hailing from across the state. If one calculates the forward and backward linkages the employment market would be of a sizeable amount. There are many more people in the surrounding villages who are earning a livelihood by supplying different items to the resort.

Jasingfaa also feels proud in stating the fact that a large number of students from the Foodcraft, a hotel management institute, situated at Rongagora, Samaguri, about 30 kms from the resort, come here to have organizational trainings. Once completed the training here the students are issued an industrial (experience) certificate only to become eligible to have their diploma/certificate. In this way Jasingfaa is contributing hugely towards the employment market of the state.

Conclusion:

In addition to having the private sector infrastructure for the fish industry to grow there should be good amount of investment in the public sector to boost the growth of the fish based eco tourism industries in the state.

Tourism is the fastest growing industry in the world and a major source of income in many countries of the world. Being a people oriented industry, tourism also provides many jobs which have helped revitalize local economies (www.unesco.org). When the employment opportunities at the time of economic reforms in India, indeed in the public sector, are squeezing, the tourism sector may show a ray of hope by employing huge numbers of unemployed youths. North East India including Assam is known for their bio-geographic richness. With its dense forests, uneven topography, flora and fauna, the majestic Brahmaputra and its tributaries, wild life sanctuaries like Kaziranga, Manas, Pabitora, Dibru-

Saikhowa, Bhalukpung, Pobitara and similar others, and many rare species of animals, Assam offers basically nature-centric tourism. There are many other tourism resources in the region but, ironically, these plentiful tourism resources are remaining unexploited leaving the region further behind the development ladder of the country. On the backdrop of this it can be said that the tourism activities in the private hands are really showing optimism. Jasingfaa Aqua Tourism Resort, a fledgling tourism project and comparatively a new and unique inclusion in the state tourism sector, feels proud to generate a good number of employment opportunities for the unemployed youth of the state. People certainly heard about 'nature-based tourism', 'ecotourism' and 'cultural tourism' but, perhaps, did not hear about Aqua tourism. Jasingfaa Aqua Tourism seeks blessings of all for its sustainable journey.

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Assessment Of Population Structure And Genetic Diversity Of Chocolate Mahseer (*Neolissochilus hexagonolepis*, Mc. Clelland, 1839) In Selected Water Bodies Of Meghalaya using microsatellite markers

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Abstract:
Present study therefore an attempt has been made to explore different rivers for the presence of *Neolissochilus hexagonolepis* and to study the population structure of *Neolissochilus* by using microsatellite molecular markers. Fish specimens collected were also sent to ZSI (Zoological Survey of India), Shillong for species conformation

Introduction:

Neolissochilus, *Tor* and *Naziritor* belong to a group of cyprinid fish called Mahseers. These fish are large scale barbels and are found in upstream, clean and fast flowing rivers (Shrestha, 1990). In North East India, Laskar *et al*., (2013) reported the presence of *Neolissochilus hexastichus* in river Diyung, Assam of North East India. In Meghalaya, there have been no reports on the presence of *Neolissochilus hexastichus* but the availability and the abundance of *Neolissochilus hexagonolepis* had been studied and reported by many authors. *Neolissochilus hexagonolepis* is locally known as Kha saw by the Khasis, Kha pnar by the Pnar and is a very important food and game fish in the state of Meghalaya. It has a very high demand in the state and is a good candidate for angling tourism and also an important from the eco-tourism point of view. These fish species are an endemic and indigenous species of Meghalaya (Mandal *et al*., 2012). Though the rivers and streams of Meghalaya are suitable for rearing and survivality of this fish species but in most places it is over-exploited by various anthropogenic activities. Mahapatra *et al*., (2011) reported the abundance of the fish species has been reduced in the state. Extensive fishing, industrialisation and degradation of spawning areas etc., has led to its population decline.

Microsatellites are short tandem repeats that are found abundant in all eukaryotic genomes. They are co-dominant and inherited in a mendelian fashion. If the flanking regions of the sequences are known, primers can be synthesised complementary to the flanking regions and can be amplified by PCR (Wright and Bentzen, 1994).

In the present study therefore an attempt has been made to explore different rivers for the presence of *Neolissochilus hexagonolepis* and to study the population structure of *Neolissochilus* by using microsatellite molecular markers. Fish specimens collected were also sent to ZSI (Zoological Survey of India), Shillong for species conformation.

Materials and Methods:

Study area:

The work was carried out from 2012-2014 in selected water bodies of Meghalaya and their geographical detail and number of samples collected is shown in Table 1.

