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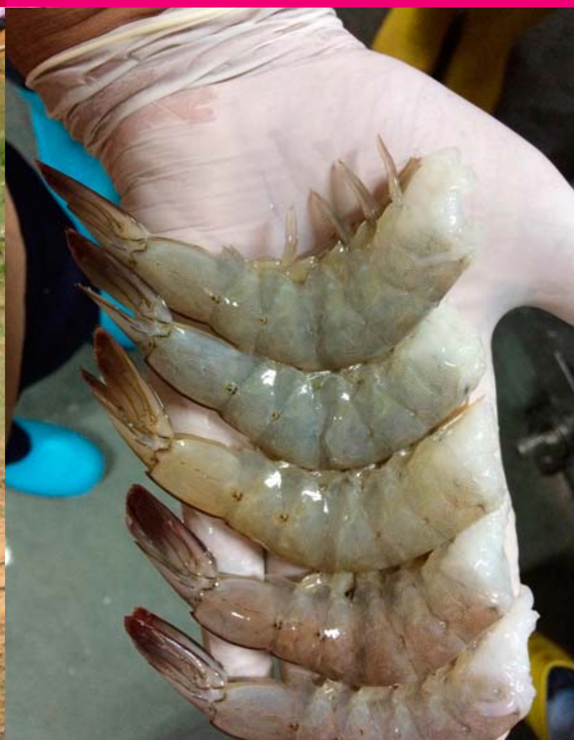
AQUACULTURE ASIA

Traditional community fishing practices, Assam

Culture-based fisheries, Cambodia

Shell colour variation

Indigeneous fish species



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Editor

Simon Wilkinson
simon@enaca.org

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.

Contact

The Editor, Aquaculture Asia
PO Box 1040
Kasetsart Post Office
Bangkok 10903, Thailand
Tel +66-2 561 1728
Fax +66-2 561 1727
Website http://www.enaca.org

Submit articles to:
magazine@enaca.org

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Anti-microbial resistance in aquaculture: It's more scary than you think

In this issue we start what will probably become something of a theme on the use of anti-microbial substances and the (consequent) development of resistant strains of bacteria, viruses and other pathogens.

We've all heard the stories about antibiotic-resistant "superbugs" that are turning up in hospitals. Bacteria that have become resistant to multiple classes of antibiotics, in some cases resistant to practically everything we can throw at them. Infections from what are in fact fairly ordinary microbes except that they are untreatable by modern medicine.

Welcome back to the pre-antibiotic era, circa 1940.

This is a problem entirely of our own devising. We made these organisms resistant through our own careless use - and it has to be said, abuse - of antimicrobial substances.

Instead of conserving these incredibly valuable resouces for times of actual need, doctors rampantly prescribe them for every running nose or stomach bug that would probably resolve by itself, left to run its course.

The terrestrial livestock industries routinely add them to feeds as "growth promoters". In aquaculture they are frequently applied to "treat" sick fish without any real idea of what the pathogen is, what antibiotics it is actually sensitive to, or whether the infection is actually the result of a pathogen or merely a symptom of an underlying problem such as a poor pond environment or bad husbandry.

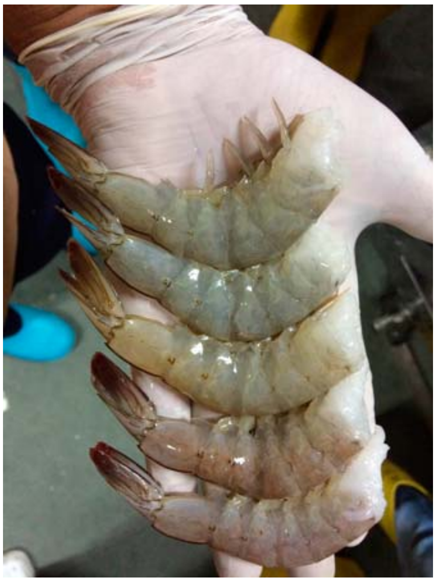
Investigating the cause of disease in aquaculture is a necessary first step before even considering the use of antimicrobial substances. If the real problem is that pond conditions are bad, antibiotics are not going to make sick fish better. If you don't actually know what pathogen is causing a disease, then you don't know what antimicrobial substances to apply - because different pathogens are sensitive to different substances. Using the wrong substance may not only be useless, but harmful to the fish and a complete waste of money.

To make matters worse, a farm that is "doing the right thing" and not using any antimicrobial substances can still become affected by resistant microbes. What happens if the hatchery you bought your seed off has been routinely using the same antibiotic in their tanks for years? When you put those fish in your own pond the resistant bacteria they carry come with them. Oops. And consider that unrelated bacteria can share genetic factors for resistance via exchange of plasmids and similar mechanisms.

Unfortunately many farmers in the region simply don't have access to professional veterinary advice or knowledge of safety protocols. The question has to be asked - in such circumstances should they be using anti-microbial substances at all?

Simon Wilkinson

AQUACULTURE ASIA



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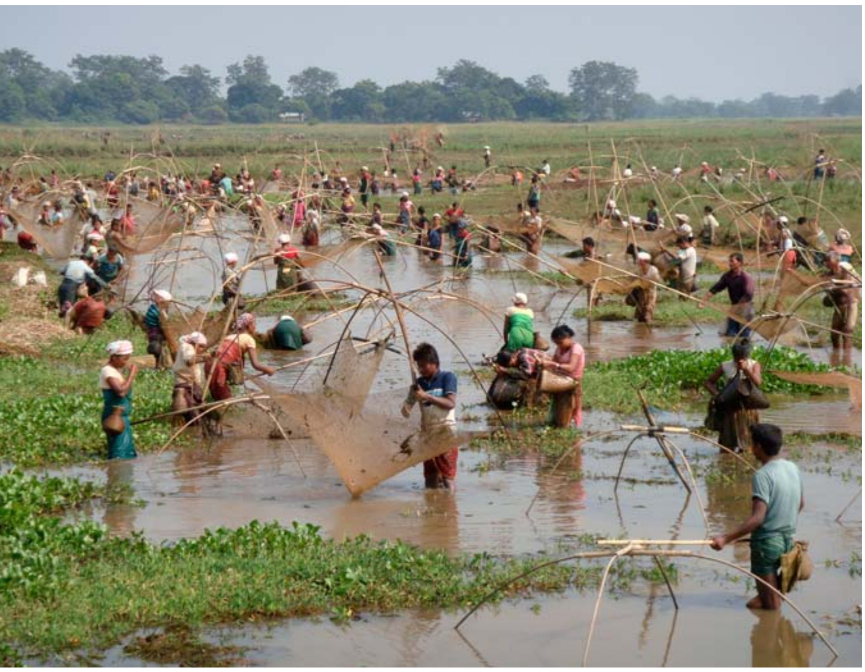
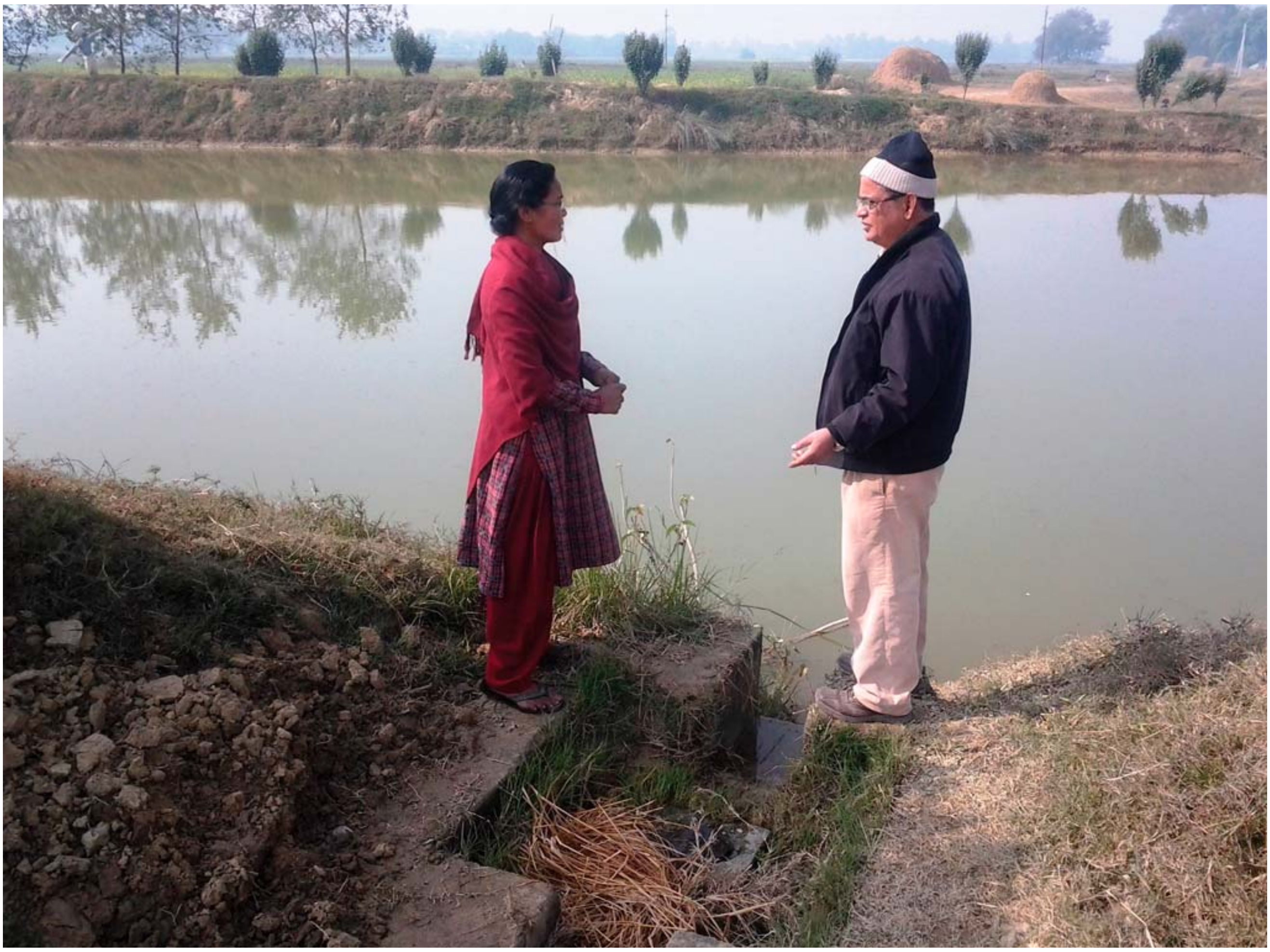


Participatory market chain approach: An unidentified sustainable supply chain model to boost fish nurseries

Shailesh Gurung

Assistant Professor, Tribhuvan University, Institute of Agriculture and Animal Science, Bhairahawa, Nepal.
Email: gurungshailesh@gmail.com



Technical knowledge sharing with Aqua extension worker.

Aquaculture, fish seed and participatory market chain approaches

In Nepal, unlike other developing nations, the prevalence of low quality and seasonal access to fish seed is an important restriction on the development of the aquaculture sector. Commercialisation of fish farming cannot progress rapidly in the absence of critical inputs and a regular supply of quality fish seed are an integral requirement for the transition of fish farming from a subsistence activity to a commercial enterprise.

Fish are a symbol of fertility, strength and prosperity in Nepal. With a wide range of aquatic habitats, from tropical lowland waters to cold highland rivers and a diverse array of fish species, Nepal offers many and varied prospects for fisheries and aquaculture development in the country (Gurung, 2003). Fishing is a long-standing tradition and customary activity in Nepalese society. However, in contrast to terrestrial agriculture, aquaculture is a relatively new and dynamic sector in Nepal (APP, 1995).

Fish breeding in Nepal started with common carp in 1960 (FAO, 2014). At present there are 52 private fish hatcheries, 13 public fish hatcheries and 123 private fish nurseries in operation within the country. However, hatchery production of carp seed, for which there is high demand, is still insufficient to meet the need of industry. Almost 77% of the carp seed in Nepal is produced by the private sector (Mishra, 2013). Overall, carps represent over 95% of national aquaculture production and approximately 70% of this figure is comprised of exotic carps.

Participatory market chain approaches (PMCA) are a key tool for the social and economic improvement of farmers and other market actors in a common platform with a dynamic solution in a joint supply chain modality (Staritz, 2012). A limited supply and monopoly market for inputs hinders the resilience of fishery sector both qualitatively and quantitatively in Nepal. We realised that a pocket-level fish thematic group concept would be very fruitful in ensuring progress by representing village and cluster-level problem solving arena among different actors, stakeholders and lead farmers. The

Calculating fish seed price in Bangladesh visit.

concept would improve the availability of quality inputs by facilitating a mutual trust-building environment over a wider area in a participatory way. This would contribute to a supply chain of quality products and improve livelihood opportunities and income as well (Stoian et.al., 2012).

Value chain modality based on PMCA, developed by the European Union funded Agriculture and Nutrition Extension Project (ANEP), has been found to be quite effective in the context of rural resource poor farmers, where both farmers and villages are scattered and timely access to resources is constrained.

The approach has helped improve aquaculture development in two districts of Nepal where conditions had otherwise proven difficult. The production of fish seed by service providers of ANEP in both Rupandehi and Nawalparasi districts were 21%, 32% and 47% of total production in 2012, 2013 and 2014 respectively, an improvement of more than double that achieved previously. Similarly, the total sale of fish seeds by ANEP project service providers in both districts was 18%, 30% and 52% of total sales in 2012, 2013 and 2014 respectively, which was also nearly double that of previous transactions of the local supply chain system (ANEP 2014).

Gender participation and fish nursery business

In aquaculture activities, gender equity is generally neglected, although female participation in the aquaculture workforce seems equally important, as illustrated by the case of Mrs Chitrarekha Tharu.

Before her involvement with ANEP Mrs Tharu was a housewife in Sapahi Village of Patkhauli VDC in Rupandehi District in the southern plains of Nepal. Being a member of a fish-loving Terai ethnic community, she was already well acquainted with fisheries. After her involvement as a group member in ANEP in 2012, she transformed her 0.32 ha of farmland into fish nursery pond and some growout ponds of her own volition.

The way she transformed her farm into an aquaculture business is a remarkable story. Two years after her husband returned from work as a labourer in a gulf country there was no particular income source for her household besides traditional farming practices. When the ANEP project entered the area she instantly became involved in a fishery group, joined capacity building training courses and participated in exposure visits. Up until then she had been reluctant to try new things due to a prior failure from her poultry business. At the initial period of second year, she got a chance to visit Bangladesh through ANEP. Immediately after her visit, she decided to take up fish nursing with technical assistance from the project team. She constructed two small nursery ponds along with two growout ponds in 2013 and started her business. In this campaign ANEP took the responsibility of contacting core as well as value chain households in the whole district using PMCA as a tool. Fish thematic group members of the PMCA tool helped her in establishing links to other beneficiaries of the value chain. As a result, she was rewarded with the success of her enterprise. In 2014, she felt encouraged and constructed an additional three ponds. Over time she has become recognised as a prominent fish farmer not only locally and in the district, but nationally.

