ISSN 0859-600X

Volume 21 No. 2 April-June 2017

AQUACULTURE ASIA

Aquaculture in Sikkim: Conservation to farming

Co-culture of tiger shrimp and freshwater prawn

Integrated livestock-crop-fish farming

AQUACULTURE ASIA

Volume 21 No.2
April-June 2017

ISSN 0859-600X

Aquaculture Asia

is an autonomous publication that gives people in developing countries a voice. The views and opinions expressed herein are those of the contributors and do not represent the policies or position of NACA.

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NACA

An intergovernmental organisation that promotes rural development through sustainable aquaculture. NACA seeks to improve rural income, increase food production and foreign exchange earnings and to diversify farm production. The ultimate beneficiaries of NACA activities are farmers and rural communities.

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Printed by
Scand-Media Co., Ltd.

Tilapia lake virus (TiLV)

I didn't want to write Yet Another Column About Why Moving Live Fish Around is Bad, but I must. There's a new disease in town, 'tilapia lake virus' or TiLV. It causes serious mortalities ranging from 20-90% and it appears to be spreading from one country to the next via the usual route of importation of infected seed. So far the disease has been reported from Ecuador, Israel, Colombia, Egypt and Thailand.

The disease was only detected in 2013, and unfortunately, it appears to have been jumping international borders even before it was known to science. Based on documented records of fish translocations (mainly fry and fingerlings), some 43 countries are believed to have imported fish that may have been infected. Please see the publication Dong, Rattanarojpong and Senapin (2017) below for the details and the list of at-risk countries.

An improved PCR method for detecting the virus has been published by Dong et al., details in the references below. Centex Shrimp is willing to provide a free positive control plasmid (pGEM-415_bp) to non-commercial agencies (or for a fee to commercial interests), contact saengchan@biotec.or.th.

It is vital that those countries at risk establish surveillance for TiLV in tilapia. Unusual tilapia mortalities should be investigated for the virus. And until such time as SPF seed is available for TiLV, it is probably a **very bad idea indeed** to import live tilapia from overseas or move it around internally between drainages.

The Editor wishes to acknowledge the generosity of the authors and/or institutions for their prompt action in making this information available to the public:

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Simon Wilkinson

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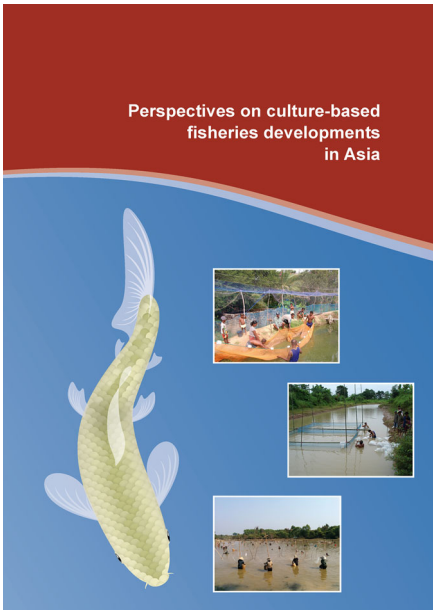

CONTENTS

Inspiring story of aquaculture in Sikkim: A journey from conservation to farming

Prakash Sharma and Riteshkumar S. Tandel

ICAR-Directorate of Coldwater Fisheries Research (DCFR; Bhimtal)

We, the authors, both scientists from Directorate of Coldwater Fisheries Research (DCFR Bhimtal), headed for Sikkim, India, in the month of December for collection of samples and data under various projects of the DCFR, reaching Gangtok in its chilly evening hours. In the early hours of the next day we visited the Directorate of Fisheries (DOF), Government of Sikkim and met the Director Mr I.P. Chettri, the Additional Director Mr. Sunil Pradhan and the Joint Director Mr D.B. Rai to discuss our visit, projects and other tour related matters. The DOF officers welcomed us with immense hospitality and assured to lend all possible assistance throughout our stay in the state. The Additional Director and the Block Officer, Mr Surendra Bhandari made arrangements for deputing at least one fisheries officer to guide us in their respective working places. We started our activity on this day itself by visiting carp farmers in the vicinity of Gangtok.

Throughout our tour program, we were assisted uncondition-ally by the Director, Additional Director, Deputy Director, Mr R.P. Subba and Mr Sonam Lepcha (Range Officers), Mr Surendra Bhandari, Mr Naresh Sunwar (Block Officer) and Mr Sonam Bhutia (Block Officer), and we wish to express our sincere thanks to them.

Team of scientists and fisheries officers interracting with farmer.

Sikkim at a glance

Sikkim is a small Himalayan state of India with total area of 7,096 square kilometers. It is surrounded by Nepal on the west, Bhutan in the east, China (Tibet) in the north and rest of India in the south. Although small, it is the most beautiful state for its natural Himalayan landscape and scenic beauty of snow-capped mountains, including mountain peaks such as Khangchendzonga, Kabru, Siniolchu, Thingchinkhang, Jopuno, Pandim, Rathong (online information, Tourism and Civil Aviation department, Government of Sikkim). The state has three climatic zones, ranging from tropical to temperature and alpine. The climate remains overall cold and humid throughout the year (State of Forest Report 2009 - ENVIS Centre Sikkim; online information). Rainfall occurs almost round the year combining pre-monsoon (April-May) and monsoon (May-October). The average rainfall from the months of May-October goes beyond 200 mm, and from June to September exceeds 400 mm at different places and altitude (online information, Meteorological Centre, Gangtok). There are three agro-climatic zones in Sikkim, namely cool type (< 10°C; 2000 m altitude and above), moderate cool type (10-20°C; 1000-2000 m altitude) and warm type (> 20°C; <1000 m altitude) (online information, Meteorological Centre, Gangtok). For aquaculture purposes, we can utilise moderate cool type and warm type agro-climatic zones for farming rainbow trout and exotic carps (grass carp; *Ctenopharyn-godon idella,* silver carp; *Hypophthalmichthys molitrix* and common carp; *Cyprinus carpio*) respectively. In the cool type agro-climatic zone breeding seed rearing and ranching of brown trout can be carried out for promoting sport fisheries and ecotourism.

Biointegration of rainbow trout and cardamom farming.

Brief background

Originally the Sikkimese population had little to do with fish consumption and fish farming. However at present time, with emerging knowledge of fish as a functional food and superior protein compared to other animal meat, fish consumption is becoming popular. As a result of this, the demand for fish in the state has reached 550 MT but the present production is only 160 MT (120 MT from capture and 40 MT from cultured; data obtained from DOF, Sikkim). Therefore, it would not be misleading to say that most of the demand for fish is being

Carp farm visit by team of scientists and fisheries officers and interaction with farmer at Tintek, East Sikkim.

met largely through import from other states, mainly Andhra Pradesh, West Bengal and Bihar. However, nature has gifted Sikkim with ample water bodies suitable for farming exotic carp species in the lower belt and rainbow trout in higher. Prior to 2008-2009, the development program for fisheries was confined to conservation of riverine fisheries, production and stocking of brown trout seed in the cold water streams and lakes for promoting angling but not for generation of livelihood for the farmers. However after 2008-2009, DOF has been moving with all possible speed in promoting fish farming to provide additional livelihood options for farmers, along with the technical and research support from DCFR. Down the line, DOF and DCFR are working hand-in-hand to harness the available water resources for the development of profitable aquaculture ventures. In doing so, DOF has started running-water exotic carp culture (2008-09) and introduced raceway systems for trout culture (2009-10) with the financial support of Rashtriya Krishi Vikas Yojana (RKVY), National Fisheries Development Board (NFDB) and the Fisheries Developmental Plan of the state government (FDP). Although the fisheries office was created in the late 1970s as a wing under Forest Department, it became a Directorate in 1995.

Contributions of DOF

Fish farming in Sikkim is in initial stage although the fisheries related activities were carried out date back from the inception of Fisheries Development Wing under Forest Department, but the activities of those times were mainly the propagation and conservation of trout (both rainbow and brown) and other naturally available hill stream fishes in rivers and lakes. But only very recently, the DOF has started promoting farming of exotic carps in mid hills and rainbow trout at higher altitudes for food security, farm income and sustainable rural livelihoods. They initiated the construction of concrete tanks (50 x 20 x 4 cubic feet) and raceways (45 x 6 x 5 cubic feet) for farming exotic carps and trout respectively, in farmers' land. The numbers of carp farming beneficiaries are increasing rapidly year after year and reached more than 1,200 at the end of 2014-2015 because of the site suitability, water availability and other operational feasibility. The growth rate of trout farming (in terms of number of beneficiaries) was not as fast as compared to carp farming. In the very first year, they were able to construct total of fifty three raceways for same number of beneficiaries. In 2010-2011, with the help of financial assistance from NFDB, RKVY and FDP, the DOF constructed additional one hundred and sixsuch trout raceways in all four districts of the state. By 2013-14, the DOF could increase the number of beneficiaries up to two hundred and forty (data obtained from DOF, Sikkim).