Table 1: Sample collection sites and sampling details.

Sl. No	Rivers	Geographic location	Code	Co-ordinates	Date of collection	Total no. of samples
1.	Amlayee	West Jaintia Hills	NB	25°40'N 91°55'E	19.06.2014	15
2.	Janiaw	East Khasi Hills	MAW	25°15.422'N 91°15.438'E	16.06.2014	15
3.	Umngi	West Khasi Hills	B	25°12'05.0"N 91°22'29.1"E	4.06.2014	8
4.	Pamblang	West Khasi Hills	P	25°13'26.3"N 92°13'33.1"E	9.06.2014	10
5.	Lakroh	West Jaintia Hills	L	25°11'25.1"N 92°13'33.1"E	9.06.2014	9
6.	Umsharing /Wah Leshka	West Jaintia Hills	T	25°15'30.7"N 92°10'15.0"E	19.06.2014	49
7.	Khri	West Khasi Hills	K	25°47'N 91°25'E	23.05.2014	48
8.	Umran	Ri Bhoi	UMR	25°52'N 91°50'E	30.09.2014	39
9.	Umiam	Ri Bhoi	UMI	25°40'N 91°55'E	28.09.2014	10
10.	Umralene	Ri Bhoi	R	25°45'0"N 91°53'0"E	12.09.2013	12

Microsatellite profiling:

Fin clipped sample was taken from fishes and total genomic DNA extraction was done by a method described by Blin and Stafford (1976). Polymerase Chain Reaction (PCR) carried out by using primers adapted from Nguyen *et al*., (2007) and also designed from *Neolissochilus* database of National Centre for Biotechnology Information (NCBI) using bioinformatics approach. PCR (Polymerase Chain Reaction) program was denaturation step 95°C for 5 minutes, Primer annealing for 50 Seconds, Primer annealing at 72°C for 50 seconds and final extension at 72°C for 5 minutes. Denaturing PAGE (Polyacrylamide Gel Electrophoresis) was used for detection and documentation of polymorphism stained with Ethidium bromide. Number of microsatellite alleles and their sizes were recorded with the help of gel documentation software.

Table 2: Characteristics of microsatellites and alleles size amplified by Polymerase Chain Reaction.

Primer Sequence (5'-3')	Repeat motif	Allele range (bp)	F_{is}	F_{st}	Across loci F_{is}	Across loci F_{st}
F-CCGAAATGCATTCTTGTCTT R-GGACTGACACTGGGGATCAT	$(ATT)_3$ $(GTT)_4(ATT)_8$	186-300	0.2074	0.0458	0.3437	0.1348
F-GAGTCCCTACAGACGTATTTCCA R-TTCAGCTCAGAGGGGACACT	$(TG)_{23}$	127-268	0.1257	0.0922		
F-TTCCTTATGTAATTGCTCTTTG R-TGTGAGTGTTTGTGCGTGTG	$(GT)_{23}$	161-235	0.8577	0.1786		
F-CTTACTATTGCTTGCTTCACT R-CTAGTGTGCAAGAATGTCTT	$(CA)_{21}$	50-67	0.6757	0.2469		

F-TTACTATTGCTGGCTCACTC R-TAGTGTGCAAGAATGTCTTT	$(AC)_{20}$	50-61	0.7967	0.1172		
F-CTAAGACAATGTTCTCAGCC R-ATGTAAGGTCAGATATATGA	$(TG)_{30}$	53-104	0.2364	0.1283		
F-TAAGACAATGTTCTCAGCCT R-AATGTAAGGTCAGATATATG	$(GT)_{30}$	57-105	0.3123	0.1451		
F-CCGGGAGATGAGCTCAGAAA R-TATGCATTAGTGAGCGTGGA	$(TG)_{21}$	59-116	0.0572	0.1103		
F-CGGGAGATGAGCTCAGAAAT R-ATATGCATTAGTGAGCGTGG	$(GT)_{21}$	59-114	0.0217	0.1569		

Results:

F-Forward Primer, R-Reverse Primer, bp-basepair, F_{is}: inbreeding coefficient, F_{st}:

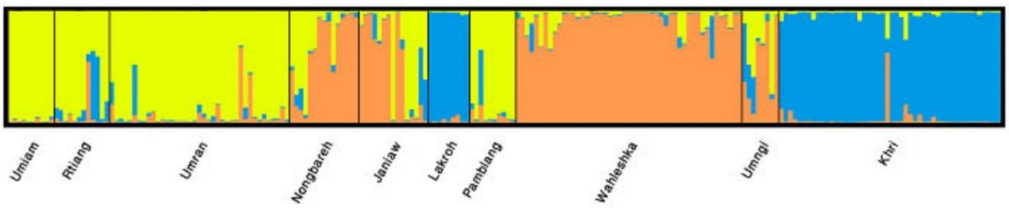

Plate 1: STRUCTURE output showing genetic admixtures and distribution of *Neolissochilus hexagonolepis* into 3 genetic clusters. Site of sampling are mentioned at the bottom.