How PMCA drives business success

Before 2012, there were no systemetic supply chain for fish seed in the Dhakdhahi cluster where Mrs Tharu lives. Seasonal unavailability of fish seeds created headaches amongst farmers, as the nearest fish hatchery was located miles away and could not fulfil their needs. Moreover, fish seed vendors from over the border with India used to deceive them by selling them low-quality fish seed. Farmers had hidden and unheard complaints about the fish seed quality, which reduced their productivity accordingly.

When the ANEP project mobilised in the area and created a better management system for fish farming activities with the participation of the local communities. For the development of a better supply chain of fish seed, a cluster-based fish thematic group operating under the umbrella of PMCA was

Delivery of fish seeds in packed bag from outside.

formed with the participation of leading farmers from each village. Mrs Tharu was elected as chairperson of thematic group of her cluster. Monthly meetings and situation based meetings started and helped to unite them at first. Participants put their views amongst the assembly, sharing problems and contraints in fish farming activities as well as solutions for common problems.

Mrs Tharu started to visit district-based fishery development centers and agriculture offices with team mates and started lobbying for development of effective aquaculture operations in their territory. She started to make requests for collection of the fingerlings in her area in regular discussion with leading farmers.

In 2013, she was nominated for a technical training cum exposure visit to Bangladesh sponsored by the Worldfish Center, one of the consortium partner of ANEP project. After the two week long visit, she realised and rectified some of the mistakes made during the course of management of her business. Afterwards she started to give more time and attention to her business than before. Through her sincere control and supervision, she produced appropriate advanced sized fish seeds in her nursery and started to sell among the farmers. The demand collection process in fish thematic meetings assures that all team members and other farmers will have a reliable supply of quality seed, improving farmer confidence.

Mrs Tharu Rs. 175,000 net profit from sale of fingerlings in 2013. Her family was highly motivated and encouraged by the result and now all members take a share of the work in the business. By the end of 2014 she had nearly doubled the income from her activities to Rs. 342,000. She has begun monitoring water quality parameters using electronic devices with training and extension support from the project.

Due to her increasing recognition and remarkable contribution in this sector Mrs Tharu has been again nominated as a member of the district fishery association and also as anexecutive member in the national level fishery entrepreneurs' association. Recently, she has started a home delivery system taking fish seed directly to the doorstep of farmers. This helps her to improve communication with the farmers, identify the real problems and understand their needs. Therefore she has established a high demand for her product and service and attained remarkable social prestige. She has become a successful enterpreneur cum service provider in fishery sector of Nepal.

Conclusion

For decades, farmers have been unable to improve aquaculture productivity in absence of quality fish seed inputs in Nepal. Although very fertile water resources are available for aquaculture, the linkage and coordination of input supplies was not systematic or effective for the promotion of aquaculture in these districts. The establishments of farmers groups, thematic groups under PMCA tool developed by ANEP, has united farmers. Their capability has been strengthened through continuous training, interaction, on-farm and off-farm visits and development of the supply chain. Over the past three years the farmers have been increasingly mobilised and empowered with positive impacts on their livelihoods and social and economic status.

Acknowledgement

The author wish to acknowledge the support from Agriculture and Nutrition Extension Project of the European Union, CEAPRED and WorldFish. Special thanks are extended to all the project staff, fish farmers, market actors and service providers who actively participated in different phases of this work. Last but not the least, we would like to extend our sincere thanks to Murshed Khondker e-Jahan for his untiring support and effort provided in ANEP.

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Traditional community fishing practices of rural Kamrup of Assam

Deepjyoti Baruah

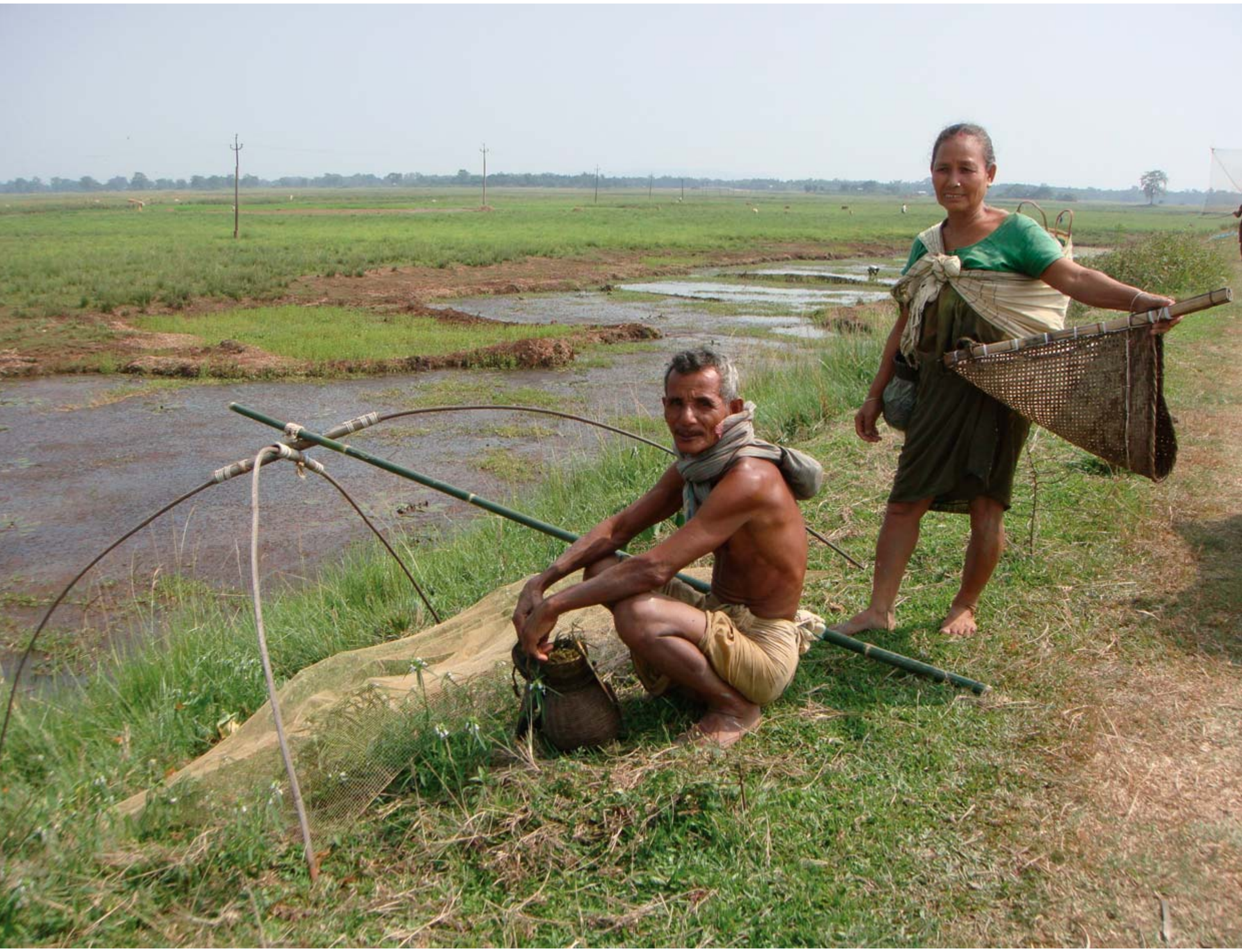
Fisheries Resource Assessment and Management, Extension and Training Section, ICAR-Directorate of Coldwater Fisheries Research, Bhimal-263136, Nainital, Uttarakhand. Email: deep_baruah@rediffmail.com.

Community fishing is a unique feature in the state of Assam of north eastern part of India. Here, fishing is done in groups of hundreds of people and thus the name. The present case study narrates a community fishing event in the floodplain wetlands *(beels)* of Kamrup District in Assam, India, witnessing participation of different tribal communities in fishing and the *modus operandi* of diverse types of fishing gears with catch details. Technical specifications of the different types of gears employed were collected from the direct observation following a prescheduled proforma[1]. The design details of the gear were documented and the photographs of different gears were prepared and gear categorisation is presented based on the FAO catalogue of Fishing Gear Designs[2].

The region

The rural part of Kamrup District lies in the lower Brahmaputra valley zone at a distance of 100 km to the west of the state capital, Guwahati. This lower Assam district covers an area of some 4,345 square kilometers and is bounded by the Brahmaputra River in the North, Morigaon District in the East, Goalpara District in the West and Meghalaya State in the South. The southern part of the district has a hilly terrain and is covered by forests and streams, while the northern part is attached to the southern bank of the Brahmaputra River and its associated tributaries and low lying floodplain zone.

Community fishing.



A tribe couple for fishing.

The fishing communities and the occasion

Local communities from different villages and localities assemble in a particular area and fish for an entire day. The process of fishing may last for a week or near to a month in specified wetlands of Assam, locally called beels. The fish catch is not made for any profit making venture and are usually used for their local consumption. None of the fishers were fishermen by profession but fish for joy and merriment. These types of community fishing practices are mostly seen among the tribal population of the state. The communities associated with traditional fishing in the district of Goalpara are the *Rabhas, Bodos, Hajong* and occasionally *Garos*. The tribesmen and women come from quite a distance with their fishing gear loaded on mini trucks which are hired for the day. The short distant travellers may come on cycles or by walk. Community fishing is done in the winter season during January-March in different parts of Assam. The depth of water in the beels during this season is usually knee height, where hundreds of fishers enter the water to fish at a time. The water is splashed and mud thumped while the gear is operated. This action is intended to disturb the bottom dwelling fishes force them out of the mud. The majority of these fishes are catfish and freshwater eels. The fishers usually carry their food for the day and a few may cook on the spot. A portion of the fishes caught during the event are also consumed directly on the fishing ground with locally prepared rice beers, rice, vegetables and meat. The tribal people cheer for every attempt made, fish merrily and are full of content for whatsoever the catch is made.

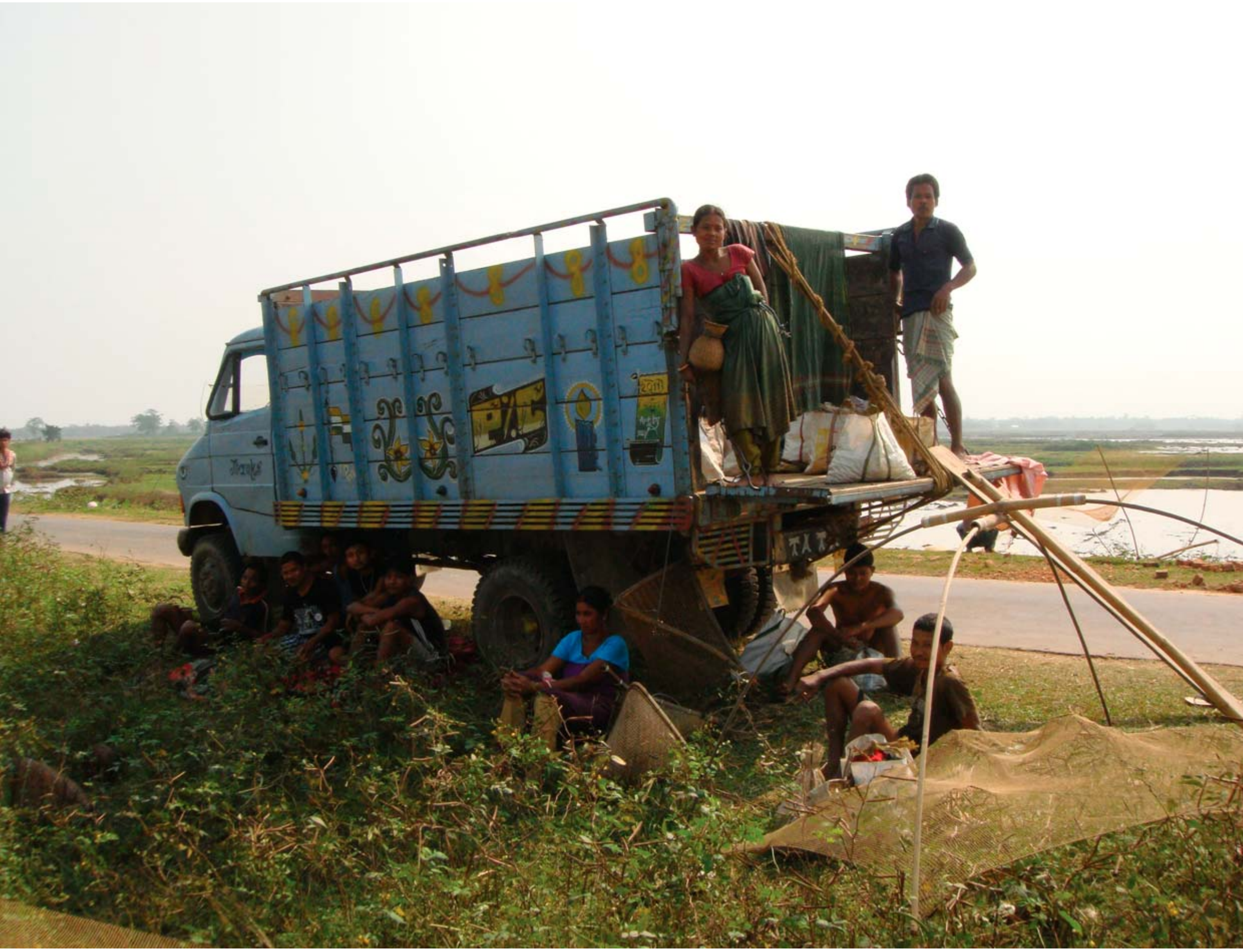
The fish catch

The floodplain of the Ganga, Brahmaputra and Barak rivers have the distinction of nurturing some of the finest wetlands of the country comprising some 213,000 hectares[3] where fish and fisheries remain a traditional economic activity with tremendous socio-economic impact in the rural sector. In India, Assam has maximum area of approximately 100,000 hectares of floodplain wetlands associated with Brahmaputra and Barak valleys[4]. These floodplain wetlands are inundated during the monsoon and therefore become nutrient rich and play a significant role as an economic resource through a substantial fisheries contribution for the people living