To date, state of Sikkim has more than 1,200 exotic carp farmers and 240 trout farmers with at least one growout tank each (data obtained from DOF, Sikkim). Recently, DOF have installed two fish feed mills in the state to meet the growing feed demand within the state. In addition to that, they

have nine carp and eight trout farms under DOF for seed rearing with total capacity of around 2 million carp seed and 500,000 – 1,00,000 trout seed per year (this is a rough figure taking mortality into consideration). In this way, the DOF is promoting fish farming to achieve production that can meet the half of the demand by 2016-17.

Despite of shortage of manpower, they are working in all aspects for promotion of fish farming, starting from selection of sites (based on water availability in terms of volume and perenniality, temperature assessment round the year), availing funds for construction of raceways, healthy stocking material (bred and reared in government farms of DOF) and feeds (procured from outside of state until now), and providing training and exposure visits to farmers, etc. They are also working on formation of fish farmers' cooperatives and creation of domestic fish markets in each of four district headquarters within these cooperatives. According to them, the cooperatives are formed in fish farming pockets that can help in collecting the fish from respective locations and bring it to the markets. The involvement of these fish growers' cooperatives in marketing activities can rule out the middlemen and maximise the margins for fish growers.

Status of exotic carp farming in Sikkim

We visited the different villages where they do carp farming, those includes Namchebung (Pakyong, East Sikkim), Rakdong-Tintek (East Sikkim), Ranka (East Sikkim) and South Regu (East Sikkim). There, we interacted with farmers about the farm management, feed and feeding and the challenges they face down the line in running a fish farming operation. Most of the farmers, at present, are farming grass carp in majority (more numbers) and common carp in minority (less numbers). According to them, grass carp grows faster than silver and common carp. In addition to this, feeding of grass carp is easier than rest two carps. The growth of this fish, based on their experience falls between 300-1000 grams in 10-12 months culture period. They complained about the size variation, slow growth specifically in common carp and high mortality in temperature extremes in case of silver carp.

Based on our survey, we came to know that the stocking time, density and variety are not uniform. Some farmers' stock seeds in the months of March-April, and this probably prove to be the best stocking time because in doing so, fish can be cultured in long high-temperature period that is from March-April to October-November (7-9 months). Otherwise, if they stock in July-August (most of them they follow this), they either have to harvest in October-November (that will be very short time for producing marketable size) or hold them through winter without any growth. Therefore, stocking in July-August is not recommended, however farmers are forced to practice this because of easy availability of seed in July-August than in March-April, and also due to the lack of the knowledge on slow winter growth. They may need proper guidelines and training on seed rearing technology, stunted seed rearing technology for raising fingerlings through winter

Carp farm visit by team of scientists and fisheries officers at Tintek, East Sikkim.

period (this can even prove as an effective two-cropping aquaculture activity for better profit) so that the stunted advanced fingerlings will be available for stocking at the onset of high-temperature period (March-April to October-November (7-9 months). If followed so it can be beneficial in following different ways:

1. Some interested farmers (who want to go for seed rearing of carp) get one additional crop (one grow-out and other seed rearing) which can prove to be the climate smart aquaculture operation.

2. Availing stunted fingerlings for grow-out may prove to be beneficial because these fingerlings if fed appropriately, in terms of nutrition and feed, can grow faster and reach marketable size in a short time.

3. Ultimately farmers can earn more profit through multi cropping (winter/monsoon) and short (mainly at the time of water availability and high temperature) farming and may help them to earn a better livelihood.

During our interaction with farmers we observed some of problems such as shortage of feed, good quality of seed, mortality at stocking and marketing issues. To meet the feed requirement they used to feed grass carp and common carp with kitchen waste, a mix of mustard oil cake, wheat flour, maize flour and rice bran in different combinations and proportions based on availability. Sometimes they feed

Rainbow trout farm of progressive farmer at Sreebadam, West Sikkim.

grass carp exclusively with grasses such as chayote/is-kush/ squash; *Sechium edule*, bamboo leaves, banana leaves, vegetable leaves, napier grass; *Pennisetum purpureum* and doob/durva; *Cynodon dactylon*.

As mentioned earlier, some of them stock seed in August-September and culture the fish with slow-to-no growth over the chill winter months and face the winter driven mortality (some of them were complaining about winter mortality). We had a thorough discussion regarding the stocking related mortality, and we could draw a hypothetical reason behind the same that pond might not have matured enough in terms of

Rainbow trout breeding and seed rearing facility of DOF, Uttarey, West Sikkim.

plankton availability, formation of natural biofiltration systems, etc. Others are not encountering such problems of mortality possibly because of stocking the seeds when the colour of tank turns green with plankton (following all protocols of pond preparation such as manuring with cow dung, liming, etc). We will discuss the marketing issue at the end collectively for both carps and trout.

Status of trout farming

To gather the information regarding trout farming, we visited the villages that are involved, which include Pangthang, Tumin, Zuluk, Phadamchen (East Sikkim) and Uttarey (in and around government trout farm, West Sikkim). We got enough opportunity to interact one-on-one with farmers, and the best thing we observed among them was that they were very much interested to expand their operations provided that feed and seed were readily available throughout the year. The motivation behind their interest in expansion of trout farming is maximum margin (currently selling @ Rs. 500-800/kg), more than they earn than any other existing farming they are involved with. We discussed feed and feeding management, the need for sorting and grading, size-specific harvesting (harvesting bigger fish earlier and letting the smaller to grow and harvest subsequently, so that all the fish in the tank get enough opportunity to grow more than 500 grams) and marketing. Because of the lack of sufficient raceways, they have insufficient space for sorting and grading; instead, some of them follow size-specific sequential harvesting.

Trout farm at panthang, East Sikkim.

Differential growth and size variation is common problem in trout farming, possibly induced by improper feed and feeding management. According to them, when feed and feeding, in terms of optimum nutrition and feeding strategy is not an issue, they get satisfactory growth of about 500-1,000 grams in 10-12 months of rearing. The raceways of beneficiaries were built in such a place where the farmers have access to optimum water source even in the months of December, and the temperature in winter and summer does not cross

Carp farm at Namchebung, East Sikkim.

the lethal value (based on the mortality information obtained from farmers), as DOF had guided each farmer in a very appropriate manner for the same.

Among the farmers we interacted with, the majority of them follow stocking @ 300-500 fingerlings per raceway but some are stocking @ 1,000-1,200 per raceway at their best management efforts. In general, they feed trout with feed supplied by DOF, but some farmers feed cooked beef liver at the very early stage of stocking to ensure better survival. We observed variation in feeding strategy from farmers to farmers; progressive farmers follow size-specific feeding strategies, feeding 4-6 times per day at early stages and twice daily at later stages. That may be the reason why they are practicing multiple cropping and getting best possible profit out of small tanks.

Overall the scope for the expansion of trout farming is more promising than with carp because of the high price of the fish and the high margins. If we can increase the raceway holding from one or two per farmer at present to at least five based on the suitability of site and the current performance of the farmers, by any means of public funding, we can ensure a best possible sustainable livelihood for the farmers.

Conclusion

Overall the aquaculture in the state is growing, although at a slow pace but the possibilities and perspectives are promising in ensuring new and better means of livelihood to the farmers. However, down the line there are many constraints, which if not addressed in time may impede the growth of the sector. Some of the common problems associated with carp and trout farming, in an ascending order of intricacy in addressing, and with their possible solutions include:

- **Mortality at the time of stocking:** This can be easily mitigated by following better pond preparation practices considering all water quality related issues prior to stocking.

- **Non availability of feed:** To address this issue, a detailed study involving the survey of availability of local ingredients is needed to be carried out for formulating and manufacturing cost effective feeds for both carp and trout so that the farmers may procure feeds easily as and when they require it.

- **Insufficient seed:** DOF is working hand-in-hand with ICAR-DCFR for breeding and seed rearing related activities. To some extent the state is becoming self-sufficient in trout seed production. However, the breeding and seed production of grass carp within the state needs serious attention and if not addressed, the farmers need to depend on seed supplied from outside the state where quality and availability is not certain.