Results and Discussion:

The overall microsatellite profiling of the 10 populations of *Neolissochilus hexagonolepis* revealed a high degree of population structure and all microsatellite are polymorphic. From the study it is evident that the inbreeding among populations of *Neolissochilus hexagonolepis* is high (F_{is}=0.34) i.e., the fishes collected from different population are breeding among themselves and also is not good from genetic diversity point of view. F_{st} value indicating genetic differentiation ranges from 0.05-0.25 (Table 2) which indicates great differentiation among the populations from different river sites of Meghalaya. Population structure (Plate 2) reveals three genetic clusters with various extents of genetic admixtures among the individuals of different population. Inbreeding of *Neolissochilus hexagonolepis* of Meghalaya is high because the fish collected from different sites are breeding among themselves. This is not a good sign for conservation studies of this particular fish species. Since the Fst value is high these species are on the verge of endangerment. This occurred due to disturbance of habitat. Immediate steps have to be taken for inbreeding of *Neolissochilus hexagonolepis* from these sites. Therefore steps should be taken to stop anthropogenic disturbance of the natural habitat of *Neolissochilus hexagonolepis.* These loci can therefore identify conservation units and population differentiation studies.

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Reproductive Biology of *Neolissochilus hexagonolepis* (McClelland, 1839) from Different Rivers of Meghalaya, India - A Comparative Study

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ABSTRACT

The reproductive biology of *Neolissochilus hexagonolepis* was carried out from May, 2012 to May, 2015. Specimens were collected from six rivers of four different districts of Meghalaya viz. Khri (West Khasi Hills District), Umran and Umrynjah (Ri-Bhoi District), Lakroh and Amlayee ((West Jaintia Hills District), Janiaw (East Khasi Hills District). The species collected were brought to the hatchery complex of Department of Fishery Science, St. Anthony's College, Shillong for rearing and further studies. The different aspects of the reproductive biology viz. Length-Weight Relationship (LWR), Relative Condition factor (Kn), Gonado-somatic Index (GSI), Fecundity and the Gonadal Cycle of the fish was studied. The exponential value of the LWR (b) ranges from 1.10 to 2.59 indicating the different growth pattern of the fish from the different rivers. The species from Lakroh and Amlayee followed the Cube Law ('b' value is 2.43 and 2.59, respectively) indicating an isometric pattern of growth in the fish whereas the species from Umran, Umrynjah, Janiaw and Khri does not followed the Cube Law ('b' value is 1.50, 1.84, 1.25 and 1.10, respectively) indicating an allometric growth pattern of the fish. The value of coefficient correlation (r) of the species from all the rivers is found to be greater than 0.8 regardless of sex and season which indicates a highly significant correlation between the length and weight of the fish. The value of Kn of the species studied from all the rivers was greater than 1 signifying the well-being of the fish. The fecundity of the fish ranged from 1500 to 3000 eggs/kg body weight of the fish. The GSI of the male species from all the rivers ranged from 0.3 to 3.0, highest being in the month of June (2.5-3.0). Similarly, the GSI of the female ranged from 1.6 to 5.0, highest in the month of July (4.5-5.0). The GSI indicates the maturity of the species corresponding to breeding period. The gonadal cycle of both testes and ovary confirms the maturity of the fish in different seasons which corresponds with the GSI. The study will help in evolving a protocol for the artificial breeding of the fish under the agro-climatic condition of the state.

Key Words: Reproductive Biology, Length-Weight Relationship, allometric growth, Gonado-somatic index, Gonadal cycle.

INTRODUCTION

Neolissochilus hexagonolepis (commonly known as 'Chocolate Mahseer') one of the important species of the Mahseer is known for its distribution to be restricted to the North Eastern Himalayan region of India and this species is native to the state of Meghalaya (Dasgupta, 1982). The species is considered as one of the endangered species but has tremendous scope for culture, tourism and aquarium trade. (Menon, 1999).