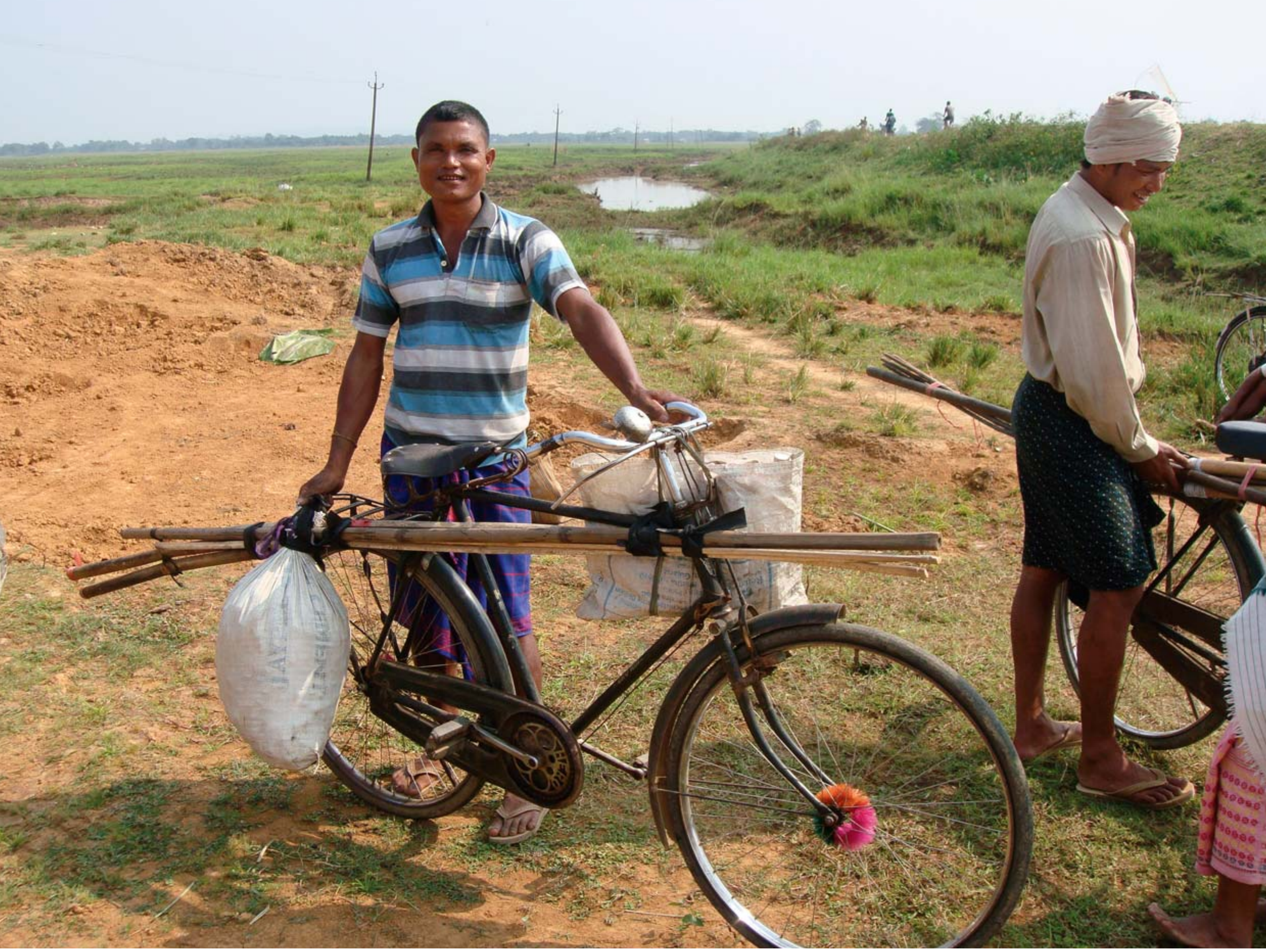
Table 1. Major type of gears operated during community fishing event.

Gear category	Gear type	Gender-wise percentage (%) contribution		Individual contribution among gears (%)
		Women	Men	
Scoop gear	Jakoi	90	10	25
	Chalonee	100	0	5
	Khorahee or Paachhi	100	0	5
Lift net	Porongi jal or Dharma jal	50	50	28
Falling gear	Polo	60	40	20
	Juluki	60	40	5
	Khewali jal	0	100	5
Spears	Jakhra	100	0	2
	Kosh or Hana	100	0	2
Push nets	Thela jal or ghoka jal or pah jal	60	40	3

adjacent to these *beels*[5,6]. These beels are one of the prime sources of natural capture fishery pre-dominated by small fish species (*Puntius* spp., *Chanda* spp., *Mystus* spp., *Nandus nandus*, *Amblypharyngodon mola*); carnivorous catish (*Wallago attu, Ailia coila, Ompok bimaculatus*); air-breathing species (*Heteropneustes fossilis, Clarias batrachus, Anabas testudineus*); murrels (*Channa punctatus, C. striata*) and featherbacks (*Notopterus notopterus, Chitala chitala*). Some of aquatic insects such as giant water bug (*Lethocercus indicus*) and diving beetle (*Dytiscus marginalis*) are also caught and relished as food by the fishers during the event. Most of the beels are given on lease these days to beel



A mini truck carrying the participants.


A participant on arrival with his fishing gear on cycle.

lessees who are also local residents of the area and are profit making associations. This at times, creates a conflict among the *lessees* and tribal communities as the latter believes that fishing in these *beels* are their birth right, as fishing and hunting has been traditionally practised since their ancestral times. The district authority comes into force in these circumstances so as to maintain the law and order in the locality. It was observed that people of different age groups from 10 years to 65 years participate in fishing. The majority of the fishers are women representing 60-70% of the total gathering. Selectivity of fishing gears is much influenced by factors such as characteristics of the water body, nature of target fish, gear materials and its operational skill and handling[7].

The fishing gears

Jakoi: This is a device made of non-textile webs in which the capture of fish is affected by a brailing or dipping action, and manually disturbing the bottom. The gear is triangular in outline and is made up of bamboo matting. The mouth of the gear is kept open by a single piece of thick bamboo split stitched to the matting at regular intervals. The same bamboo split extends further beyond the apex to form a short handle. A string or rope is attached to two arms of the mouth near to its base. The operator places the gear with its mouth facing him and disturbs the bottom mud with its feet, so that in trying to escape the fish enter the trap. The gear is scooped periodically to remove the harvest. This gear is versatile and found in almost all the districts of Assam, and is effective in capturing most of the bottom dwelling fishes such as *Mystus* spp., *Mastacembelus* spp., *Macrognathus* spp., *Heteropneustes* spp. etc.

Chalonee: This is a saucer shaped circular sieve made of bamboo matting with a diameter of 0.8-1.2 m. The device is inserted below a patch of floating water hyacinth in weed infested water bodies such as *beels* and ponds. Fish taking shelter underneath and within the roots of the water hyacinths are shaken on the sieve thereby forcing the fishes to fall on the sieve from the root tufts. Murrels, perches, eels etc. are its major catch. The gear is operated during the winter months (December-February).

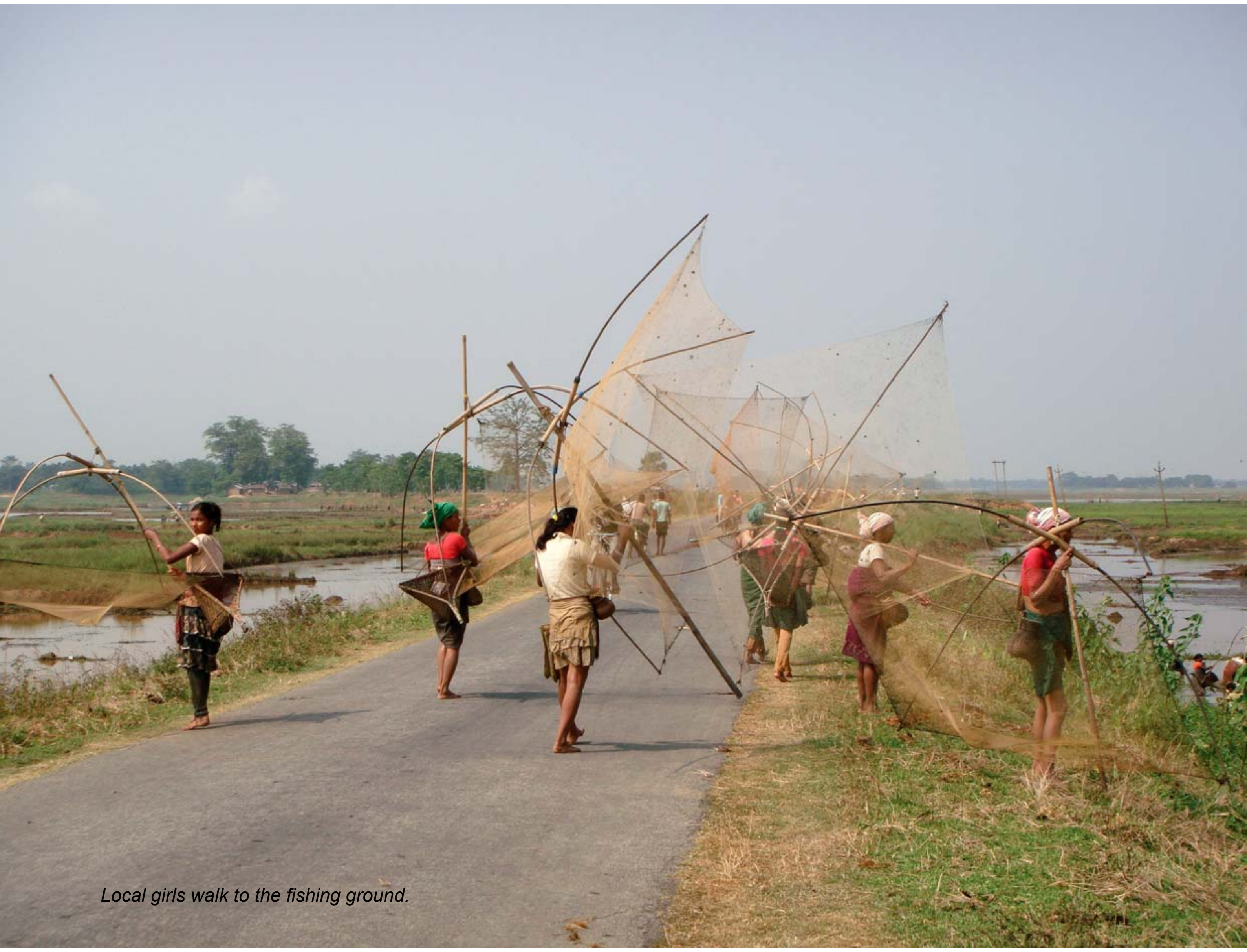
Khorahee or ***Paachi***: This device is similar to the above gear in the mode of operation, fishing season and the catch composition. However, these are bowl shaped (concave) baskets and thereby reduce the chances of fishes from escape. A *paachi* is a bigger basket than *khorahee* and can lift heavier load of floating weeds and have higher longevity. The catch composition of both the gears is mostly small prawns, *Puntius* spp., *Chanda* spp., *A. mola*, *Channa* spp., *eels* etc.

Porongi jal or ***Dharma jal***: This is a hand lift net, framed with a small piece of webbing, held horizontally and used entirely by hand or partly by mechanical power, in which the capture is affected by vertical lifting motion of the gear. This gear has a frame in the form of two split bamboos crossing each other and fixed in the form of an arch. To this is attached the square shaped net which has an uneven mesh size ranging from 15-60 mm which is stretched by the frame. The intersecting point of the cross bars/splits are fastened to a handle made of a whole bamboo piece of desirable length. The cross bars are approximately 2.4 m in length. The bamboo handle is used to facilitate the manipulation of net. The net is operated by hand or installed to shore. The net is set either at the bottom or in mid water for some time and then lifted to trap the fish swimming above it. The webbing material of the net is polyamide 210/1/3. A single person usually operates the net. Small sized fish are its usual catch such as *Danio* spp., *Barilius* spp., *Rasbora* spp., *Clupisoma garua*, *Eutropiichthys vacha* etc.

Polo: This is a covering pot or plunge basket of wicker construction, and the principle is to catch the fish by covering from above. This device is bell-shaped entrapping device devoid of a non-return valve with an opening both at the base and the apex. The gear is locally known as *polo* and is made of finely woven bamboo strips. The strips are 0.5 cm thick and are stitched by cane ropes at a interval space of 0.5-1.5 cm and 5-12 cm within vertical and horizontal strips respectively. The height of these gears varies from 47-155 cm with a diameter of 57-125 cm at the base and 15-25 cm at the apex. The fisher carries the trap in hand, slowly wades and plunges it into water in a probable place. The fisher firmly presses the pot; insert one hand through the top/apex opening and takes out the fishes caught inside. Medium sized fishes are the usual catch such as murrels, featherbacks, carps etc.

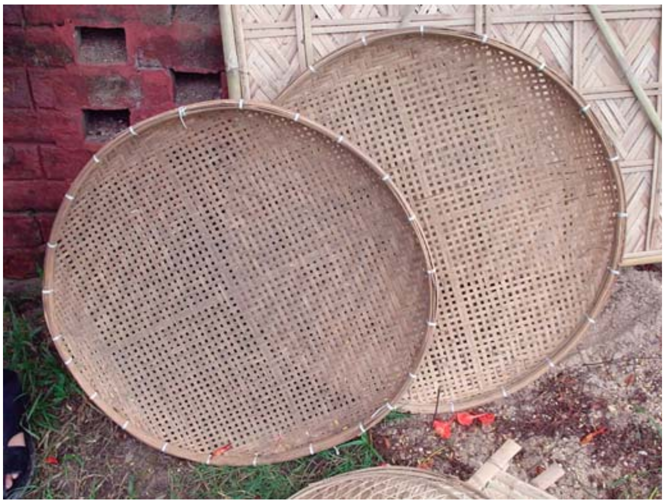
Juluki: The design, mode of operation and size of this pot is similar with that of *polo*. However, the interval spaces between adjacent woven bamboo splits are much smaller (2-3 mm) as compared to *polo*. As a result, very small sized fishes like minnows and barbs are caught in this gear. In certain locations, bait such as rice bran, flour is applied over a small canopy in shallow water areas to attract fishes before operating the gear. This gear is used year round.