Carp farm visit by team of scientists and fisheries officers and interaction with progressive farmer at Tintek, East Sikkim.

- **Marketing issues:** DOF has taken initiatives to form fish farmers cooperatives, these cooperatives in turn can run and regulate cold storage equipped fish markets in each district. By doing this, the influx of middlemen can be reduced that in turn can ensure best margin for farmers and lowest possible price for the consumers. Even cooperative personals can operate the feed manufacturing and distribution side-by-side the marketing of farm products that can ensure even better flow of farm input and output.

Acknowledgement

The support provided by the Director, Dr A. K. Singh, ICAR-DCFR and Director, DOF, Sikkim and other Fisheries officers, DOF, Sikkim during the visit is deeply acknowledged.

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Farming of scampi and tiger shrimp together: A case study from West Bengal, India

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Scampi produced at Mrityunjoy's farm.

In tiger shrimp *Penaeus monodon* farming, farm ponds connected to estuaries, brackishwater rivers and creeks are considered ideal since pond water salinity of 12-20ppt is a favourable parameter and basic requirement. The giant freshwater prawn *Macrobrachium rosenbergii*, which has become an important cultured species in freshwater aquaculture systems, requires pond water conditions similar to the Indian major carps. Recently it has been experienced that remarkably both *M. rosenbergii* and *P. monodon* could be cultured simultaneously in the same environment, i.e., freshwater ponds. Sri Chandra has worked extensively as technical supervisor to commercial shrimp and scampi producers in brackishwater and freshwater farms respectively in Purba Medinipur District in West Bengal.

Sri Mrityunjoy Bal, S/o Sri Bishnupada Bal, residing at Vill. Gorbhera under Dighanagar Mouza, P.O. Gurgram, Block Bhagabanpur-1 under PS Bhagabanpur, Dist. Purba Medinipur, West Bengal, is a moderately resource-rich professional prawn farmer, who has been involved in nursery rearing and grow-out monoculture of M. rosenbergii since 2004. He owns three scientifically-managed, perennial and rain-fed grow-out ponds of approximately 0.1 ha, 0.2 ha and 0.36 ha in area, having 1.2-1.8 metres depth. Since March-April 2013, he has been practicing farming of both these species together in his first two freshwater ponds. During March-April, he procures seeds of *M. rosenbergii* (5-8mm; paddy grain size, counted by spoon) and *P. monodon* (PL-15; 14-15mm size) from professional riverine prawn/shrimp seed fishers; seeds of such size of these two species are available in the Rupnarayan River (captured at Kolaghat, distance of 65km from Gorbhera village) and the Keleghai River (at Sabang) in this district during March to July. Mainly scampi seeds are available in the Keleghai River. Seeds are transported at his pond site either in aluminium hundi or empty dalda oil plastic containers of 15 litre capacity, with pores on lid, each containing 5,000-5,500 pieces. Each seed of *M. rosenbergii* and *P. monodon* costs Rs. 2.00-2.50 and 40-50 paisa respectively. Scampi seeds available during July-August are not much preferred for farming.

Scampi and tiger shrimp.

During April, in a 400m^2 nursery pond he normally stocks 10,000 M. rosenbergii and 20,000 P. monodon seed and rears them together for 35-45 days, within which *M. rosenbergii* and *P. monodon* attain 3.9-5cm and 7.7-9cm (3g) in body size respectively, suitable for grow-out farming. Since pond soil pH in this region is between 4.5-5.0, a higher dosage of lime is applied before seed stocking. Commercially available granular-type feed is provided to both species @ 80-100g/10,000 seed every day during the first ten days of rearing, 100-140g/10,000 seed during the second ten days, 140-480g during the third ten days and 480-880g/10,000 seed every day during the fourth ten days (ie. until day 40). Although it is scampi feed, it is given to both species and *P. monodon* accepts it.

In the end of June and at the onset of monsoon, in his 0.2 ha grow-out pond, Sri Mrityunjoy had stocked 10,000 *M. rosenbergii* juveniles obtained from nursery pond and 4,000 of *P. monodon* of size 7.7-9cm. *P. monodon* is harvested in the end of September or early October before Durga Puja and in this four month period of grow-out culture, tiger shrimp attained 40g body weight on average, almost of same size with only 5g size variation and 70-75% survival. It fetches him a farm gate price of Rs. 400-450/- (US$6.15-6.92) per kilogram. Protein-rich pelleted feed 'Waterbase Magnum XL Premium Prawn Feed' (25kg sack, Rs. 80/- per kg; 1.5-2.0mm pellet diameter) is provided to both scampi and tiger shrimp in the pond four times a day; a strict feeding schedule is maintained beginning with 7% feed application per day in the first week of culture (considering 2.5-3.0g average body weight (abw)), 6% feed every day in the second week of culture (considering 4-5g abw), 5% feed every day in the third week of culture (6-7g abw); it continues and ends up with 1.5% feed every day in the thirteenth week of culture (considering 35-37g abw), 1.2% feed every day in the fourteenth week of culture (38-40g abw); in the continuation period of culture beyond 90 days, the final schedule is maintained. Sri Mrityunjoy uses 'grower' type feed (1-2mm diameter pellet) to scampi and tiger shrimp up to 25gm size and 'finisher' type feed (2-3mm pellet) is used thereafter till time of harvest.

M. rosenbergii is harvested from his pond at the end of January of the next year and in this seven month period of grow-out culture, beginning from June-July, scampi attains 45g body weight on average, with wide variation in size from 25g to 90g. Farm gate price of such scampi is Rs. 500-550/- per kg (US$8.46) and Rs. 600/- (US$9.23) for those above 100g weight. In days of insufficient rainfall, tubewell water/ groundwater is let into culture ponds. Sri Mrityunjoy's elder brother Sri Gangadhar Bal is also a professional Scampi producer and practices monoculture of *M. rosenbergii* only.

Both of them mentioned that occurrence of *P. monodon* seeds in river Rupnarayan at Kolaghat and nearby areas is less in comparison to *M. rosenbergii* seeds and also demand for

hatchery-bred *P. monodon* seeds is much greater than for wild riverine seeds. Seed collectors prefer to capture and segregate *M. rosenbergii* seeds. According to them, hatchery-produced *P. monodon* post larvae will not survive in scampi culture ponds; it will require brackishwater conditions. Only riverine *P. monodon* seeds can be cultured in association with *M. rosenbergii*. Although present, the availability of tiger shrimp seeds in the Rupnarayan River at Kolaghat (salinity: assumed maximum 4-5ppt, in March-April) is not sufficient and those are mainly found in Ramnagar Canal, Mandarmoni Canal and Pichhaboni Canal, which are naturally-occurring creeks in the same district, much nearer to the estuary and Bay of Bengal and have 12-18ppt salinity. Sri Mrityunjoy mentioned that *P. monodon* seeds collected from these creeks will not be able to survive in his freshwater scampi ponds, and but that they are ideal for brackishwater ponds. Kolaghat station in the Rupnarayan River is located at a distance of 135 km from the sea.

Sri Mrityunjoy applies dolomite and triple super phosphate in recommended dosages during the culture period and uses a mini pump (drawing up pond water and forced release/ flushing out up to a distance from pond dyke) to maintain the dissolved oxygen level in the pond water. He has not faced any problems of viral infection (WSSV or MBV) in growing *P. monodon* in his freshwater scampi culture ponds in last three years. In his opinion, there is much less risk of occurrence/ outbreak of devastating viral diseases in farmed *P. monodon*, when cultured in freshwater conditions in low density and using seed obtained from regions such as the Rupnarayan River with less than 4-5ppt water salinity. It has been determined in previous studies that water salinity in Rupnarayan at Kolaghat is 0.01ppt in monsoon, 0.20ppt in post-monsoon, another study showed 0.22ppt, maximum salinity in year 1993 was 0.9ppt, salinity as mean of three seasons: 0.5ppt. Scampi farmers can also obtain *M. rosenbergii* seeds of

Sri Mrityunjoy with his mixed harvest.

10-20mm size from the Shilabati River at Ghatal in Dist. Paschim Medinipur during March-May. Juvenile-sized scampi seeds are available in the Keleghai River at Egra and Potashpur in Purba Medinipur during July to October. In Purba Medinipur District of West Bengal, which is the major district where *M. rosenbergii* is cultured in monoculture systems on a commercial scale, the main producing areas include Bhagabanpur, Moina, Sabang, Pingla and Junput Police Stations/Blocks. In 25-30 villages of the aforesaid blocks, presently there are about 1,250-1,300 professional prawn farmers. The farming practice shown by Sri Mrityunjoy Bal is expected to encourage tiger shrimp farmers to rear the species in freshwater systems in low density, so that the risk of viral disease problems can be reduced.