The chocolate Mahseer is a commercially important species and is widely recognized as a sport fish due to its tremendous size and strength facilities. It is highly esteemed by the anglers. But compared to the last two decades, the catch per unit effort (CPUE) has drastically decreased (Marwein, 2000; Mahapatra *et al*., 2004). Recently, this fish species is popular as ornamental fish among hobbyists, both locally and globally (Mahapatra *et al*., 2003)

In Meghalaya, the species locally known as 'Kha saw' is one of the important food as well as game fish of the region. The rivers have been known to be the natural habitat for Mahseer. But in recent years, due to various anthropogenic activities, the population of the fish has declined sharply (Sarma and Bhuyan, 2007). The present study reports some observations

made on the reproductive biology of *Neolissochilus hexagonolepis* from different rivers of Meghalaya.

Materials and Methods

Habitat

Reproductive biology of *Neolissochilus hexagonolepis* was carried out from May, 2012 to May, 2015. Specimens were collected from six rivers of four different districts of Meghalaya viz. Khri (West Khasi Hills District), Umran and Umrynjah (Ri-Bhoi District), Lakroh and Amlayee ((West Jaintia Hills District), Janiaw (East Khasi Hills District). The sampling area from Amlayee and Lakroh rivers are situated at 25°31'N, 92°14'E and 25°10'N, 92°09'E, respectively. The sampling area from Umran and Umrynjah rivers are situated at 25°46'N, 91°52'E and 25°42'N, 91°58'E, respectively. The sampling area for Janiaw and Khri rivers are situated at 25°14'N, 91°35'E, respectively.

Sampling

Monthly samplings were obtained from the different rivers using cast nets of different sizes. The species collected were brought to the hatchery complex of Department of Fishery Science, St. Anthony's College, Shillong. The fishes were measured and those live fishes were released in the hatchery ponds for rearing and further studies. The death fishes were dissected to obtain the different organs needed for further studies and the rest of the fish was kept in 5% formalin for preservation.

Analyses

The different aspects of the reproductive biology viz. Length-Weight Relationship (LWR), Relative Condition factor (Kn), Gonado-somatic Index (GSI), Fecundity and the Gonadal Cycle of the fish was studied. Initially, each mature fish was examined externally for the extrusion of milt or eggs by applying slight pressure on to the belly. The total length and weight of each fish (both mature and immature) were measured to the nearest 1 mm and nearest 10 mg, respectively. The gonads were dissected out, weighed to the nearest 1 mg and developmental stages were observed and noted. The photographs of gonads (Testis and Ovary) were taken monthly wise and classified into four different seasons of a year (pre-monsoon, monsoon, retreating monsoon and winter (Plate- I & II) for morphological studies and were placed in maturity scale (Table-I & II) based on Khanna (1993). The LWR of the fish was determined by Le Cren's method (1951) and Kn by Fulton's method (1904). The fecundity was determined based on the method by Bagenal (1978). The GSI (i.e. the weight of gonad as a percentage of the body weight) of the fish was calculated as proposed by Nikolsky (1963).

RESULTS

Length-Weight Relationship (LWR)

The LWR study of *Neolissochilus hexagonolepis* from different rivers reports the exponential value 'b' ranges from 1.10 to 2.59 indicating the different growth pattern of the fish from the different rivers. The species from Lakroh and Amlayee followed the Cube Law ('b' value is 2.43 and 2.59, respectively) indicating an isometric pattern of growth in the fish whereas the species from Umran, Umrynjah, Janiaw and Khri does not followed the Cube Law ('b' value is 1.50, 1.84, 1.25 and 1.10, respectively) indicating an allometric growth pattern of the fish. The value of coefficient correlation (r) of the species from all the rivers is found to be greater than 0.8 regardless of sex and season which indicates a highly significant correlation between the length and weight of the fish (Table 1).

Table 1: LWR of *Neolissochilus hexagonolepis*

Sampling site	No. of fish studied	b	r
Amlayee	40	2.59	0.85
Khri	40	1.10	0.97
Umran	40	1.50	0.81
Lakroh	40	2.43	0.89
Umrynjah	40	1.84	0.92
Janiaw	40	1.25	0.93

b = slope of regression, r = coefficient of correlation

Relative Condition Factor (Kn)

The value of Kn of the species studied from all the rivers was in the range of 1.02- 1.32 which was greater than 1 signifying the well-being of the fish (Table 2).