Khewali jal: These are conical shaped nets usually operated by one person which are thrown or cast to cover the fish without waiting for a long time. The lower edges of these nets are folded or turned up inwardly and stitched to the webbings at regular intervals to form peripheral pockets. The nets are

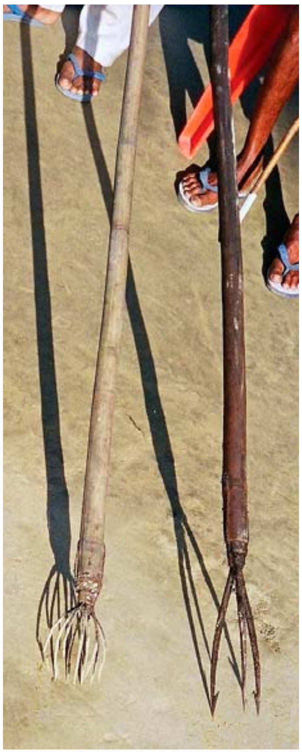


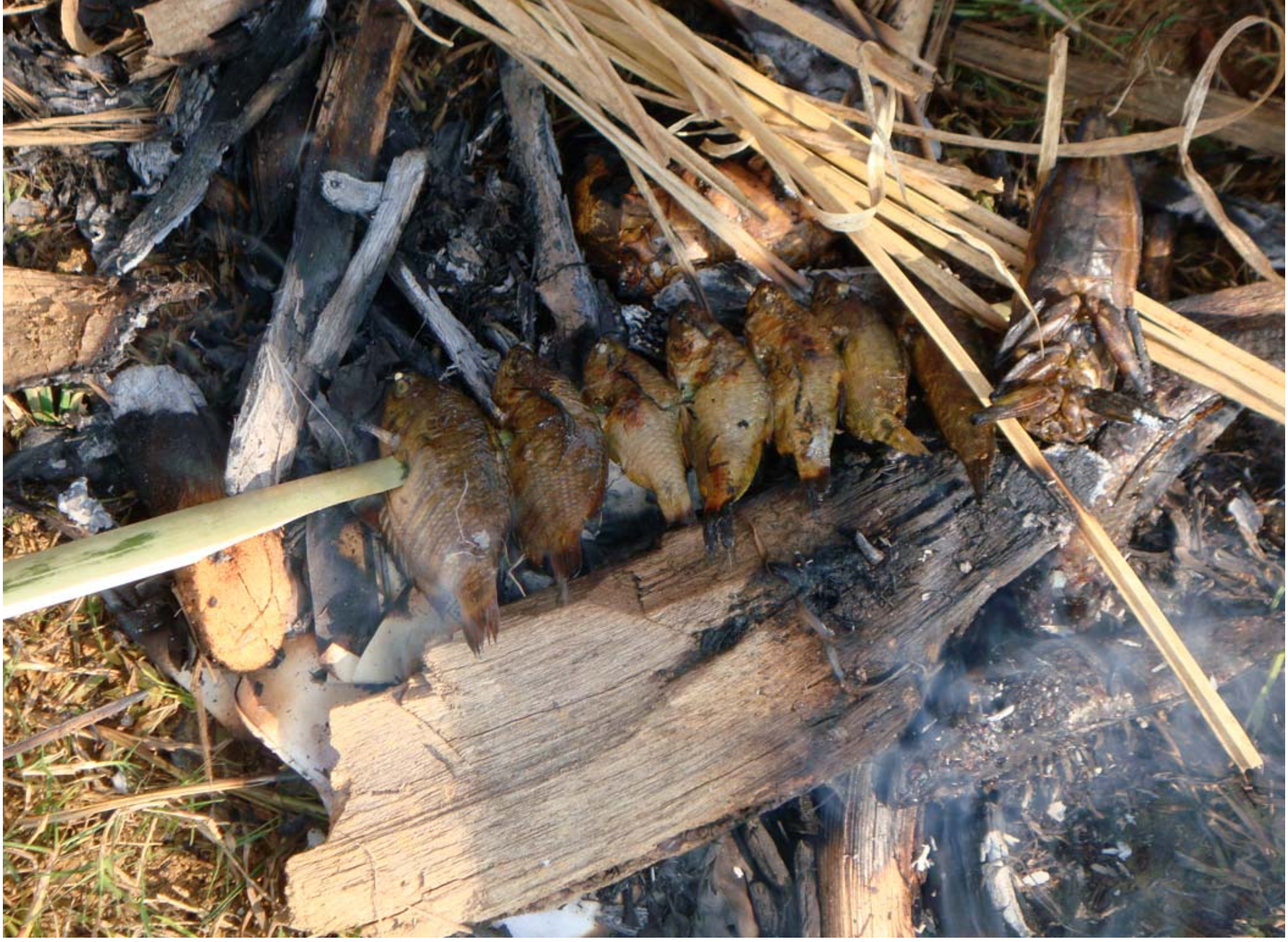
Local girls walk to the fishing ground.


The wetland.

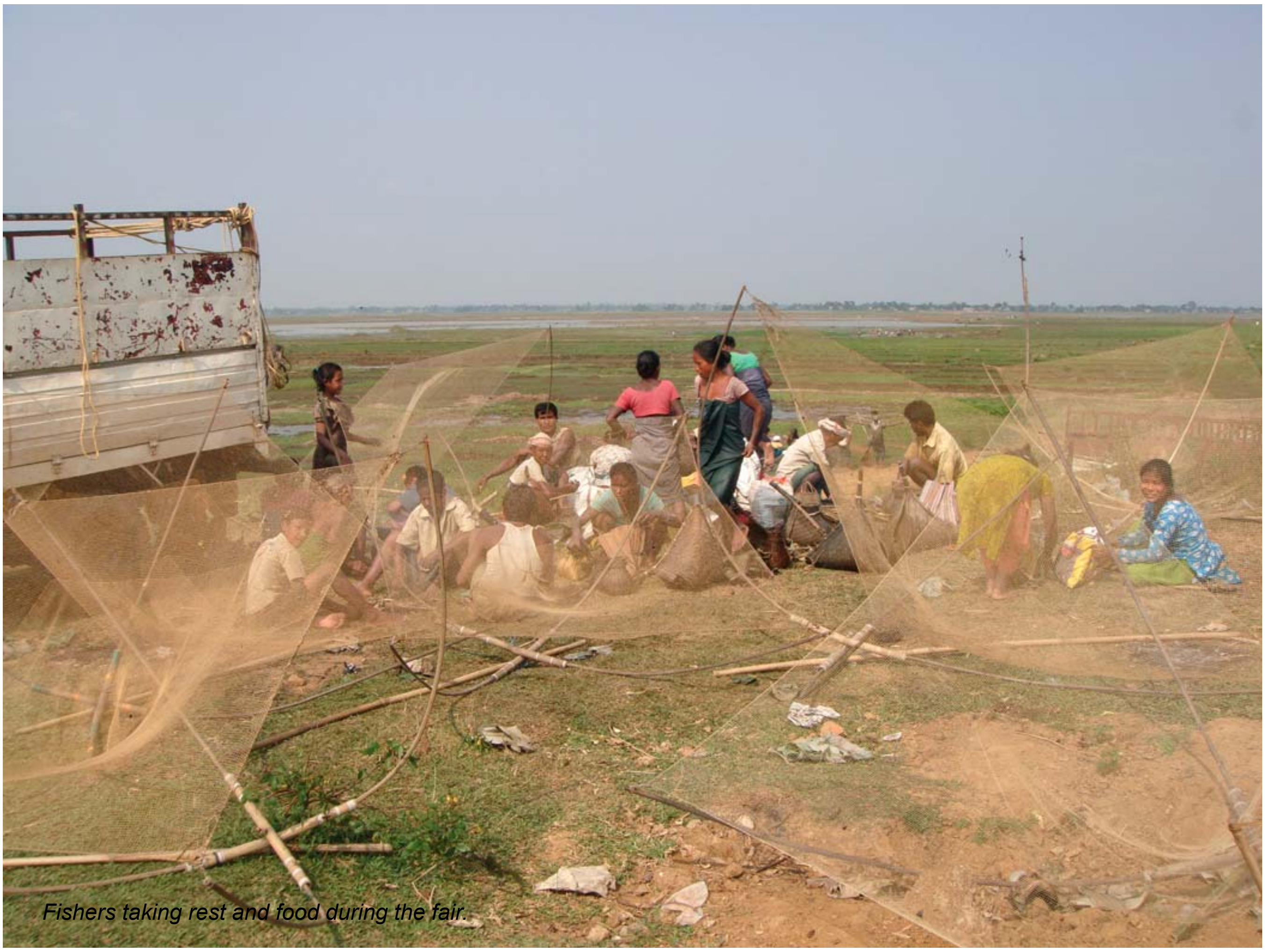

A Chalonee.


Polo and Juluki.


A Hana or kosh.



Preparation of fish for consumption.



Fishers taking rest and food during the fair.

A young girl operating a jakoi.

heavily weighted around the base by fixing iron weights to the free edges of the pockets and each is provided with a retrieving line attached to the apical portion. All the lines/strings converge to the centre where they are tied to a central cord which passes through a ring forming the apex of the net. As soon as the net is thrown, it goes down due to its weight as well as the weight of the sinkers. When the net is hauled the sinkers disturb the fish, which enter the pockets and are secured there. Based on the mesh number and net size the cast net is known by various local names viz., *'khewali jal', 'asra jal', 'rekh jal', 'pachon jal', 'afolia jal', 'jhaki jal', 'athar jal'* and *'angtha jal'*. Among these the 'athar jal' is the largest and cannot be operated by a single person. The other nets are relatively smaller in size and are operated by a single person. The overall length of these nets varies from 3.0-6.5 m from the apex to the base. The mesh along the circumference at the apex and the base ranges from 3-200 numbers and 144-2000 numbers respectively. The nets have mesh size ranging from 15-160 mm and the webbing is made of polyamide (210/12/3, 210/9/3). The size of the sinkers is 1.5 x 1.2 x 0.4 cm or 16.0 x 1.5 x 0.6 cm. The catch composition varies with net size which includes *Labeo bata, L. gonius, L. rohita, L. calbasu, Cirrhinus mrigala, C. reba, Catla catla, Hypophthalmichthys molitrix, Ctenopharyngodon idella, Aorichthys aor, Channa marulius, C. striatus, Chitala chitala,* etc.

Jakhra: This is a wounding gear provided with pointed, barbed or barb less blades, which may be detachable or non-detachable from the handle or shaft and thrown by hand. This instrument possesses 20-24 pieces of bamboo splits, firmly tied together as a bunch towards the butt. The other end has prongs and are arranged in a way as to cause them to diverge from one another. The pointed ends are capped with simple, sharp iron points. This is a heavy weapon and requires considerable strength to hurl. It is generally thrown by a man standing at the prow of a boat, sometimes from the bank of a stream. The gear is operated to catch medium to large sized fishes such as carps, murrels and a few catfishes.

Kosh or ***Hana***: The length of the bamboo pole is around 2.5 m. The piercing part is made of either split bamboo strips or iron rods having barbs at each point. It is operated in beels and rivers. *Wallago attu*, murrels, *Mystus* spp. and *Puntius* spp. are the catch.

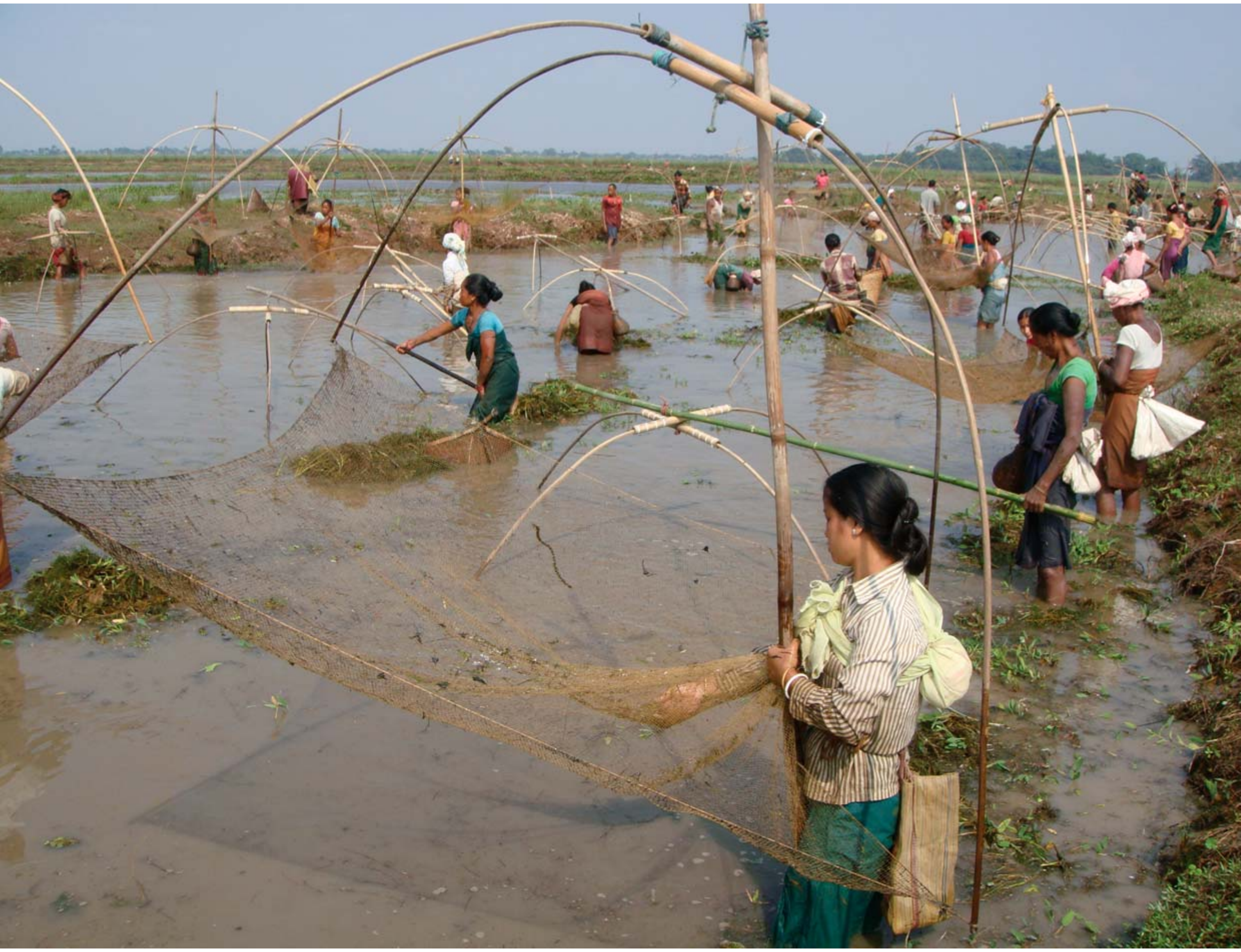
Thela jal: These are triangularly-framed push nets operated by one man and the capture affected by a forward, horizontal pushing motion along the bottom of shallow waters by hand wading or from boats by handle. Locally push nets are also known as *ghoka, pah jal* or *thela jal*. These nets resemble the skimming nets in all details. The triangular frame consists of three bamboo poles. One of the intersecting poles is longer than the other and the extended portion serves as the handle. The webbing of this gear is made of mosquito net or polyamide which is hung as a long cod end for 2.3 m from the frame. The overall length of the gear varies from 1.3-1.5 m, and the width at the base is 1.3 m. The net is operated in beels and the catches are mostly small sized fishes, fingerlings and prawns.

All the fishing gears used during the event are traditionally prepared and are eco-friendly, light weight and low cost. Destructive fishing techniques such as chemicals, poisons, explosives, electro-fishers, water suction pumps, unauthorised fish nets and similar are not used. It was observed that fishing at this time of the year also does not have any impact on the propagation of fish stock or decline of fish population as the beels are land-locked and typically dry out completely by late winter. It was also observed that fishing methods that disturb the mud release trapped noxious gases, which makes the environment suitable for fish and potable for the grazing cattle.