Haul of scampi and tiger shrimp.

Labeo pangusia:
A potential candidate species for diversification of hill aquaculture

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Bhimtal, Upland Central, Himalayan Lake.

The hill regions of India harbour a diverse array of fisheries resources, including both indigenous and exotic, cultivable and non-cultivable species. Most of the available species are used for food, while few of them are used for sports and ornamental purposes. In the last few decades, the demand for fish has increased drastically, due to population increase and urbanisation in the hills and its adjoining regions. The coming decades are expected to pose newer and greater challenges to coldwater fisheries sector both in the development of aquaculture and conservation practices in the hill regions of the country.

The coldwater fisheries comprise vast and varied aquatic resources with streams and rivers (10,000 km), natural lakes (20,500 ha), reservoirs (50,000 ha) and brackish water lakes (2,500 ha) (Mahanta & Sarma, 2010). The upland fish fauna comprises 258 species, belonging to 21 families and 76 genera. Out of these, the maximum of 255 species have been recorded from North-East Himalaya, 203 from the West and Central Himalaya and 91 from the Deccan Plateau (Vass & Raina, 2002). Among these, mahseer and brown trout are known for their game and sports quality, while a few have ornamental value and most of them are used as food fishes including endemic and exotic species such as snow trout, rainbow trout, loaches and Chinese carps.

The highlands of the north eastern region are the abode of many endemic species and it is believed that many species in the remote mountainous areas are still to be identified and exploited. *Labeo pangusia* is one such prized hill stream carp predominantly found in the deeper pools of upland streams. It shares similar habitats to those of mahseer (Mahanta & Sarma, 2010). *L. pungusia* grows to a fairly large size and is highly preferred by consumers as it is considered to be nutritious and good for the health (Sarma et al., 2014). It is sometimes considered as the 'rohu' of the hilly region perhaps due to its resemblance with *L. pangusia* can thrive well in lakes and fast flowing streams of hilly regions, with a preferred water temperature ranging from 10-20°C. They can also survive in Himalayan tropical waters having a maximum temperature of up to 30°C. Obviously, because of its high demand, the species is rampantly caught and this has led to its drastic depletion over the years. Since aquaculture is one of the fastest growing sectors in the world, this high priced hill stream carp can be considered as a candidate species for diversification in freshwater aquaculture, particularly of hill aquaculture.

Unless an effective conservation strategy is immediately taken, this prized species may be wiped out in the wild before long (Mahanta & Sarma, 2010). One conservation strategy for a threatened species is in-situ conservation through captive

Sangetser, a high altitude North Eastern Himalayan Lake.

rearing and breeding. Despite its importance as a food fish, no major attempt has been made to rear the fish in controlled conditions. Therefore, in the present communication, certain aspects of the biology, habitat ecology, rearing and breeding possibilities of *L. pangusia* in captive environment has been discussed.

Identification key of *L. pangusia*

Body elongate and dorsal profile more convex than ventral. Overhanging small mouth with distinct lateral lobes. Eyes small, lips thick and non-fringed. One short maxillary barbels, concealed in labial fold. Dorsal fin inserted to snout tip, pectoral fins do not extend up to pelvic fins and fin deeply forked. Lateral line complete with 40 to 43 moderate scales.

Labeo pungusia.

Segregation of female.

Fish body colour varies with water colour. In rivers, the fish exhibits brownish colour above, yellowish and white at sides and below (Vishwanath et al, 2011).

Biology

L. pangusia exhibits seasonal feeding intensity with bimodal peaks: One in March - April and other in September - October (Mahanta & Sarma, 2010). The fish lay eggs in the mid of April to end of July when the water temperature is between 24-28°C in the north eastern region. The species attains maturity in the second year of life (Mahanta & Sarma, 2010) at a length of 2-30 cm in both males and females. It is a highly fecund fish and the fecundity ranges from 750,000 to 800,000 eggs. The maximum length recorded is 90 cm (Menon, 1999). It is a slow growing species. Although males grow faster than females, the female attains a larger size than the male. Spawning occurs coinciding with monsoonal rain and fingerlings are usually encountered in August-September when the floodwater recedes. *L. pangusia* can breed in the natural environment.

Selection of male.

Table 1: Water quality parameters recorded during the captive breeding program.

Water quality parameters	Optimum range
Temperature	28 -30°C
pH	7.5-8.5
Dissolved oxygen	6-7 ppm
Total hardness	250-300 ppm
Total alkalinity	200 - 250 ppm

Table 2: Weight of injected brooders during the breeding trial.

Weight of male brooders (kg)	1.5± 0.01 kg
Weight of female brooders (kg)	2.0± 0.06 kg
Ovatide dose (ml/kg)	0.5-1.0 ml/kg

Stripping of eggs.

Captive rearing and breeding of *L. pangusia*

The IUCN classify *L. pangusia* as 'near threatened' (IUCN, 2014). Therefore, an attempt has been made for captive rearing and breeding of *L. pangusia* at Nameri Eco Camp, ABACA, Nameri National Park in Assam, India. The breeding trial commenced on 11 July 2015 with the selection of male and female broodstock. The broodstock were of 3+ years in age and were reared in a cemented tank of size 200 m^2. Only broodstock that had fully attained gonadal maturity under pond conditions were selected. The length of the brooders ranged from 35-50 cm and they weighed between 1.0-2.0 kg. The brooders were administered with inducing agent Ovatide @ 0.5ml-1ml/kg body-weight in both male and female brooders (2:1 ratio). The fish were kept in breeding hapas overnight for courtship and mating. Spawning occurred 6-8 hours after hormone injection with 70% fertilisation success. The fertilised eggs were transparent, white and round in shape. A total of 750,000-8 00,000 fertilised eggs were achieved during the breeding trial.

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

L. pangusia is a highly preferred, high-priced species. If the culture protocol of the species is perfected and seed availability in a large scale is assured, it has the potential to fetch higher market demand in the domestic markets of Himalayan states. The cost of fresh fish may increase up to Rs. 500-600 during the festive seasons in the north eastern part of India. The price of the species is reported to be two times higher than the Indian major carps, which may generate more profit to the famers. The highly coiled intestine and the nature of the gut contents indicate that the species browses in the river bed for periphyton and detritus and therefore, the species is a detritophagus in feeding habit. Since the fish is bottom feeder in nature, it can be considered as an alternative to other bottom feeding fishes in composite fish farming, without compromising the yield and profit. Also, in order to save the germ plasm of *Labeo pangusia* from extinction in nature, it is important to culture them in pond conditions and propagate their seed on a large scale, with due regard for the genetic

Stripping of milt.

diversity of hatchery-produced and wild populations, for release into the rivers/streams to increase their population as well as rehabilitation of the fish in the natural eco-systems.

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Analysis of water quality parameters.

Sustainability of an integrated livestock-fish-crop farming system as a small scale enterprise

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A model integrated livestock fish crop farm.

Operation of a single commodity farm such as fish, poultry or livestock may not be sustainable in the long run because of high input costs as well as risk involved and cumulative impact of waste disposal on the environment. Scientific integration of different farm components such as livestock – fish - crops etc. can be a viable option for sustainable production of different commodities with lower investment, mitigation of risk factors and environmental impact. The present communication deals with sustainability of an integrated farming system over the long term. This system incorporating fish, livestock and crops in an ecologically balanced proposition may be an ideal example for economically sustainable small scale agri-enterprise through utilisation of available resources. Calculation of benefit cost ratio and analysis of cash flow patterns reveal that the system is economically sustainable in the long run. Additional advantages like mitigation of environmental pollution through waste recycling, avoidance of health hazards, convenience in management and reduction of risk add distinction to the system as farmer-friendly and eco-friendly.

Over the last three decades India has witnessed considerable growth in fish production from inland aquaculture through intervention of science and technology as well as intensification in farming. Intensification of fish farming practices is cost intensive and as such often beyond the reach of poor or marginal farmers. Further, intensification of fish culture is often linked with degradation of environment and beset with problems such as the unavailability of essential inputs like low cost, balanced feeds and essential equipment, particularly in rural areas. In view of the above emphasis has been paid to popularise fish farming based on integrated farming practices with low external input requirements and almost zero harmful impact on environment. One such technology is the integrated fish livestock farming system, in which livestock manure is recycled in fish ponds for production of fish without any external supply of manure and feed. Different forms of integrated livestock fish farming viz. pig-fish, poultry fish, duck fish etc. have been evolved and popularised in India.