Table 2: Relative Condition Factor of *Neolissochilus hexagonolepis*

Sampling site	No. of fish studied	Relative Condition Factor (Kn)
Amlayee	40	1.14
Khri	40	1.28
Umran	40	1.02
Lakroh	40	1.23
Umrynjah	40	1.19
Janiaw	40	1.32

Fecundity

The fecundity of *Neolissochilus hexagonolepis* was studied and ranged from 1500 to 3000 eggs/kg body weight of the fish with the highest being from Amlayee River (3000 eggs/kg body weight) and the lowest from Khri river (1500 eggs/kg body weight)

Gonado-Somatic Index (GSI)

The GSI of the male species from all the rivers ranged from 0.3 to 3.0, highest being in the month of June (2.5-3.0) as shown in Table 3. Similarly, the GSI of the female ranged from 1.6 to 5.0, highest in the month of July (4.5-5.0) as shown in Table 4.

Table 3: Gonado-somatic Index of male species

Months	Amlayee	Lakroh	Khri	Umran	Umrynjah	Janiaw
January	0.8	0.62	0.3	0.48	0.53	0.32
February	1.15	1.02	0.59	0.84	0.98	0.61
March	1.38	1.28	0.85	1.17	1.25	0.98
April	1.74	1.62	1.21	1.35	1.5	1.24
May	2.48	2.35	1.76	1.96	2.22	1.82
June	3	2.83	2.53	2.58	2.65	2.5
July	2.86	2.61	2.18	2.38	2.43	2.25
August	2.54	2.25	2.02	2.17	2.2	2.08
September	2.13	2.09	1.69	1.89	2.03	1.74
October	1.78	1.61	1.25	1.49	1.52	1.33
November	1.24	1.2	1.03	1.11	1.2	1.09
December	1.03	0.98	0.79	0.9	0.93	0.86

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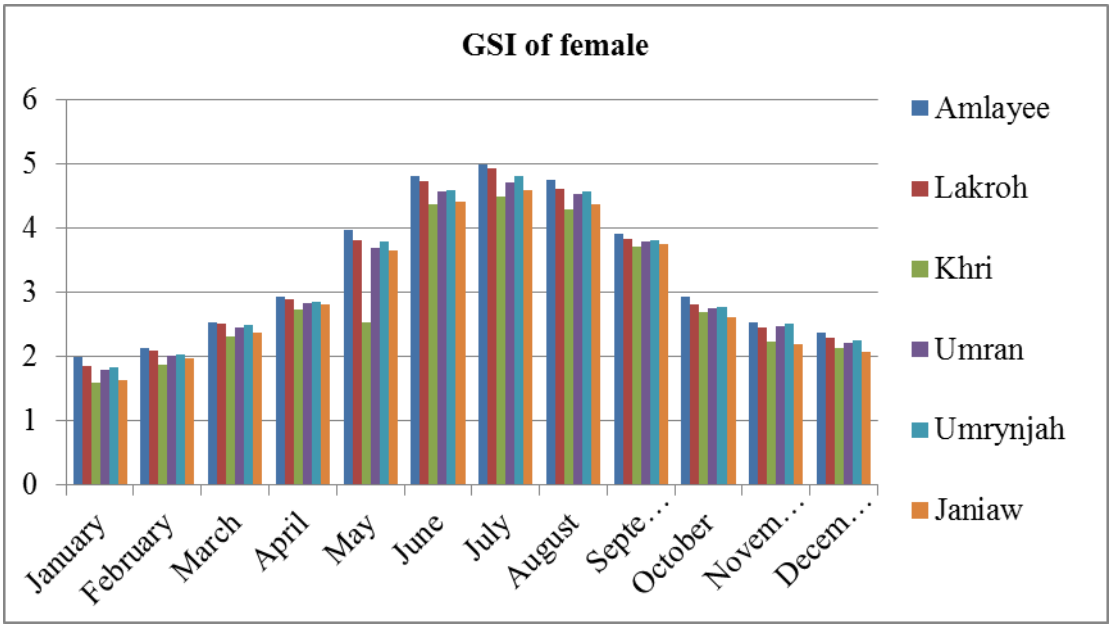