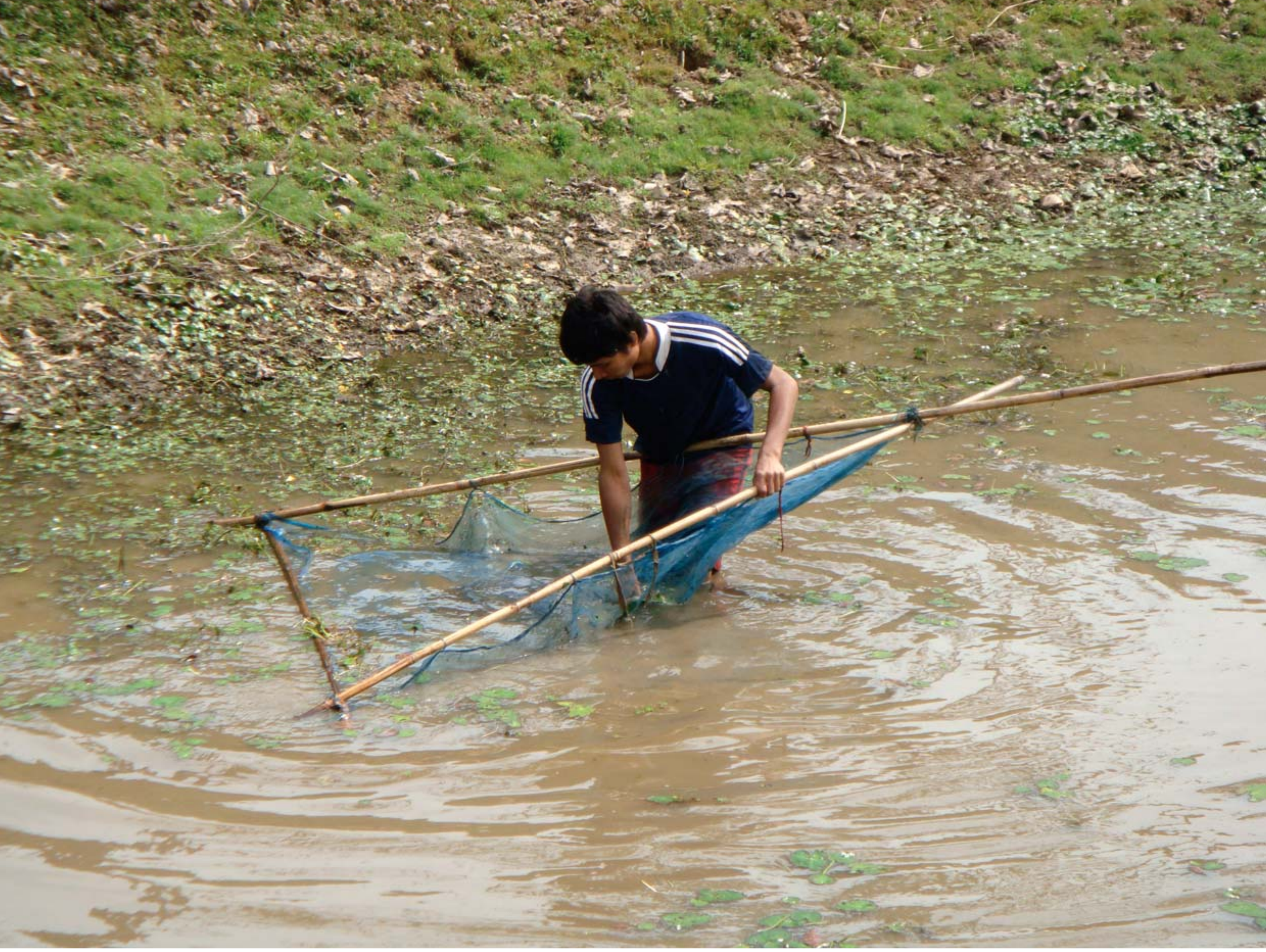
Tribal fishers were of the opinion that community fishing has lost much of its past glory due to several factors such as modernisation, anthropogenic changes and occupational status. It was said that community fishing is just not about

A Khorahee.

catching and selling fish, but a community festival, locally called *mela* which is based on the present day barter system where commodities and products are exchanged instead of currency. Villagers from distant places take part in this community fair with a perception that the practice of fishing brings goodwill and togetherness among the people of the villages. Similar occasions (*melas*) were also observed



Women operating Porongi Jal.



A Thela Jal.

specially among the *Tiwa* tribe of Assam using traditional fishing methods, on the eve of *Bhogali bihu* festival in a particular *beel* known as *Joonbeel* in Morigaon district. The event is popularly known as *Joonbeel mela* which is believed to have begun in the 15th Century A.D. and was first organised by *Tiwa* and *Ahom* Kings to exchange views and ideas on the then prevailing political situations. Therefore, it can be concluded that these floodplains of the Brahmaputra and Barak river basins serve as some of the finest resources to sustain such traditional activities with tremendous impact on the rural harmony as well as in conserving the techniques of usage of locally made fishing gears and their methods for harvesting fish. Considering the cultural perspective in the state, similar fishing activities can also be promoted under fish based eco-tourism and recreational fisheries for celebration of many local occasions to increase the solidarity among the villagers in other parts of the state.

Acknowledgement

The author is highly thankful to Dr Puthra Pravin, Assistant Director General (Marine Fisheries), ICAR Headquarters, New Delhi from whom technical specifications were learnt to carry out such programmes on scientific lines.

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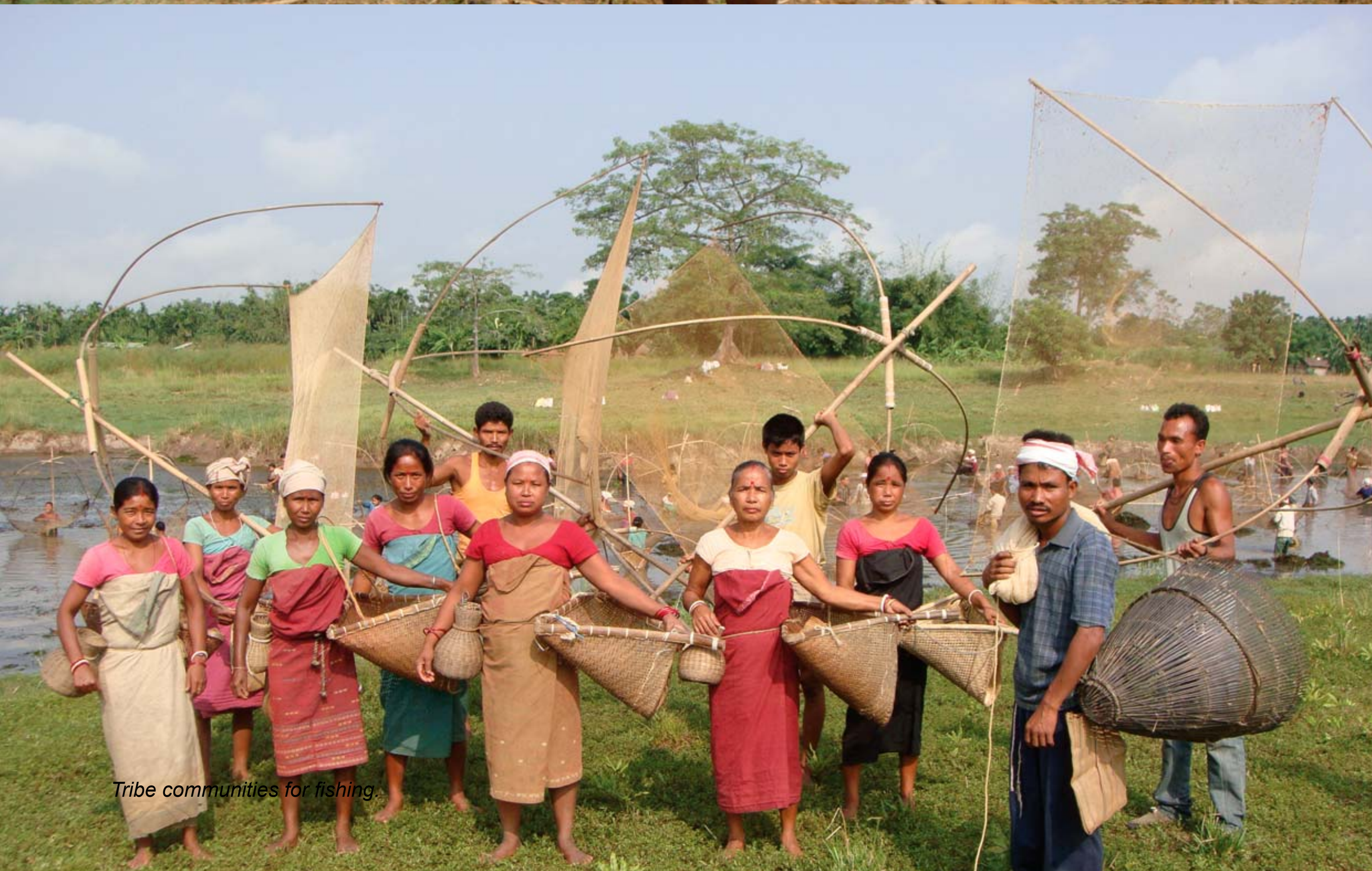
A man with his collapsible fishing gear.



Tribe communities for fishing.

Practical significance of restricted feeding regime in aquaculture

Pankaj Kumar[1]*, Arun Sudhagar S.[1], V. Harikrishna[1] and Manish Jayant[2]

1. ICAR- Central Institute of Fisheries Education,Rohtak Centre, Lahli, Rohtak 124411, India. 2. Department of Fish Nutrition & Physiology, ICAR- Central Institute of Fisheries Education, Fisheries University Road, Versova, Mumbai-400 061, India. Email: kumarpankajfnb@gmail.com.

Feed is the most expensive component of an aquaculture enterprise, typically accounting for 40-60% of the operating cost depending on the intensity of production. Successful cultured fish production therefore requires optimisation of feeding practices to ensure the most economically effective growth rates and feed utilisation efficiencies. One of the major problems faced by fish culturists is the need to obtain a balance between rapid fish growth and efficient use of the supplied feed. Due to day-to-day and rhythmical variations in appetite, regular feeding practices may lead to feed waste and reduced feed conversion. When fish are fed using self-feeders fish can regulate feed intake in relation to their energy needs and feeding rhythms. Nevertheless, a restriction of the time during which feed is made available may lead to reduced feed waste without any alteration of growth performance, provided that the feeding periods are in phase with their feeding rhythms.

Reducing feed costs for culture practices in practical manner, can be achieved by taking the advantage of the phenomenon of restricted feeding strategies. In a broad sense, restricted feeding supports compensatory growth, which has been demonstrated in a variety of warm-water and cold-water fish species. Various feed restriction and refeeding protocols have been utilised to express the phenomenon of compensatory growth amongst these fish species often with a variety of physiological responses. Some responses to the period of feed restriction upon refeeding have included hyperphagia, enhanced feed efficiency, and improved growth rates. These responses have increased interest in the study of compensatory growth as a management tool in aquaculture. Such feeding strategies could improve management of personnel time, water quality, as well as fish-feeding activity and improvement of economic performance. The improved rates of gain during the compensatory phase would be expected to place extra demands for metabolic energy as well as increase amino acid requirements for protein synthesis during this period. The added demands for energy would be expected to come from increased rates of protein growth and elevated metabolic processes to support this growth.

Moreover, an important approach to reduce feeding costs and thus increasing profits in aquaculture farming system is to develop proper feeding management. Feed management strategies must match feed supply (feed delivery) to demand (appetite and the nutritional requirements of fish) incorporating such factors as feeding rate, frequency, duration and the choice of feeding regime. Efforts have been made to reduce feeding cost, while increasing growth rate and maximising feed utilisation by including digestive enzymes in the diet. Other methods tested include the use of mixed feeding schedules of varying high and low dietary protein levels in feed and optimising the feeding rate. Feeding regimes using restriction and re-feeding strategies have been shown in many species as a simple, easy, practically applicable and affordable means of reducing feeding cost. Under a restricted feeding regime, some fish convert a greater portion of feed to body weight without any adverse effect on their growth and nutrient utilisation than they do under unrestricted daily feeding ration regime.

Growth in fishes obtained through restricted feeding strategies, seemed to be closely related to the duration and severity of feed restriction imposed before refeeding. Thus, knowing the appropriate feeding regimes that achieve compensatory growth of fish is necessary before the practical application to aquaculture. The duration of feed deprivation that provokes compensatory growth also varies among fish species.

Effect of restricted protein feeding on growth performance, nutrients utilisation and body composition in fishes

Researchers have demonstrated that improvements in growth rates in response to a period of feed restriction may be as simple as an increase in feed consumption driving the higher plane of growth. Such feeding strategies to elicit compensatory growth could be beneficial in commercial aquaculture in ways other than just enhancing growth and feed efficiency. Feed restriction and re-feeding has been described for many groups of fishes including cyprinids, gadoids, pleuronectids, molatids, cichlids, ictalurids, salmonids and clariids.

Furthermore, results of feeding trial in farmers' ponds clearly demonstrated that the mixed feeding schedule of a low protein diet alternated with a high protein diet resulted in better growth, feed utilisation and production than feeding sutchi catfish and silver carp with a high protein diet continuously. This was considered as a possible way of reducing feed cost. Mixed feeding schedules using diets containing low and high-protein provided an increased and decreased nitrogen retention and loss, respectively, in tilapia and carps. The existence of rhythmic metabolic activities in fish indicates that they may not require a similar amount of nutrient intake daily. It has been reported that a mixed-feeding schedule of alternating the high-dietary protein diet with lower dietary protein level diet reduced the overall feeding cost without compromising growth of tilapia.

Conclusion

It is apparent from the various studies that, the discriminate restriction to feed for one or two days offers an opportunity to protect fish farmers against unfavourable situations such as feed shortages or high cost of feed. This strategy provides opportunities for fish farmers to reduce the cost of production. Restricted feeding regimes may be promising tools for increasing the efficiency of fish production. By not feeding or by limiting feed during the winter, producers can save money by reducing feed and labour costs, and possibly decreasing disease losses as well. Further research is needed to determine the optimum length of time to restrict feeding for different sizes of fish in order to maximise the effects of compensatory growth and optimise disease resistance. Satiation feeding may cause severe deterioration in water quality.