Livestock production is important for the majority of farmers in developing countries especially for small and marginal farmers. FAO used the term ‘Livestock Revolution’ to describe the expected massive increase in livestock production in developing countries to meet the increasing demand for livestock products due to growing world population. But the livestock revolution is afraid to compete strongly with human food production. Presently, the livestock industry already

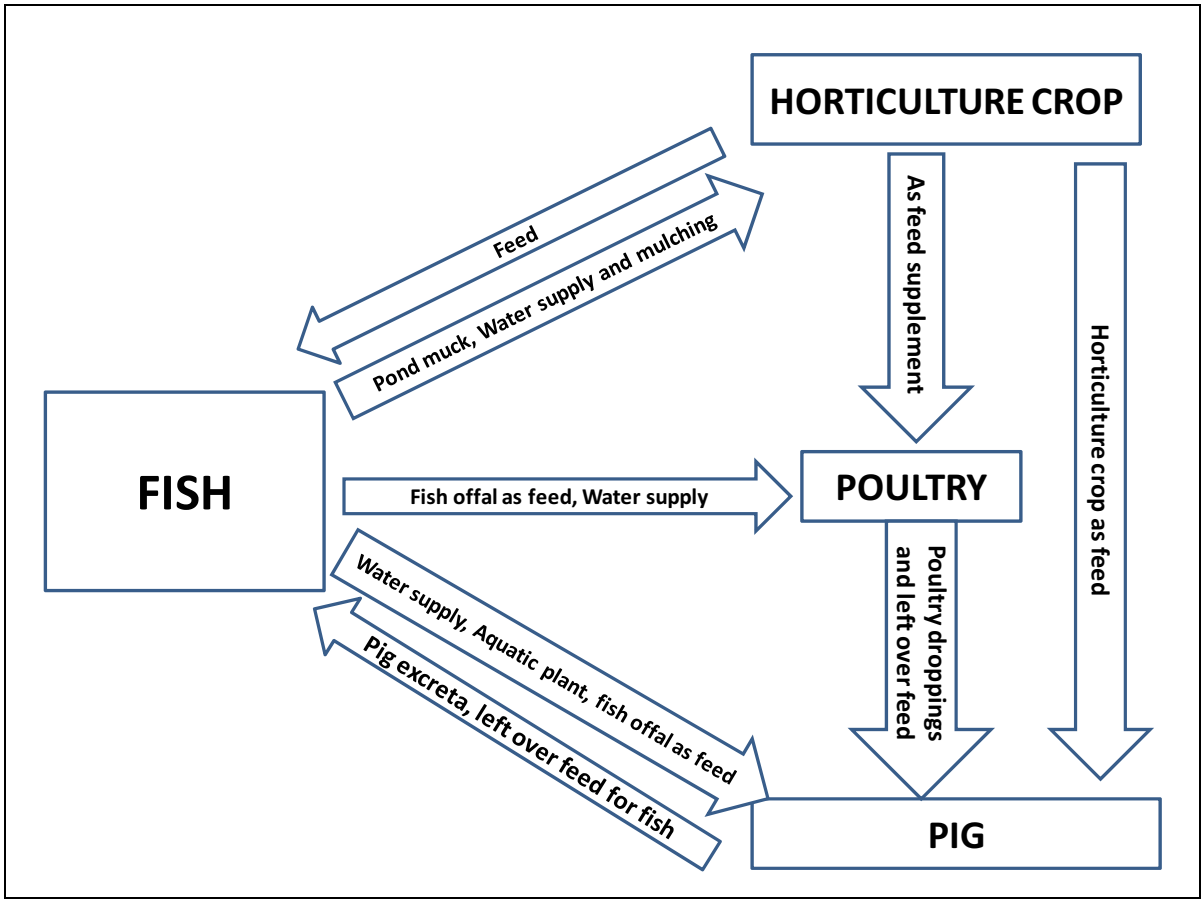
consumes almost 50% of world cereal grain supplies[4]. It is therefore very important to develop livestock production systems which do not depend completely on cereal grain. Alternative low cost and eco-friendly feed sources for livestock nutrition are very important for sustainable livestock production. Technologies developed so far are mainly for intensive and industrialised livestock production systems that do not fit well with the socio-economic status of poor and marginal farmers of India. An analysis of different livestock projects revealed that many were inadequately adapted to the social, economical and cultural reality of the families belonging to the targeted population[1]. A common strategy used by rural families to counteract risks and optimise opportunities under changing and adverse circumstances is to diversify their activities[5]. Integration of livestock with other farming components is the most easily adoptable strategy to address these factors.

In view of the above, studies have been undertaken at Fisheries Research Centre, Assam Agricultural University, Jorhat, Assam, India to develop a sustainable integrated farming model for small land holdings. This model is an ecologically sustainable livestock-fish crop farming technology suitable for small and marginal farmers. It is low cost and facilitates maximum utilisation of available biological resources and recycling of organic wastes. In this system, raising of two livestock components, pig and poultry was integrated with fish farming and horticulture crop production. Poultry droppings were used to supplement pig nutrition and pig waste was recycled in fish ponds, whereas the pond muck and excess livestock waste were used for fertilisation of horticultural crops. For rearing of the two livestock components (pig and poultry) simultaneously, specially designed housing units were constructed in the pond embankment. Each unit is comprised of two subunits arranged vertically one above the other. The upper subunit was designed to raise poultry as per standard practice of poultry husbandry and the lower subunit was constructed as per specification for pig husbandry. A perforated floor between the two subunits and a galvanised iron sheet fixed just below the perforated floor in a slanting manner, facilitated use of poultry droppings and leftover feed as pig feed. The pig droppings and left over pig feed were washed down to the pond through a cemented drain connecting the floor of the pigsty to the pond.

Six species were used in semi-intensive carp farming ie rohu, catla, mrigal, common carp, grass carp and silver carp following the standard package of practices for pig-fish farming. Ponds were stocked with carry over seed (yearlings) at a density of 8,000 ha. No extraneous supply of feed or manure was used except for grass carp feed in the form of aquatic or terrestrial vegetation. Stocking rates of pigs were kept at 40 /ha and 10 birds (layers or broilers) per pig to supplement around 40% of pigs' daily feed requirement[2]. The ratio of chicken : pigs : fish was kept at 10: 1: 200 in this system. Every six months pigs attaining slaughter size were disposed of and new batches were procured. Water quality parameters were monitored and pH of water was regulated by interim application of lime. Desilting of the pond bottom, bottom raking as well as control of algal blooms as and when required was done by following standard methodology. The pond embankments, inter pond spaces and other free areas of the farm were used for crops such as banana, lemon, areca nuts and coconuts etc. Regular observation of health and weight gain of the livestock and fish was conducted. Data on total production of fish, pigs, poultry, horticultural crops, total investment revenue generated and net income were collected annually. Analysis of cash flow, calculation of percent profit over operational cost, benefit cost ratio, and

Specially designed house for poultry and pigs.

Figure 1:



internal rate of return was conducted for the entire period (13 years) following standard methods to ascertain the economic sustainability of the system.

In intensive production systems generally resources or raw materials are extracted from the earths' surface, turned into desirable products and then byproducts of this process in the form of massive amounts of waste materials are discharged back, the cumulative impact of which leads to air, water or soil pollution. This linear model, often referred to as 'cradle to grave' model is not sustainable in the long run, as earth's surface does not have the capacity to endlessly supply increasing amounts of resources, or to absorb all the pollution and waste indefinitely. In contrast, sustainability can be achieved in the 'cradle to cradle' model for production where the concept of waste is eliminated entirely, as the wastes produced during production of one commodity are recycled or utilised for production of other commodities[3].

The pattern of nutrient flow in the system under study makes it a perfect paradigm for sustainable 'cradle to cradle' model. In this integrated system all waste is reutilised as input for another component of production. This circular model for production will not exploit nature for raw materials or degrade it with pollution. External input for the whole system includes 100% ration for the poultry and 60% ration for pig. Exclusion of external feed and manure input for fish crop reduces the cost of production of fish to the tune of 60 - 70% and use of poultry dropping, left over horticultural crops, aquatic weeds etc. in pig production reduces costs 50-60%. Production cost of horticulture crops are also reduced to around 60% through utilisation of organic wastes as manure as well as mulching material. Hence this system involves low external input costs but assures production of multiple commodities from unit area through nutrient flow from one commodity to other forming a food circle. The cash flow analysis done on the system indicated a steady positive cash flow from second year onwards which indicated the economic viability of the system. The cost benefit ratio calculated for the last 13 years (2.68-3.04) also supports the economic viability of the system.