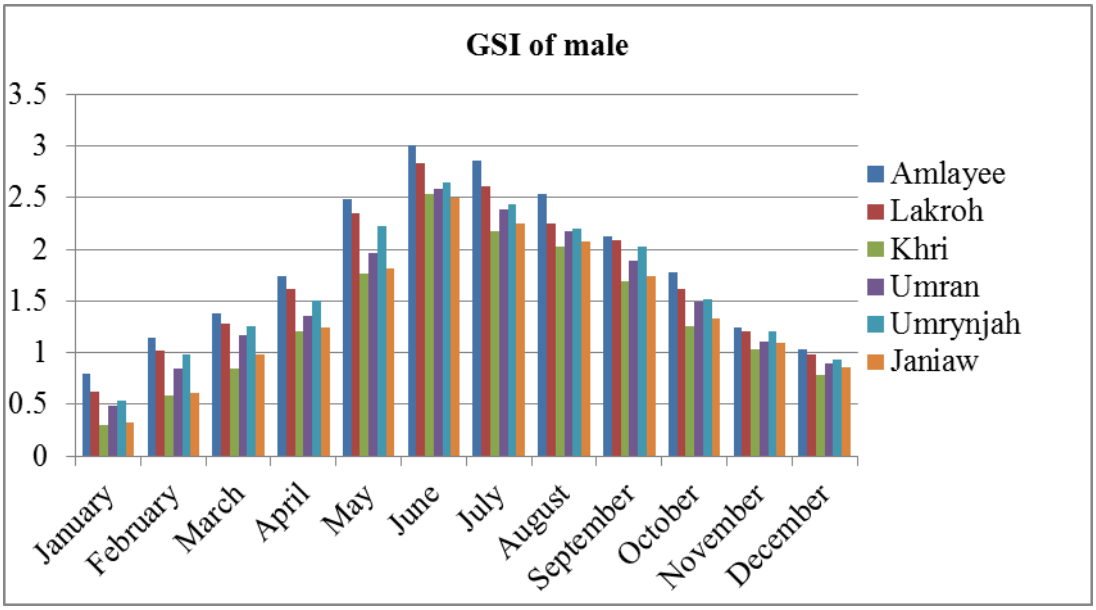

Table 4: Gonado-somatic Index of female species

Months	Amlayee	Lakroh	Khri	Umran	Umrynjah	Janiaw
January	2	1.86	1.6	1.79	1.83	1.63
February	2.14	2.09	1.88	2.01	2.04	1.98
March	2.53	2.51	2.32	2.45	2.49	2.38
April	2.94	2.9	2.74	2.84	2.86	2.81
May	3.98	3.81	2.54	3.7	3.79	3.65
June	4.82	4.73	4.38	4.57	4.6	4.42
July	5	4.94	4.5	4.71	4.82	4.59
August	4.75	4.61	4.29	4.53	4.58	4.37
September	3.92	3.84	3.72	3.79	3.81	3.75
October	2.94	2.81	2.69	2.75	2.78	2.62
November	2.53	2.45	2.23	2.48	2.51	2.19
December	2.38	2.29	2.14	2.21	2.25	2.08

Gonadal Cycle

The gonadal cycle of both the testis and ovary of *Neolissochilus hexagonolepis* was examined to study the gonadal maturity of the fish corresponding with the Gonado-somatic Index. The gonads are paired, elongated organs suspended one on each side from the dorsal wall of the body cavity. These become progressively enlarged as the fish attain sexual maturity (Chaturvedi, 1974). Accordingly, four stages have been classified for both males and females.

Stage I (Immature) – Though winter season starts from December but its effects extend from January to February. During this period, the gonads mostly remain at resting stage or immature stage. The testis is very thin and translucent. The ovaries were thin and the ova were not visible to the naked eye.

Stage II (Maturing) - The Pre-monsoon season initiates from March and continues up to May. During this period, environmental temperature gradually increases and the gonadal development becomes very fast producing maturing sperms and ova. Testis thickened and became creamy white in colour. Ovaries became larger, thicker. Vascular supply increased and blood capillaries became conspicuous.

Stage III (Mature) - Monsoon season extends from June to September. During the monsoon period matured eggs and sperms are produced and natural breeding of fish starts. Testes were enlarged at this stage, became opaque and pure whitish in colour. Ovaries were much enlarged, occupying the entire body cavity. Ova were found extruded on gentle pressure on the abdomen.

Stage IV (Spent) - During retreating monsoon (extending from October to December) the eggs and sperms are released and gonads become flaccid. Testes were flaccid and became translucent. Ovaries were flaccid and shrunken, reduced in volume, dull in colour.