Bangana dero: A potential indigenous fish species for diversification of carp culture in north east India for sustainable aquaculture

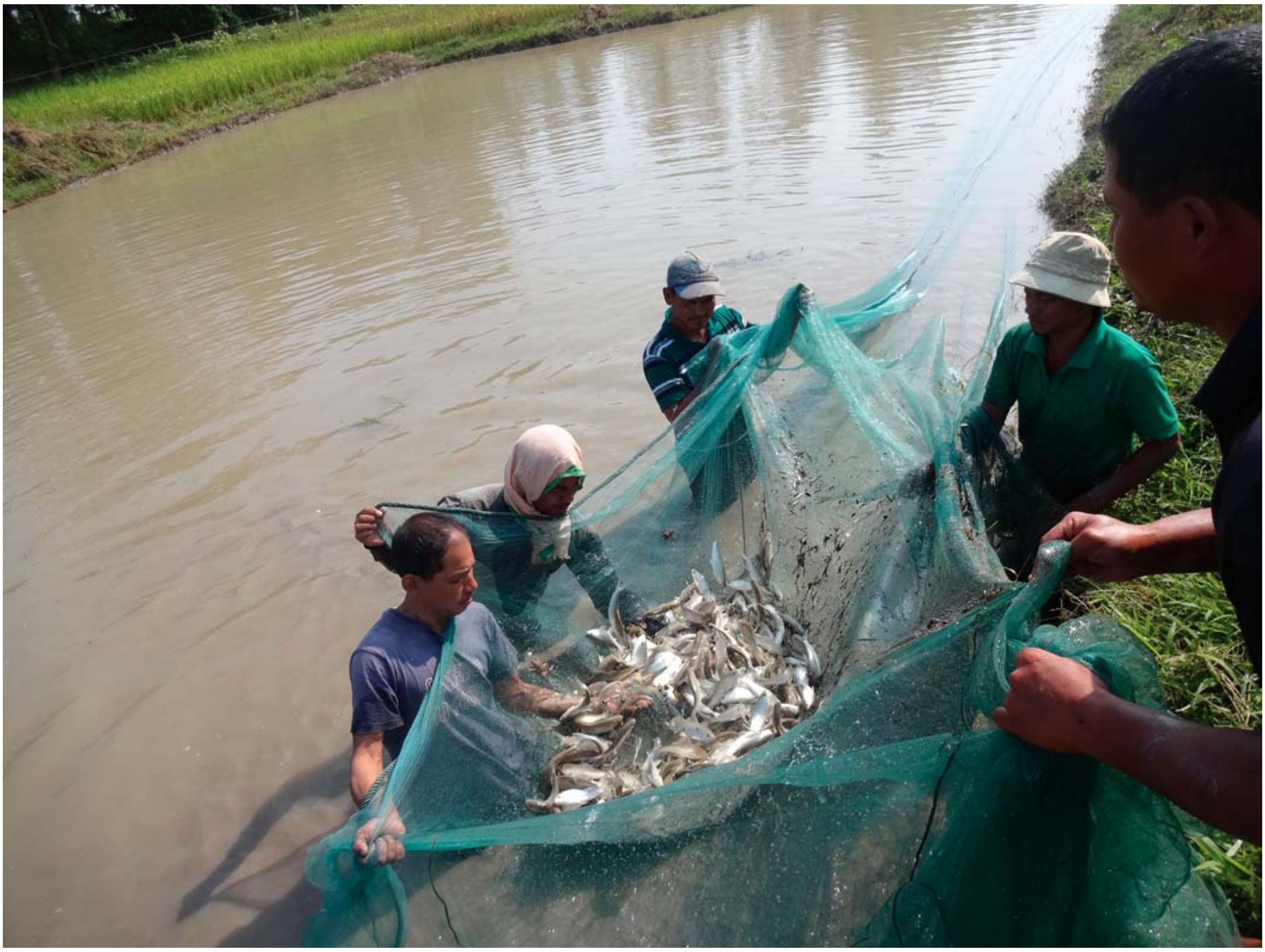
Ch. Basudha, N. Sobita Devi and Sinthoileima, Ch.

ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal 795004, Manipu, India.
Email: devibasu@yahoo.com

Bangana dero (Hamilton 1822), commonly known as kalabans, or ngaton or khabak (in Manipuri), khital (Tangkhul), or ngatai (Myanamar) is endemic to Asia's inland waters. It is one of the most popular indigenous minor carps in the north eastern states of India. It is distributed throughout the Himalayan foothills, in India, Nepal, China (Zhu 1995) and Sri Lanka (Talwar and Jhingaran 1991). It is also found in Iran (Coad 1995), Afghanistan (Petr 1999) and Bangladesh (Rahman 1989). The species is also found in some of the national parks of Nepal, e.g., Koshi Tappu Wildlife Reserve, Chitwan National Park and Karnali National Park (Shreshtha 1999). The fish is characterised 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. Its flesh is well flavoured and highly esteemed as food. It attains a length of 35-40 cm and can readily be caught with cast-nets. According to CITES (2013) this fish species is categorised as Least Concern.

This fish is bottom feeder and feeds on insect larvae, molluscs, algae, zooplankton and detritus. Sexes can be distinguished during the breeding season. The pectoral fin of male is rough and the female dorsal side of the pectoral is smooth. The genital aperture of the female is reddish and swollen and has soft belly. In the case of male, the genital opening is not prominent however, when applying gentle pressure on the belly it oozes milt. The fish matures at 2+ years and males mature earlier than the females. It is a riverine and seasonal spawner and breeds during the south west monsoon (June-August) in adjacent shallow inundated terrain during floods. The relative fecundity had been recorded to be around 3, 25,000 eggs per kilogram of body weight of female brooder. Adults inhabit torrential hill-streams in shallow waters. They migrate to warmer regions of lakes and streams during winter.

This fish species is one of the most important indigenous minor carps in north east India especially in Manipur. It has a ready demand in the local market fetching triple the prices



Bangana dero harvest.

Packing of Bangana dero seeds.

of Indian major carps. The fish occurs in the waters of the Litan, Iril, Thoubal, Sekmai rivers and its adjoining lakes in Manipur. Shoals of advanced fry and fingerlings of this fish species occur in the months of October and November every year. Over the last two decades the occurrence of fries and fingerlings of this high priced fish have become drastically reduced.

In India, particularly in North Eastern states, aquaculture sector plays a vital role in the socio economic development and is recognised as a powerful tool for income and employment generation. This sector stimulates the growth of a number of subsidiary industries and is a cheap nutritious food. However, the production of fish has not reached up to the expected level due to non-availability of quality seeds of cultivable fish both exotic and indigenous. Recently, notable progress has been achieved in widening the spectrum of aquaculture practices using viable fish species including Indian major carps and many indigenous fishes in different parts of eastern India. Development of technology for seed production and culture of local fishes creates opportunities for the fish farmers to diversify their aquaculture practices.

Induced breeding

Efforts have been made by ICAR Research Complex for NEH Region, Manipur Centre, Imphal to domesticate this high priced indigenous fish since 2009 by induced breeding using different hormones. Success was achieved using Wova-FH, Ovaprim and Ovatide (0.5ml/kg body weight of female and 0.2ml/kg body weight male) and low dose of carp pituitary (2.0mg/kg body weight) and obtained maximum egg laying capacity, fertilisation rate and hatching rate at 2:1 male-female ratio. The fertilised eggs were spherical, translucent and demersal measuring 1.8±0.2 mm in diameter. Unfertilised eggs were paler and opaque. Fertilised eggs were hatched out after 18-24 hours of fertilization at temperatures of 25.2-26.8°C. The freshly hatched larvae measure 4.5 mm long and 1.5 mg in weight. They do not take exogenous food for about 72 hours at 26°C. The yolk sac is fully absorbed on the 4th day and the hatchlings grow to 6.5 to 7.0 mm long. Four days after hatching the spawn were ready to release into well-aerated nursery tanks. The duration of hatching depends on water temperature.

Hatching in hapas

Two enclosures or hapas are used one inside the other (outer hapa). The inner hapa or trays are made of nylon net mesh size 2-2.5mm and the outer hapa has a mesh size of 0.5mm. After hatching, the larvae move out of the inner hapa/hatching trays through its large mesh and are collected at the outer hapa. The empty egg shells are left in the inner hapa which are removed along with the inner hapa after the hatching is completed.

Larval care and nursery rearing

Early larval stages are the most crucial and vulnerable stages in the life cycle of a fish. The freshly hatched larvae measure 2.4-4.2 mm long and 1.5mg in weight. They do not take exogenous food for about 72 hours at 26°C. The yolk sac is fully absorbed on the fourth day as the hatchlings reach to 4.0 -5.0 mm long. At this stage, the fish are referred to as post-larvae and they start feeding on exogenous food. Generally, *Bangana dero* seed is classified into three categories viz, spawn, fry and fingerling. The spawn can be kept in the incubation chamber until the yolk sac is absorbed and then are shifted to separate tanks for nursery rearing.

By the fourth day after hatching, the spawn are released into well-prepared nursery tanks free from aquatic weeds predators for growing the post-larval stage. In a well prepared nursery pond *Bangana dero* carp can be stocked @ 10-15 million/ha. Small ponds of 0.02-0.10 ha with depth of 1.0-1.5 m are preferred for nurseries though areas up to 0.25 ha can be used for *Bangana dero* carp fry production. The socking of spawn in nurseries is done preferably during morning or evening hours by acclimatising them to the new environment. The water depth at the time of stocking should be limited to 40 cm. Later, after four days of stocking, water depth can be increased in a phased manner. Low initial depth is advantageous to carp spawn. After 45 days of rearing fish may grow to 1.5 cm and are ready for rearing ponds. Under a given set of conditions, the growth rate of fry of *Bangana dero* is

Fertilized eggs of Bangana dero.

Bangana dero.

extremely high in the first 10 days, with the fish doubling their weight every second day and becoming about 19 mm long weighing 0.09 g in 10 days, and 37 mm long weighing 1.1 gm in 20 days. With adoption of scientific methods of rearing, the fry attains the desired size of 20-25 mm with survival of 70-75% in a 15 days rearing period. Since the nursery-rearing period is limited to 15-20 days, the same nursery can be utilised for multiple cropping, at least for raising 2-3 crops in case of earthen ponds and 4-5 crops in case of cements cisterns in a season.

Bangana dero fingerlings are produced using different techniques. Only one cycle of production is achieved by the majority of farmers in one season. They grow up to fingerling size in single or in dual stages. If fingerlings are produced in single stage, a stocking density of fish is about 0.8–0.9 million newly hatched spawn/ha. Fingerlings of 5.0cm size are harvested after 60–70 days of rearing. Survival is usually low in this rearing system. Another way of fingerling production is the dual stage system. About 2-5 million fish spawn per hectare are stocked and harvested within 15–20 days. After harvesting, the fry are stocked in fingerling rearing ponds, at the stocking density of 1-2 million/ha. Fingerlings are harvested after 45 days to 2 months. Most of them are 4.0-5.0 cm, but 10–15 percent of fish are harvested later at the size of 6.5-7.0 cm.

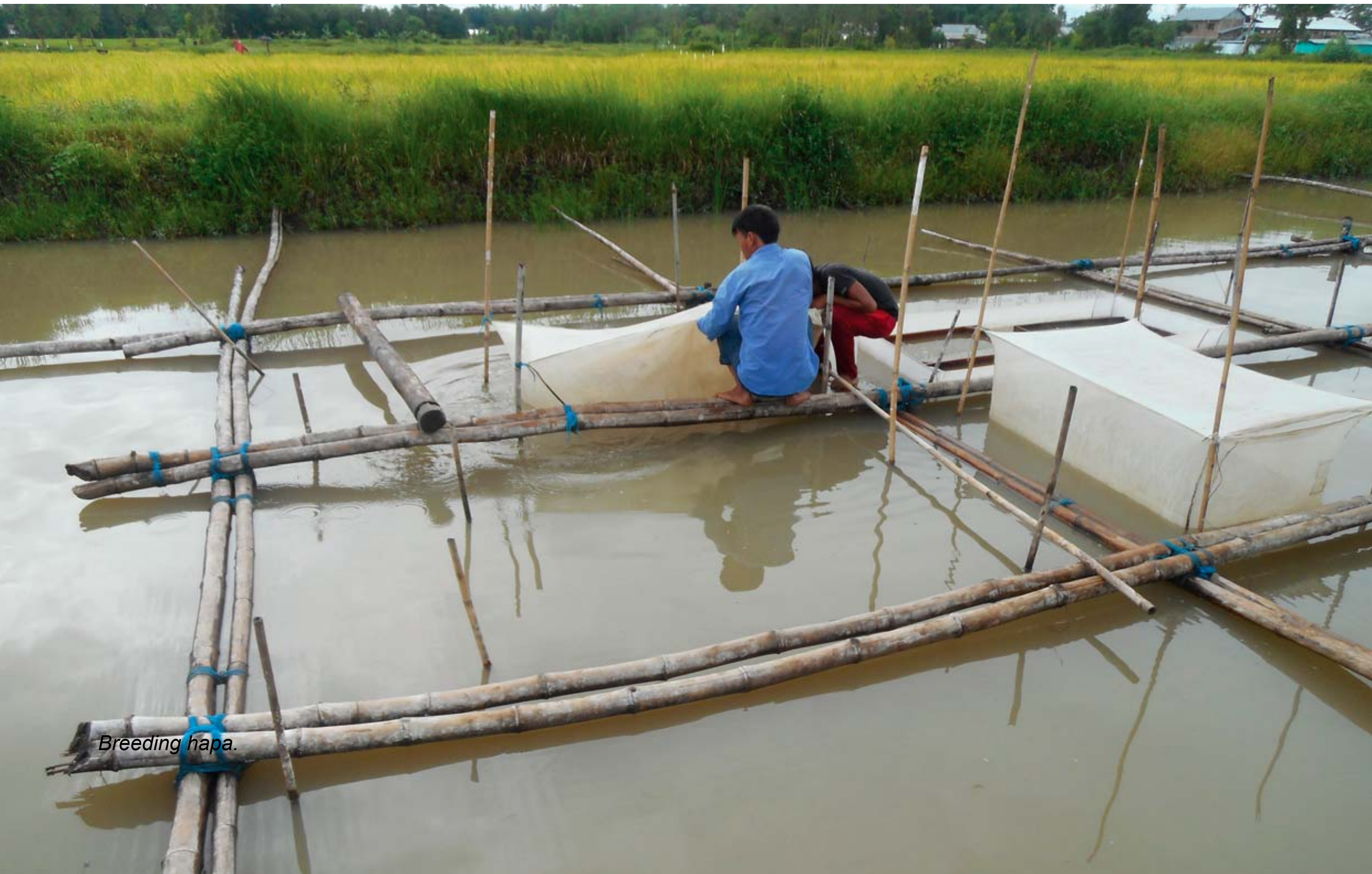
Water quality of nursery ponds

Plankton are the preferred natural fish food organisms that are produced by fertilising the culture ponds. The ponds used for seed production are first limed after the removal of unwanted predatory and weed fishes depending on the pH of soil. After liming, the ponds are treated either with organic manure such as cow dung, poultry dropping or inorganic fertilisers or both, one following the other. A mixture of 750 kg, cow dung 200 kg, and single super phosphate 50 kg/ha is effective in production of desired plankton. Half of the above amounts, after being mixed thoroughly by adding water to make a thick paste are spread throughout the nursery 2-3 days prior to stocking. The rest is applied in 2-3 split doses depending on the plankton level of the pond.

Bangana dero farming

Packages of culture practices have been developed at the ICAR Research Complex for NEH Region, Manipur Centre for *Bangana dero* culture in ponds ranging from 0.25-0.75.0 ha in area and 1.0-2.5 m in depth in different regions of the valley area of Manipur, resulting varying rates of production. While small and shallow stagnant ponds have several inherent problems, which adversely affect the growth of fish, the large and deep ponds have their own problems of management. Ponds of 0.25-1.0 ha in size with water depth of 1.5-2.0 m are considered to be best for management. The management practices in *Bangana dero* culture along with other carps involve environmental and biological manipulations, which can be broadly classified as pre-stocking, stocking and post-stocking operations.