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Sustainable coastal aquaculture in India

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Fisheries is a sunrise sector both at the national and state levels in India, playing a vital role in the economic development of the country. However, it was recognised as an important allied sector of Indian agriculture only after independence. When our country gained independence food storage was the most important problem and hence the First Five Year Plan addressed this issue almost exclusively. In order to evolve technologies for increasing fish production, the erstwhile Central Marine Fisheries Institute (CMFRI) at Mandapam and Central Inland Fisheries Research Institute (CIFRI) at Barrackpore were established in 1947. Since then, several fisheries research institutes have been formed. The vibrancy of the sector can be visualised by the 11-fold increase in fish production in just six decades, i.e. from 0.75 million tonnes in 1950-51 to 10.07 million tonnes in 2014-15. The unparallel average annual growth rate of over 4.5% over the years has placed the country on the forefront of global fish production, only after China. Besides meeting domestic needs, the dependence of over 14.5 million people on fisheries activities for their livelihood and foreign exchange earnings to the tune of 304 billion rupees (2014-15) from the fisheries produce, amply justifies the importance of the sector on the country's economy and also livelihood security.

Shrimp farming is the most important aquaculture activity of the coastal States and Union Territories along the 8,118 km coastline of India. Since the late 1980s the shrimp farming sector has witnessed a boom resulting in many entrepreneurs opting for setting up of hatcheries, feed mills and integrated farms in many areas of the coastal states. However, the unregulated growth of shrimp farming since 1990 has posed a number of social, ecological and economic issues mainly due to improper planning and lack of regulatory frameworks. The *Coastal Aquaculture Authority Act 2005* received the assent of the President of India on 23rd June 2005 and consequently was promulgated by the government. The Act provides for the establishment of a Coastal Aquaculture Authority (CAA) for regulating the activities concerned with coastal aquaculture in the coastal areas and for matters connected therewith or incidental thereto in the notified coastal areas and to promote responsible and sustainable aquaculture.

The major problem faced by the farmers practising the black tiger shrimp, *Penaeus monodon*, culture was the lack of quality seed. Viral infections, which plagued the shrimp sector, could not be contained and the shrimp production in the country declined to a level of 76,000 metric tonnes in 2008-09 from 140,000 metric tonnes in 2005-06. Consequently, the area under shrimp culture declined; many developed farms were abandoned; several hatcheries were closed. This was reflected in the decline in feed production and usage of other inputs, decline in exports of shrimps and loss of labour and the consequent impact on the livelihood of dependent coastal people. Crisis in the shrimp aquaculture prompted the farmers and hatchery operators to look for alternative species for culture and strategies to tide over the crisis. Considering the success of SPF *Litopenaeus vannamei* culture in many of the Southeast Asian countries and China, the Indian Government decided to introduce the species initially on experimental basis and based on the results of experimental culture and risk analysis studies, decided to allow commercial scale farming of SPF *L. vannamei* after formulating guidelines.

In view of the regulations, SPF *Litopenaeus vannamei* is taking strong roots in India and the results achieved thus far have been spectacular. Identification of broodstock suppliers based upon evaluation of genetic as well as disease status has ensured supply of quality SPF broodstock to Indian shrimp hatcheries. Farms with poor productivity have successfully been utilised for highly productive SPF *L. vannamei* farming with adequate biosecurity and effluent treatment systems. Cluster-based farming systems, where small-scale farmers with properties in a local area are brought together to cooperate, were introduced in order to facilitate farmers having small farm holding by having common ETS and biosecurity measures. Many abandoned shrimp farms, closed hatcheries and feed mills have been revived after the introduction of SPF *L. vannamei*. All these have culminated in Indian shrimp production and exports reaching all-time high levels with substantiall increased productivity, increased employment generation and development of many ancillary industries dealing with inputs, equipment and processing. In order to fully harness the advantage of the coastal aquaculture sector, all the stake holders need to comply with the notified statute, rules, guidelines and regulations of CAA and ensure that biosecurity is not compromised in hatcheries and farms and that good aquaculture practices (GAP) are adopted to prevent introduction and spread of diseases and negative impacts on the coastal environment.

Tiger shrimp farming

The coastal aquaculture activities in the country have been involved in the farming of three species, *L. vannamei, P. monodon* and scampi *(M. rosenbergii)*. Tiger shrimp farming has been undertaken for a long time and India dominated the international market for tiger shrimp, particularly for the Japanese market, in the past. Brackishwater aquaculture in India has been concentrated around the black tiger prawn as the single most important species.

In terms of farm area where tiger shrimp was cultured, we see a disturbing trend. The area under tiger shrimp farming halved from 157,400 ha in 2001-2002 to 71,400 ha in 2014-15, about a 56 % decline. The maximum area under tiger shrimp farming was 157,400 ha in 2001-02. West Bengal and Kerala were the two coastal states where traditional tiger shrimp farming is still undertaken, mostly as an extensive method of farming with minimal or no input use.

Farmed tiger shrimp production too followed a similar trend. It went down from 102,940 metric tonnes in 2001-02 to 73, 156 tonnes in 2014-15, declining about 29 %. It peaked in 2006-07 with an estimated output of 144,347 tonnes. West Bengal doubled its tiger shrimp production. Orissa too reported an increase but Kerala saw a decline in the output. The major loss was in the case of Andhra Pradesh which

reported a production of 51,230 tonnes in 2001-2002 which increased to 75,414 tonnes in 2006-07 but fell to a mere 2,962 tonnes in 2014-15. Thus, tiger shrimp production has become almost confined to traditional extensive farming in West Bengal, Orissa and Kerala. Though farmers evince interest in the revival of tiger shrimp farming the lack of availability of SPF tiger shrimp seed in the country still remains a constraint. The Department of Animal Husbandry, Dairying and Fisheries of the Ministry of Agriculture and Farmers Welfare is seized of the matter and has commenced permitting of broodstock multiplication centres (BMCs) for both *P. monodon* and *L. vannamei* to minimise dependence on supply of SPF broodstock from overseas.

L. vannamei farming

Decline in the tiger shrimp farming due to diseases particularly whitespot (WSSV) led to introduction of exotic Pacific white shrimp, *Litopenaeus vannamei*, because of its fast growth, perceived low incidence of native diseases, availability of specific pathogen free domesticated strains and culture feasibility over a wide salinity range with possibility of high density farming. With the production levels of 10-12 tonnes/ha/crop in 3-4 months the production of this species has reached to phenomenal levels.

The Coastal Aquaculture Authority was established in 2005, replacing the erstwhile Aquaculture Authority by an act of Parliament called The Coastal Aquaculture Authority Act, 2005 on the directions of the Supreme Court of India to regulate coastal aquaculture in the country. A risk analysis study on the introduction of SPF *L vannamei* broodstock from overseas for healthy seed production and farming was commissioned and the central Institute of Brackishwater Aquaculture (CIBA) was engaged to carry out the study. Also, pilot scale import of the SPF broodstock was permitted to two private hatcheries for seed production and farming. Based on the recommendations of the study as well as on the results of pilot scale shrimp seed production and farming it was decided to allow import of SPF *L vannamei* broodstock for healthy seed production and farming in 2009. A process was carefully developed for this purpose. First the CAA will approve the farm and hatchery as per the guidelines framed for this purpose. Overseas suppliers of SPF *L vannamei* broodstock were shortlisted by the Technical Committee of the CAA based on certain features like the genetic history of the stock, disease free status as per OIE list, government guarantee that no OIE disease was reported in the country of origin of the supplier, etc. The approved hatchery would then obtain a Sanitary Import Permit (SIP) from the Union Ministry of Agriculture and Farmers Welfare based on the Annual Import Allocation order issued by the CAA. The Anna International Airport in Chennai, Tamilnadu State was designated as the single port of entry for the SPF broodstock into the country. Once the SPF stock enters the port then it would be taken to the Aquatic Quarantine Facility specially created for the *L vannamei* where it will be kept and tested for presence of OIC list of pathogens. After the clearance by the AQF the broodstock will be handed over to the hatchery operator who will then take it to the hatchery for seed production as per the CAA guidelines. The shrimp hatcheries shall abide by the technical guidelines and other rules of the CAA and the CAA regularly monitors the hatcheries for compliance of the guidelines.