This classified stages of gonads in *Neolissochilus hexagonolepis* has been confirmed with the calculated Gonado-Somatic Index of the fish (Table 3 and 4).

Plate 1: Maturity stages of testis at different months

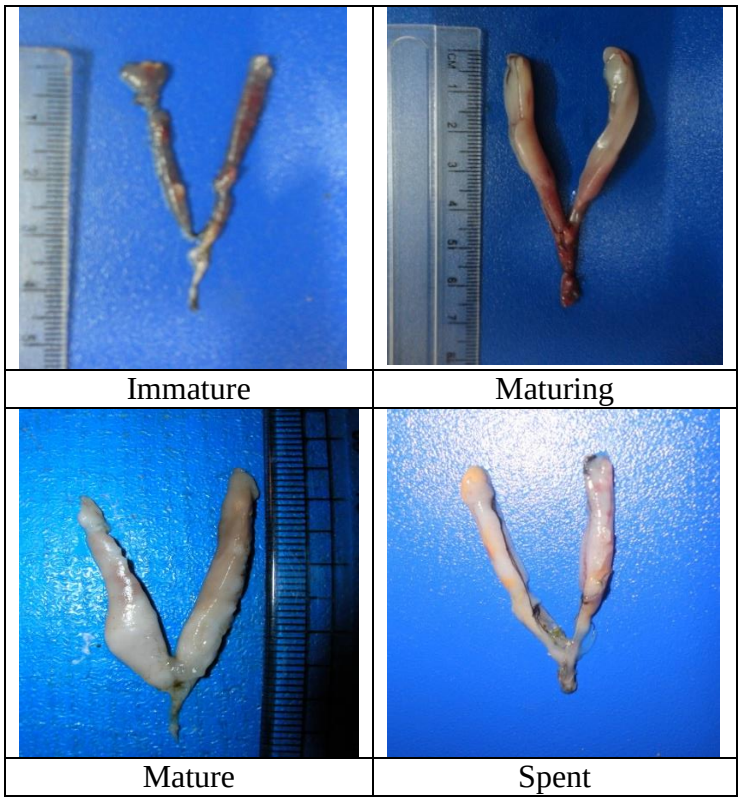

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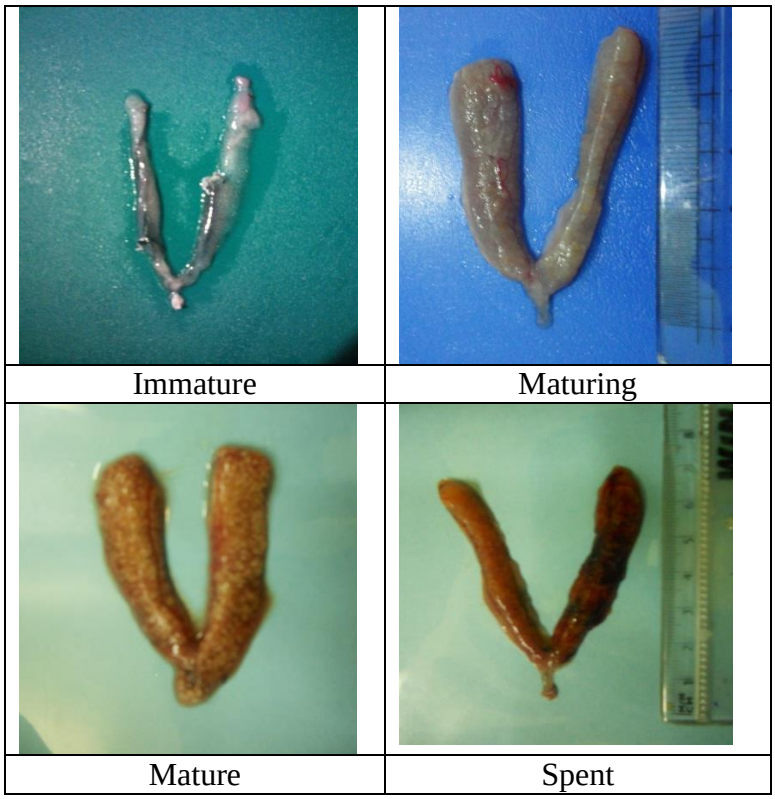
Plate 2: Maturation stages of ovary at different months