Ponds are stocked with *Bangana dero* seed of appropriate size after acclimatising them to the new habitat when it is ready after fertilisation. Both the size and density of fish are important to achieve high yields. Fingerlings of over 100 mm in size are recommended for stocking in grow out culture ponds. As *Bangana dero* is bottom feeder it can feed on decayed vegetation, zooplanktons, worms, unicellular algae and other organisms at the bottom and margins of the pond. Fingerlings (100-110 mm) and combination of two or three



Breeding hapa.

carp species may be stocked at the densities 12,000-15,000 for single stocking and single harvesting and 20,000-25,000 for single stocking and multiple harvesting.

Short duration farming

Short duration fish farming is a process of carp polyculture along with indigenous fish species in suitable combination with other carps reared in ponds with high densities for 6-7 months duration. Fish species such as *Bangana dero* and Osteobrama belangeri along with catla, rohu, mrigal and grass carp can be farmed for a period of 7 months in ponds and harvested.

In this farming practice, good water quality of the ponds was maintained throughout the farming period. About 10,000-12,000 fingerlings of mixed carps comprising *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Ctenopharyngodon idella*, *Bangana dero* and *Osteobrama belangeri* in different ratio were reared. Stocking of mrigal and *Bangana dero* together made a total of 30% of bottom feeder component as both species are bottom feeders. The fishes were stocked in the month of March-April and harvested in the month of October. Fishes were fed with pellet feeds, a mixture of rice bran and oil cake (1:1). Good survival of pengba was observed at 80-85% in the valley. The survival of *Bangana dero* was found to be highest among the culture fishes, 87-90% in different locations. However, different growth rates were observed in different locations. It perhaps as a result of different water management, feed management and husbandry practices. The fish production ranged from 5,000-6,000 kg per ha / 7 months (Basudha et al., 2015).

Conclusion

In view of the limitations of land and water resources, exploding population and stagnancy in fish production from capture fisheries sources, aquaculture has become crucial in the national perspective. Rising global consumption of farmed fish constitutes a great challenge and opportunity for the country and the north eastern region of India as well. A diversity of species, cultured with sustainable methods and leading to high added-value products, can be a driver for growth of the market share of regional aquaculture in local and global markets. The introduction of new species in the aquaculture system has been improving the efficiency of resource use and may be reducing negative environmental impact. Introduction of needs-based modification of production technology and development of indigenous species production for enhancement or restocking is continuing and might be promoted in the future as a means for improving livelihoods for many people that rely on fisheries and aquaculture as part of their livelihoods. It is also evident that the use of indigenous species has reduced the disease risks involved in and have provided more stability to aquaculture production.

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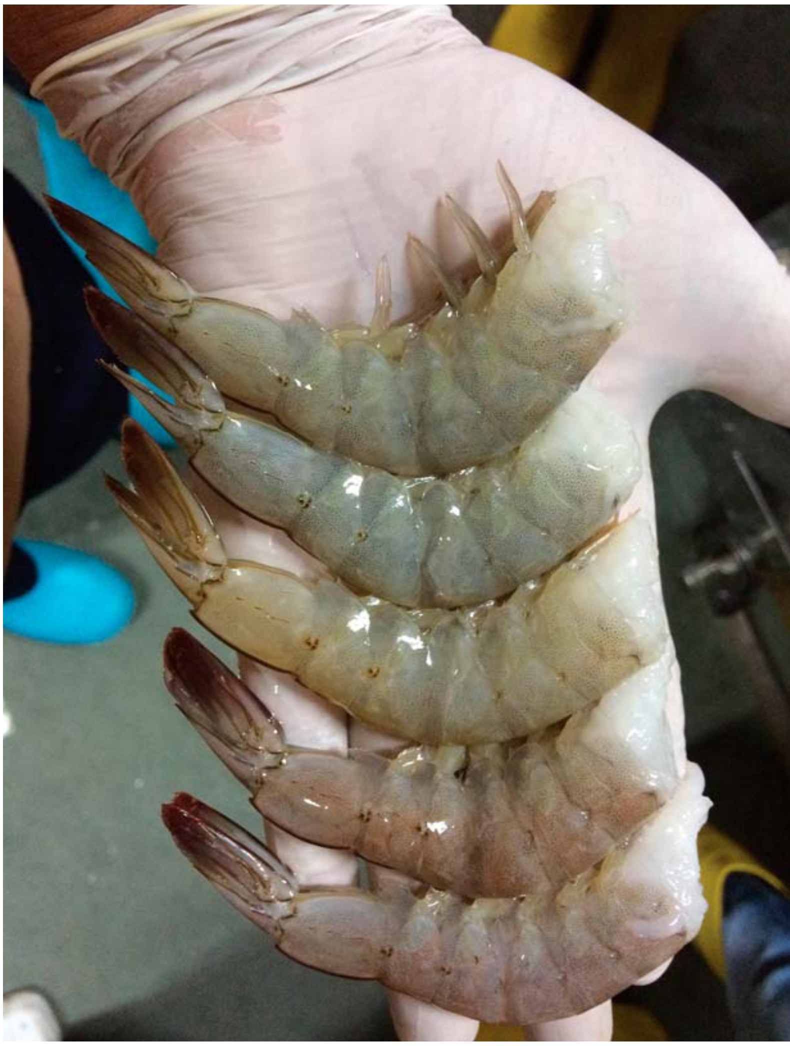
Shell colour variation in farmed *Litopenaeus vannamei*: Comparison of white shell (regular) and brown shell (unusual) *L. vannamei*

B. Madhusudana Rao, P. Viji and Jesmi Debbarma

Visakhapatnam Research Centre of ICAR-Central Institute of Fisheries Technology (ICAR-CIFT), Ocean View Layout, Pandura ngapuram,Visakhapatnam-530003, Andhra Pradesh, India. Email: bmrcift@gmail.com

The introduction of Pacific white shrimp, *Litopenaeus vannamei* and its exponential farming has resulted in substantial increase in the quantity of frozen shrimp exported by India[1] (Arathy et al., 2015). Colour is an important factor that determines the consumers' selection of food[2] (Stahl, 2012) and carotenoids are responsible for pigmentation in crustaceans. Colour of the shrimp is largely influenced by a multiplicity of pigment, feed, animal and disease and environmental factors[3,4]. The regular shell colour of farmed *L. vannamei* is off-white to greenish-white but instances of *L. vannamei* with brown-shell colour do occur in farmed shrimp (Figure 1, 2a). Physically, except for colour, the white shell vannamei and brown shell vannamei appear similar.

A study was conducted to determine if there were differences in the white shell and brown shell shrimp vis-à-vis shell colour, meat colour, meat composition and meat texture. White-shell vannamei (n=10) and brown shell vannamei (n=10), harvested from a shrimp culture farm in Andhra Pradesh, India were randomly picked and transported at <4°C to the laboratory and analysed.



Shell Colour variation in farmed Litopenaeus vannamei.

Colour analysis of white shell vannamei and brown shell vannamei

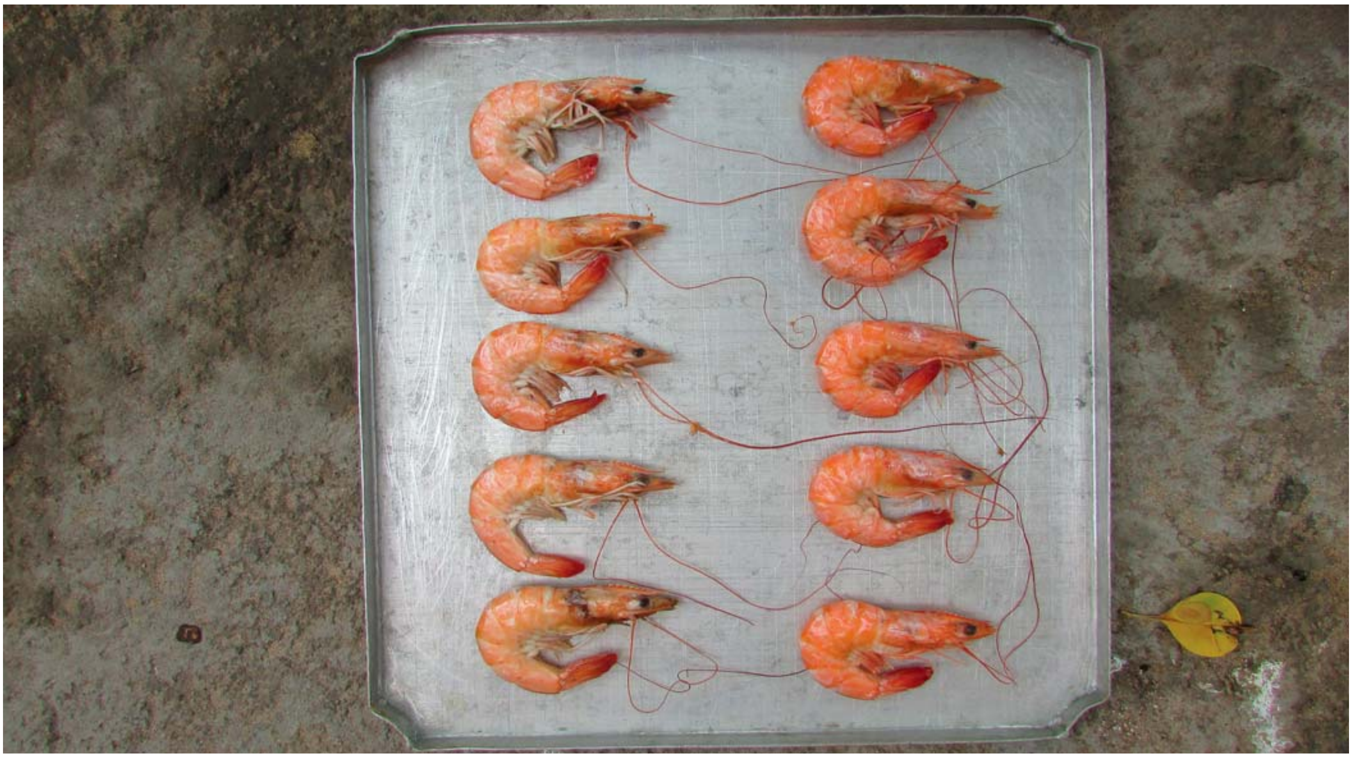
The L* (lightness), a* (positive value =red, negative value=green), b* (positive value=yellow, negative value=blue) values were measured using colorimeter (ColorFlex EZ, Hunter Lab). The shell colour of raw and cooked white shell vannamei and brown shell vannamei was determined. Raw white shell vannamei and brown shell vannamei shrimp (each type, n=5) were peeled and the peeled shells were used for colour analysis. Whole white shell vannamei and brown shell vannamei shrimp (each type, n=5) were cooked for 5 min, peeled and the cooked and peeled shells were used for colour analysis.

Cooked shells

A major difference in the redness (a*) value and very minor difference in lightness (L*) and yellowness (b*) values was observed between white shell vannamei and brown shell vannamei. The result of colour analysis indicate that redness (a*) was significantly higher (P<0.05) in brown shell vannamei, both for raw shell (7.9 ±0.3) and cooked shell (17.9 ±0.8) compared to white shell vannamei (4.8 ±0.3 for raw; 14.4 ±1.6 for cooked) indicating distinct colour difference between the two shell types of vannamei shrimps (Table 1).

The main carotenoid pigment responsible for the colour of shrimp is astaxanthin ie 3,3 dihydroxy β-carotene 4,4-dione[5,6]. In live shrimp, astaxanthin is bound to a protein, crustacyanin as astaxanthin-crustacyanin complex and gives a blue-green colour to the shrimp shell. However, the complex is not heat-stable and becomes disassociated up on cooking and releases astaxanthin which makes the cooked shrimp shell appear red in colour. Pigment content in the shrimp exoskeleton is always higher than on the abdominal muscle[7]. The result of colour analysis of shrimp meat indicate that a* value (redness) was significantly higher (P<0.05) for brown shell vannamei, both for raw meat (9.1 ±0.5) and cooked meat (26.0 ± 2.3) compared to white shell vannamei (2.7 ±0.2 for raw meat; 16.81 ±0.8 for cooked meat) indicating distinct colour difference in the meat of the two shell types of vannamei (Table 2). Lightness (L*) values of the meat of white shell vannamei and brown shell vannamei did not differ but a significant difference (P<0.05) was observed for yellowness (b*) value. Based on the results, it can be inferred that brown shell vannamei yield a brighter red coloured cooked shrimp product compared to white-shell vannamei shrimp.

Meat composition and texture profile analysis of white shell vannamei and brown shell vannamei



Shell colour variation in raw and cooked farmed Litopenaeus vannamei. A. Raw brown shell vannamei (top), raw white shell vannamei (bottom). B. Cooked brown shell vannamei (left), cooked white shell vannamei (right).

Protein, fat, calcium, potassium, and sodium content of white shell vannamei and brown shell vannamei were determined as per standard methods[8]. Texture profile analysis[9] was performed at room temperature employing a food texture analyser (Lloyd Instruments, UK), equipped with a load cell of 50N. Texture measurement were performed on shrimp meat, compressed twice by a cylindrical probe having a diameter of 50 mm and a test speed of 12 mm/min. Hardness, springiness, adhesion and cohesion are the basic mechanical variables that characterise texture of food.

The results of meat composition analysis (Table 3) indicate that the white shell vannamei had a higher content of sodium (552 mg%) and calcium (264mg%) compared to brown shell vannamei (sodium 331mg%; calcium 188mg%) indicating that mineral imbalance might be a possible reason for the difference in shell colour of vannamei. The meat characteristics as indicated by texture profile analysis (Table 3) showed that white shell vannamei has better texture as indicated by relatively higher values for hardness 1 (13.47N), hardness 2 (7.33 N) and chewiness (11.34 Nmm) compared to brown shell vannamei. The softer texture of brown shell vannamei indicates that these shrimp might have been under certain stress. Several factors were known to influence redness in shrimp. Shrimp become more reddish in colour when infected by a wide range of organisms or when exposed to toxic conditions, which is thought to be due to the release of carotenoid pigments that are normally stored in hepatopancreas[10]. Martinez et al. (2014)[11] demonstrated that redder colour in shrimps may result from exposure to copper. Metals such as cadmium, copper, lead and mercury combine with astaxanthin and form novel complexes that are redder in appearance[12]. Carotenoid supplementation in the diet of *L. vannamei* resulted in redder individuals[13]. Further studies are needed to ascertain the stressors responsible for the variation in shell colour of farmed *L. vannamei*.

Conclusion

Comparison of white shell vannamei (regular) and brown shell vannamei indicate that white shell vannamei was better in meat composition and texture profile but brown shell vannamei yielded bright red coloured cooked product.