Pacific white shrimp was farmed in 283 ha in 2009-10 when it was just introduced into the country to replace tiger shrimp. It recorded increase in the farm area continuously reaching 57,267 ha in 2013-14 but fell to 50,240 ha in 2014-15 due to diseases and other farm problems. In terms of production, Pacific white shrimp output was estimated at 1,731 tonnes in 2009-10 which rose to 353,413 tonnes in 2014-15 recording increase in the farm production every year. The trend is expected to continue in future too.

Sustainable farming

CAA has been taking steps to ensure compliance with technical guidelines and related rules for sustainable coastal aquaculture in the country. It shortlists overseas suppliers for SPF *L. vannamei* broodstock. The registered hatcheries should import such stocks from them only after obtaining Sanitary Import Permit (SIP) issued by the Union Ministry of Agriculture and Farmers Welfare. The hatcheries should use the imported SPF broodstock for six months only for seed production and after six months they should discard this stock and inform the CAA accordingly. CAA monitors this activity regularly. The Seafood Exporters Association of India has signed an MoU with the CAA under which CAA supplies the list of importers of the SPF *L. vannamei* broodstock for the last six months which the Association publishes in the newspapers in Andhra Pradesh. CAA also publishes the list in its website www.caa.gov.in. This initiative was undertaken to disseminate information on actual importers of broodstock so that the shrimp farmers could buy healthy seeds from any of them. Any registered farmer could also complain to CAA if unhealthy seeds were sold to them.

Disease is another major issue and many institutions are involved in addressing this issue. The Central Institute of Brackishwater (CIBA), Chennai, MPEDA, RGCA and state fisheries colleges are undertaking regular disease monitoring activities and necessary advisories are issued by the competent authority. Good management practices (GMP) are to be followed by the stakeholders. Many awareness and capacity building programmes are being undertaken regularly by all relevant institutions. CAA also conducts Trainers Training Programme (ToTs) to the officials of the state departments of fisheries on such issues besides the technical and legal aspects of coastal aquaculture.

CAA is mandated with registration of inputs and formulation of standards for the inputs used in coastal aquaculture. Accordingly it started registering such inputs since 2015. So far 842 input products from 135 companies under 8 categories have been registered by the CAA and the farmers are advised to use these products as they were certified free of antibiotics. Rejection of Indian exports of marine products had become another major issue and all institutions are engaged in addressing this issue at their respective level. The list of such registered products are available in the CAA website. CAA plans to make this voluntary initiative into a mandatory activity and CAA will regulate the use of the inputs in accordance with the CAA Act 2005 and other relevant guidelines and notifications for sustainable coastal aquaculture.

Conclusion

Pacific white shrimp has successfully replaced tiger shrimp in India, thanks to the rigid policy framework implemented by the CAA with necessary government support besides other

related government institutions. CAA registers all coastal aquaculture activities in the country and the area between HTML and 2 km towards land comes under its jurisdiction besides saline waters like estuaries, backwaters, lagoons, etc. It is headed by a chairperson, a judge of the High Court (the apex court in each state in the country) and run by a member secretary who is an academician of not less than 25 years of academic or research experience in coastal aquaculture and holds the rank of Additional Secretary in the Union Government. It has experts in coastal aquaculture, environment protection, trade, agriculture in addition to four representatives (usually secretaries or commissioners of fisheries) from coastal states on rotation basis. It has various committees to shortlist overseas suppliers of shrimp brood-stock, and to undertake technical work relating to aquatic quarantine activities among others. It registers all coastal aquaculture activities in accordance with the *Coastal Aquaculture Authority Act* 2005, rules, regulations, government notifications and technical guidelines and has legal power to close down any such activity which does not conform to these rules. It is registering all coastal aquaculture inputs to ensure that they are antibiotic free. The CAA is working for the sustainable coastal aquaculture towards the goal of doubling the coastal aquaculture output in the next few years.

Potential scope and prospects of domestic fish market in Kawardha District, Chhattisgarh, India

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Fisheries have been recognised as significant sector in the state of Chhattisgarh as prospective entrepreneurial enterprise as well as potential source for income. Nevertheless, it has been opined that the fisheries sector contributes to the livelihood of a large section of economically underprivileged population in India (Ayyappan and Krishnan, 2004). More than 250,000 people of the state, basically the economically weaker section of the society, depend on this sector as reliable occupation for their livelihood. Despite vast inland fisheries resources in the form of reservoirs, rivers, tanks and ponds, Chhattisgarh is yet to achieve self-sufficiency in fish production. Insufficient understanding of existing marketing network also contributes to extended marketing channels and marginalisation of fishers. Institutional changes are therefore important to improve the economic prosperity of fishers who are often exploited by middlemen (Rao, 1991). Moreover, a well organised marketing network is essential for distribution of fish at reasonable prices (Goswami, et al. 2002). No information or data is available on the fish market in spite of the growing importance of fish trade in the state. With this background, the present study was undertaken with regards to the socio-economic status of different stakeholders in the fish market and to understand the prevailing marketing system, market flow of fish, marketing channels and constraints that act as hindrance to the growth of fish markets in Kawardha District.

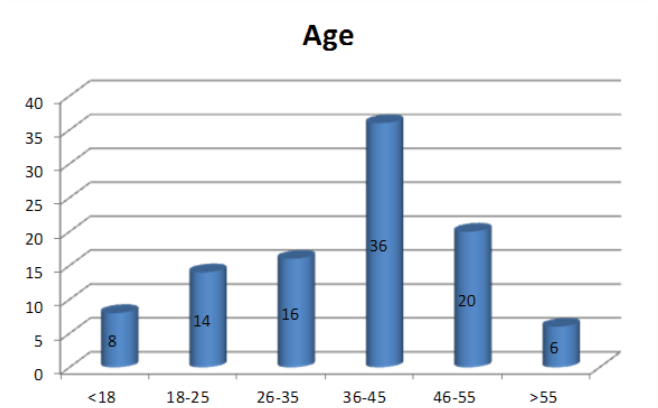
Socio-economic profile

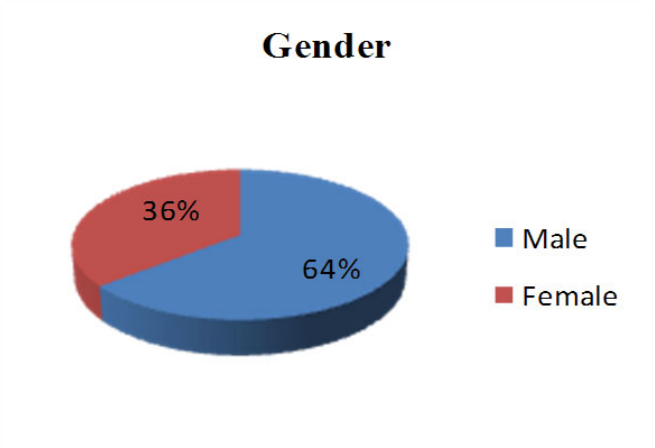
Figure 1 shows the socio-economic profile of the fifty respondents. It was observed that majority of them (36%) were in middle age (36-45 years) and 8% were below the age of 18 years which consisted largely of children who were engaged in sale of semi-processed fish products like smoked and sundried fish; only 6 percent of respondents were above 55 years of age. Young adults (18-25 years) and adults (26-35 years) respondents were 14.00 percent and 16.00 percent, respectively. Most of the respondents engaged in various market activities of fisheries were male (64%). This indicates the male-oriented nature of this sector in the study area. Regarding marital status, 74 percent of the respondents were

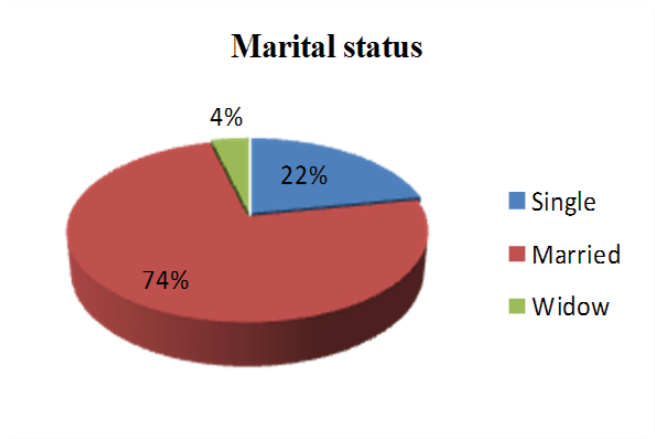
married and 22 percent were single and 4% were widowed. It was interesting to note that most of the respondents in the fish market attained primary education only (64%) and only a very meager proportion (6%) were found to be illiterate. Furthermore, 28% were educated up to higher secondary level, while only one of the respondents was a graduate. Most of the respondents (64%) had joint families while remaining 36% have nuclear families. As summarised in Figure 1, 52% of the respondents were earning Rs.10,001- 15,000/- (US$ 154 – 230) monthly followed by 26% who had a monthly income of Rs. 5,001-10,000/- (US$ 77 – 154). Eight percent of the respondents were earning more than Rs 25,001/- (US$ 384). Only two respondents (4%) had monthly income below Rs. 5,000 (US$ 77) per month. Experience-wise a majority of 32 percent fell into the category of 15-20 years and 18 percent of them had experience of more than 20 years in this field and 8 percent were below five years of experience, which consisted mainly of women and children.