DISCUSSION

The study of reproductive biology is considered to be one of the most fundamental aspects of applied fishery research. It is impossible to gain any real understanding of captive breeding under controlled condition without some apprehension of reproductive biology (Mahapatra, 1994). The exponential value of the LWR (b) representing the body forms is related to the ecological and biological factors such as Dissolved Oxygen content in the water, food supply, spawning conditions and other factors such as sex and age of fish (Zakeryudin et al.,2012). The variation in the 'b' value for the same species could be attributed to difference in sampling, sample size or length ranges (Hossain, 2010). In the present study, the species from Lakroh and Amlayee followed the Cube Law ('b' value is 2.43 and 2.59, respectively) indicating an isometric pattern of growth in the fish (Dasgupta, 1991) whereas the species from Umran, Umrynjah, Janiaw and Khri does not followed the Cube Law ('b' value is 1.50, 1.84, 1.25 and 1.10, respectively) indicating an allometric growth pattern of the fish. The differences in the 'b' value may be attributed to the ecological features of the area studied. The value of the correlation coefficient (r) calculated indicates a high correlation between the length and weight and proved to be highly significant. The value of the species from all the rivers is found to be greater than 0.8 regardless of sex and season (Begum et al., 2010) which indicates a highly significant correlation between the length and weight of the fish.

The Relative Condition factors (Kn) provide external measures of overall health of the fish (Naeem *et al*., 2011). The Kn value indicates the size at which the fish matures and the variation in the value in relation to size may attribute spawning and feeding intensity due to availability of choose food or absence of food (Mohanraj, 2008). The value of Kn > 1 indicates the well-being of the fish to be good. The higher values of 'Kn' in a particular period seem to be the preparation for the reproductive activities (Telvekar et al., 2006). The

value of 'Kn' usually shows fluctuations which may due to sample size, different stages of maturity, spawning on the parts of females or difference in weight of food content in the stomach (Dars *et al*., 2010; Yilmaz and Polat, 2011).

The fecundity of *Neolissochilus hexagonolepis* was found to be low. The finding of the present study confirms the earlier observations (Dasgupta, 1982). However, there was slight difference in results which could be attributed to the change in the seasonal rhythm of environmental factors specific to the area. The environmental factors like water temperature, photoperiod, rainfall, etc. are known to play a significant role in gonadotrophic activity of pituitary gland which in turn plays a major role in gonadal development (Lin and Peter, 1996).

The analysis of Gonado-Somatic Index (GSI) confirmed that *Neolissochilus hexagonolepis* becomes fully gravid during the month of May to August with peak maturity in the month of June (in case of male species) and in the month of July (in case of female species). Thus the natural peak breeding season of the fish would be during July and August. In this context, it could be noted that there are reports of natural breeding of chocolate Mahseer during rainy season in Assam (Langer *et al*., 2001). However, the gradual change of morphological appearance of gonads, both testes and ovary and corresponding Gonado-Somatic Index confirms that the important sport fish of the state has a longer spawning period in comparison to other carps, extending from June to September under the agro climatic conditions of Meghalaya particularly Khasi and Jaintia Hills Districts. This was in total agreement with the reports on the prolonged spawning season of Mahseer from Pagladia River of Assam and Simsang River of Garo hills (Dasgupta, 1982).

It has been observed that the morphological appearance of gonads, both testes and ovary, could be correlated with the climatologically classified season of the year of North East India in general and Meghalaya in particular (Barthakur, 1986). It has also been observed that the size at maturity differs in male and female sexes. The size difference between the two sexes is basically due to reproductive requirements as the female carrying the bulky eggs is larger than the male (Bond, 1979).

It has been also observed that the male fish reaches sexual maturity in the first year of its life. However, the female takes almost four years to become sexually mature under the captive rearing condition. This indicates that the ecological transition from riverine to captive condition has not much impact on the gonadal maturation of the fish. But the difference in age for sexual maturation has great impact on development of protocol for artificial propagation of the fish.

CONCLUSION

The present study revealed the condition of all the rivers studied are good habitats of *Neolissochilus hexagonolepis* and signifies the well being of the fish. The study also confirms a highly significant correlation between the length and weight of the fish. Corresponding with the Gonado-somatic Index, the gonadal cycle of both testes and ovary confirms the maturity of the fish in different seasons. The reproductive biology of Chocolate Mahseer from Meghalaya will help in the artificial breeding for increased production of fish in the state as the fish is very good candidate species for the culture fisheries of the state. The study will help in evolving a protocol for the artificial breeding of the fish under the agro-climatic condition of the state. This will further help in the ranching of the fish in the natural habitat leading to conservation of the species.

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