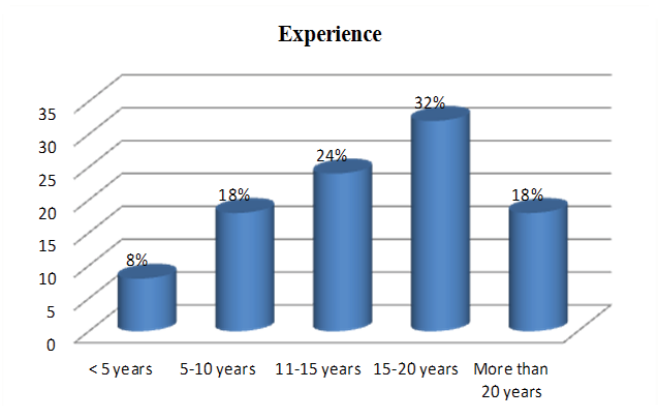
Market Infrastructure: The existing market infrastructure is of traditional one with no permanent structure; shed seller's sold fish on their previous occupancy using plastic sheets and aluminium containers on the semi-cemented floor in an open system. There is no fixed timing for the market and usually it starts at around 2.00 pm until the stock is exhausted or the unsold fish were either smoked using straw or bamboo twigs and branches or sundried for sale later. The source of water in the market is a hand pump. The drainage system in the market is very poor. Supply of electricity is good throughout the market. The mode of transportation is mainly by privately owned motor vehicle or bicycle.

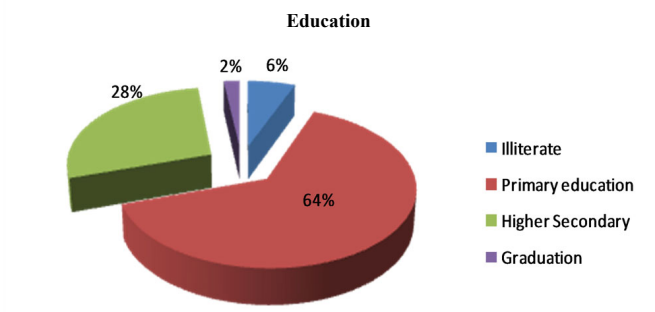
Fig.1. Socio-economic profile of the respondents (N= 50).





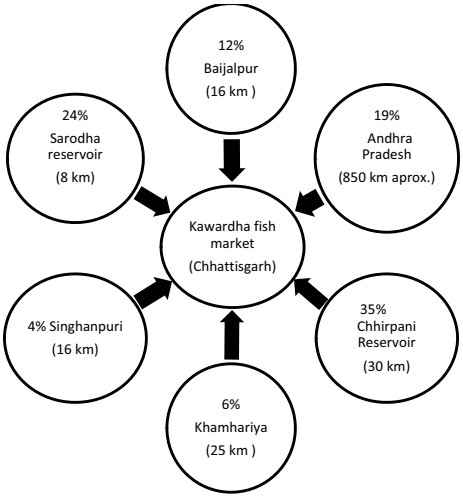






The flow of fish to the Kawardha fish market is presented in Fig. 2. Fish are supplied from different locations of the state as well as outside the state. 35 percent of fish were from Chhirpani Reservoir, 24 percent from Sarodha Reservoir and 12%, 6% and 4% from Baijalpur, Khamhariya and Singhanpuri, respectively and 19% from outside the state. The commercially important species were mainly the Indian major carps which were also imported from Andhra Pradesh (19%), indicating a high demand of fish in the study area.

Fig 2. Flow of fish to Kawardha fish market.



Species diversity in market arrivals

Table 1 shows the diversity of fish species available in the market. Arrivals of fish species vary with the season. Locally available species were observed more in winter and the wet season compared to summer. Commercially important species are available throughout the year. Besides fresh fish, semi-processed products such as smoked and sun-dried fish are also available in the market, which are sold mainly by women and children of a different age group.

Market channels

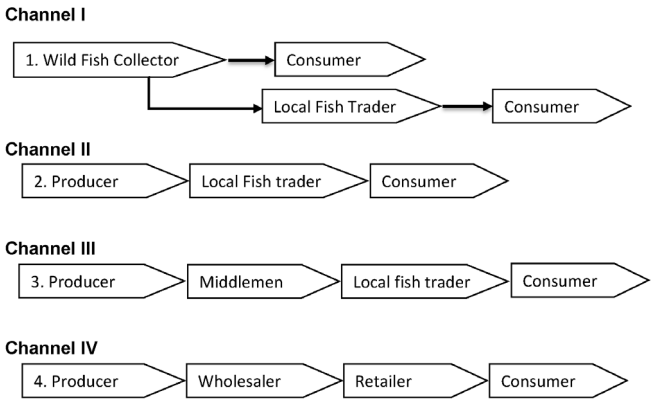
The study revealed that the market chain of freshwater fish includes wild fish collectors, middlemen, local fish traders, wholesalers, transporters as well as the fishers. The locally

Table 1. Fish species available in the market.

Name	Scientific name	Retail / kg
Locally available fish species		
Climbing perch	*Anabas testudineous*	120
Murrel	*Channa striatus*	150-200
	Channa punctatus	100
Goby fish	*Glossogobious sp.*	60-100
Eel	*Mastacembalus armatus*	180
Mola	*Amblypharyngodon mola*	100
Tilapia	*Oreochromis sp.*	50-80
Magur	*Clarias batracus*	150-200
Singhi	*Hetereonoptis fossilis*	250
Loach	*Lepidocephalus guntea*	120-150
Feather-back	*Notopterus sp.*	80
Tengra	*Mystus sp.*	150
Puntius	*Puntius sp.*	50
Chinghri	*Macrobrachium choprai*	100
Freshwater shark	*Wallago attu*	200-250
Commercially Important species		
Catla	*Catla catla*	140
Rohu	*Labeo rohita*	120
Mrigal	*Cirhhinus mrigala*	100
Common carp	*Cyprinus carpio*	120
Grass carp	*Ctenophyaryngodon idella*	100
Silver carp	*Hypophthalmicthys molitrix*	80-100
Pangus	*Pangasius sp.*	80-100
Bighead carp	*Hypophthalmicthys nobilis*	120-150
Locally processed fish		
Traditional smoked fish	All varieties of fish	Number basis
Sun-dried fish	Prawn, *Puntius sp.*	Number basis

Source: Primary survey.

Fig 3. Existing marketing channel in the fish market.



available indigenous species were collected by wild fish collectors and they directly sell to the consumer or else supply local traders. The high value fish species were sold to wholesalers and retailers through middlemen or directly by local fish traders. The disposal of fish is undertaken in the following prominent market channels as shown in Figure 3.

The market demand for fish is high while price of fish is also very low compared to other markets of the state, hence disposal of fish has never been a problem for the fish traders.

Constraints

The major constraints are mainly related to the unorganised marketing system prevailing in the study area. Some of the major setbacks of the present market are mentioned below:

- Low market price of fish as compared with other fish markets of the country.
- Lack of cooperative marketing organisation.
- Inadequate credit facilities for purchasing necessary inputs.
- Lack of knowledge on hygienic handling of fish which affects the quality of fish.
- Lack of transport, storage, ice and parking facilities.
- Inadequate awareness among the stakeholders on available schemes of central and state government.

Conclusion

Although the domestic fish markets play a significant role in the livelihood of the rural population the state is lagging behind in terms of an organised fish marketing system with a proper strategy and institutional arrangement. The present fish marketing system requires modernisation and demands a needs-based training of the stakeholders with assistance from concerned line departments of the state government. A lack of transportation and communication facilities has restricted the sale of fish to low prices from limited outlets. In order to curb constraints from time-to-time awareness and upgrading of

knowledge through capacity building programmes, exhibition, front line demonstration by the concerned departments and SAUs, scientists and experts is required. It has also been concluded that state government's interventions will help to go a long way in the development of fish markets in the district and so also in the state.

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