Acknowledgements

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Table 1. Colour values of the raw and cooked shells of white- and brown-shell vannamei

	White shell vannamei		Brown shell vannamei	
	Raw shell	Cooked shell	Raw shell	Cooked shell
L* (Lightness)	37.1 ±1.4a	50.0 ± 2.3b	36.9 ±2.1a	49.2 ±0.8b
a* (Redness)	4.8 ±0.3a	14.4 ±1.6c	7.9 ±0.3b	17.9 ±0.8d
b* (Yellowness)	10.2 ±0.8a	16.5 ±0.7b	9.8 ±0.5a	17.1 ±0.8b

n=5; mean±SD. Values within a row with different superscript letters are significantly different (P<0.05).

Table 2. Colour values of raw and cooked meat of white- and brown-shell vannamei

	White shell vannamei		Brown shell vannamei	
	Raw meat	Cooked meat	Raw meat	Cooked meat
L* (Lightness)	43.8 ±1.7a	64.2 ±0.9b	45.7 ± 0.2a	63.5 ±2.1b
a* (Redness)	2.7 ±0.2a	16.81 ±0.8c	9.1 ±0.5b	26.0 ± 2.3d
b* (Yellowness)	6.5 ±0.2a	21.6 ±0.3c	9.3 ±0.3b	23.6 ±1.7d

n=5; mean±SD. Values within a row with different superscript letters are significantly different (P<0.05).

Table 3: Meat composition and texture profile analysis of the white- and brown-shell vannamei shrimp (raw).

	White shell -vannamei	Brown shell –vannamei
Protein, %	24.09	21.03
Fat, %	3.28	3.82
Sodium, mg/100g	552.18	331.12
Potassium, mg/100g	1131.67	1129.14
Calcium, mg/100g	263.95	188.74
Hardness 1 (N)	13.47	8.477
Hardness 2 (N)	7.33	4.847
Springiness (mm)	3.5	3.0
Cohesiveness	0.239	0.229
Adhesiveness (kgf.mm)	0.011	0.005
Chewiness (Nmm)	11.34	5.68

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Shell Colour variation in raw and cooked farmed Litopenaeus vannamei a)Raw Brown shell-vannamei (top) Raw White shell-vannamei (bottom).

Culture-based fisheries: A low-tech, greenhouse friendly approach to improving food and income for Cambodian families

Simon Wilkinson

Network of Aquaculture Centres Asia-Pacific

Existing agricultural activities provide nutrients that stimulate production of natural food supplies that can be used by fish.

People have a fascination with technology, and so it is with the aquaculture industry. It is widely stated that agricultural systems must be urgently intensified in order to increase production to meet the food needs of our growing population. And it is often assumed that "more technology" - high-tech, mechanised, centralised and industrialised approaches - are the path that will deliver the food that we will need. But there are other means that can contribute to this end.

Culture based fisheries offer an alternative to the paradigm of intensification via industrialisation, increasing food production by harnessing the natural productivity of small water bodies. Put simply, culture-based fisheries are practices to enhance fish stocks in waters that don't have enough natural recruitment to sustain a fishery. They are usually applied in small water bodies such as village dams and agricultural reservoirs, including ephemeral water bodies that dry up or are drained on a seasonal basis. Unlike intensive aquaculture practices, there is usually no feeding or aeration provided and stocked fish are left to forage on natural food supplies.

Improvements to fish yield in small water bodies as well as to the incomes and nutritional status of rural communities have been demonstrated in Laos, Sri Lanka and Vietnam[1,2,3] but culture-based fisheries practices are not yet widespread, despite having significant potential in tropical climates.

Since 2015 NACA has been implementing a project that aims to introduce culture-based fisheries practices to Cambodia, working with communities around 24 small inland water bodies in six provinces circumnavigating the Great Lake (Tonle Sap). The project is funded by the Australian Centre for International Agricultural Research (ACIAR). In February NACA staff visited project sites and held consultations with communities participating in the project.

One of the challenges in establishing culture-based fisheries in Cambodia is that inland waters are open access for fishing. In the interests of food security, and by law, anyone is free to fish. This means that fingerlings are vulnerable to fishing-related mortality immediately upon being stocked, whereas

A culture-based fishery, Cambodia.

usual culture-based fisheries practice is to refrain from taking fish for a period to let them grow to a reasonable size before harvesting starts. Many water bodies in Cambodia may also retain water year round, rather than drying up seasonally or being drawn down during a crop cycle, which makes complete harvesting difficult or impracticable.

To reduce predation and fishing-related mortality of young fish stocked the project has taken advantage of another Cambodian legislative arrangement, which is that each water body must have a conservation area set aside where fishing is not allowed. Rather than releasing fingerlings directly into the open waters, part of the conservation area was netted off by the project to form a nursing ground for a period to allow them to grow prior to release.

The good news is that it seems to have worked. While data analysis is progress, all participating communities reported substantial increases in daily catch rates on the order of 1-3 kg / day / fisher from around 0.2 – 2 kg / day / fisher previously. The number of people participating in fishing activities has increased substantially at all sites, in response to the improved fisheries resource, with both locals and outsiders from neighbouring districts coming in. For the local people fishing is generally a supplementary activity, with gear set in the evening and harvested in the morning before engaging in their regular agricultural activities, which is chiefly rice farming.

The improved availability of fish has had several knock-on effects. As households now often have fish surplus to their immediate requirements some have begun to sell their excess fish for cash, representing a significant boost to their incomes. Household food costs have also fallen, as they have less need to purchase fish, given that they can obtain their own more easily and excess fish may be preserved for later consumption by manufacture of fermented fish paste. As we have observed elsewhere, the community-managed nature of the culture-based fisheries activity generated synergies and improved harmony in participating communities[4].

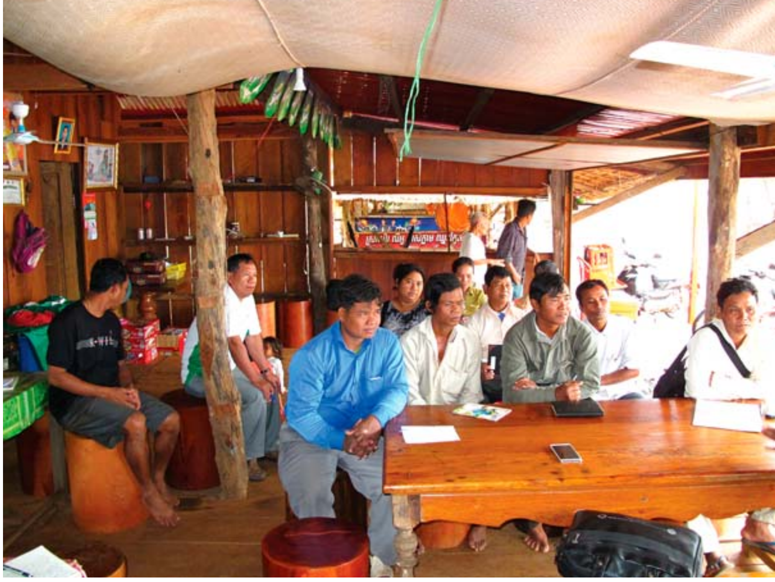
An effect that we did not plan or anticipate is that the value that participating communities place on the conservation areas has greatly increased. Communities strongly attribute their increased catches to the stocking and nursing of fingerlings within the conservation area. As a result, communities are taking a more active role in protecting the conservation areas and they are also assisting local authorities to crack down on use of illegal fishing gear. This appears to have increased catches of naturally recruited species, ie. those that were not stocked by the project.

While the yield per unit area of culture-based fisheries is low compared to intensive aquaculture systems that rely on feeds and power to boost productivity, the benefits to poor rural communities in developing countries such as Cambodia can be very high. Regular supplies of fish for the table or a couple of dollars of extra income per day represent meaningful improvements to household nutrition and incomes, especially in rural communities where employment opportunities are scarce.

With adaptation culture-based fisheries practices can potentially be applied across a wide variety of rural settings, supplying local demand for food rather than foreign supermarkets and relying on scale and distribution of production rather than raw intensity and centralised monocultures.

Consider also the environmental implications of culture-based fisheries: No feeding means no water pollution, in fact nutrients are extracted from the water body when fish are harvested. Since the fish are produced mainly for local consumption and there is no aeration or power consumption involved, there are negligible greenhouse gas emissions associated with fish production or transportation.

Unfortunately one of the limitations of project-based funding is that projects have to end and funding for the present project runs out in June. There has been considerable discussion with communities on how to sustain culture-based fisheries activities once project funding, which was primarily used to purchase seed and hapas, is withdrawn. As in other countries such as Lao PDR, target communities are discussing models for collecting contributions from the enhanced fisheries resource to fund stocking in the next season. While the approach varies from village to village, a common theme is making use of existing village revolving funds, or establishing reservoir management committees to coordinate funding and stocking activities.



Project team discussing arrangements with a community in northern Cambodia.

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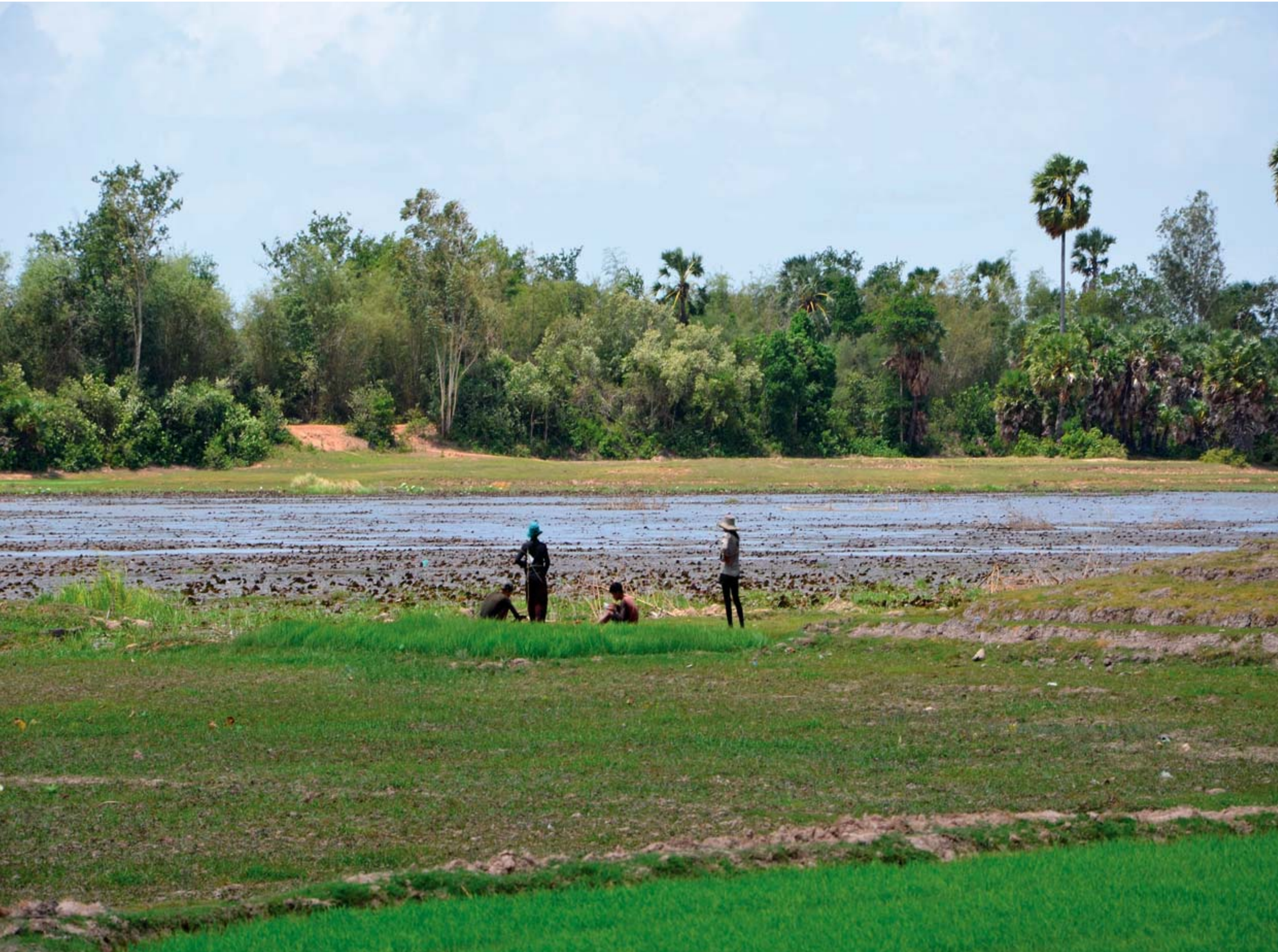

NACA Newsletter

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15th meeting of the Asia Regional Advisory Group on Aquatic Animal Health

The advisory group was established in 2001 to provide advice to member governments on aquatic animal health management. The activities of the group include evaluating disease trends and emerging threats in the region; identifying developments in global aquatic animal disease issues and standards of importance to the region; reviewing the regional aquatic animal disease reporting system and to provide guidance on strategies to improve aquatic animal health. The group is the linchpin of a regional network of experts, research centres and reference laboratories.

The 15th meeting was held from 21-23 November 2016, in Bangkok, Thailand. Members of the group include invited aquatic animal disease experts, representatives of the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO) and collaborating centres such as the SEAFDEC Aquaculture Department. Dr Melba Reantaso (FAO) was selected as the incoming chair, relieving Dr Kjersti Gravningen (Aquafuture, Norway) who had served as Chair from 2014-2015. Highlights of discussions are summarised below.

Over the past year NACA had completed a project on development of a Code of Practice for the Trans-boundary Movement of Aquatic Organisms in the Lower Mekong Basin, for the Mekong River Commission. The code was developed in consultation with the fisheries line agencies of MRC member countries, with additional input via national surveys and a regional consultation workshop. The final draft of the code is available for download from the NACA website at: http://enaca.org/?id=38.

FAO had initiated and progressed some technical cooperation projects on aquatic animal health. These included:

- Development of preventative aquatic animal health protection plan and enhancing emergency response capacities to shrimp disease outbreaks in Indonesia (new).
- Strengthening aquaculture biosecurity capacity of Malaysia's Department of Fisheries (new).
- Strengthening biosecurity capacity of Palau (new).
- Development of a national strategy for aquatic animal health, in the Federated States of Micronesia (new).
- Acute hepatopancreatic necrosis disease (ongoing), involving India, Iran, Philippines and Sri Lanka.
- Infectious myonecrosis virus (ongoing), involving China, Indonesia and Thailand.

FAO had also initiated several donor funded projects including on aquaculture certification (funded by the EU), antimicrobial resistance (funded by USAID) and on preparation of the Fiji National Aquatic Biosecurity and Aquatic Animal Health Strategy (funded by JICA).

The Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC AQD) had conducted twelve in-house studies in 2016. These were aimed to i) investigate the efficacy of probiotics and rationalise use of diagnostics, ii) to promote the wider use of conventional and new diagnostic methodologies, iii) find safe and effective alternatives to use of drugs and chemicals in aquaculture and iv) to increase the capacity of fish health specialists in fish disease diagnosis using gross clinical examination, bacteriology, mycology, parasitology and histopathology techniques.

The newly formed Aquatic Animal Health Research and Development Division of the Thai Department of Fisheries had been established from 1 October 2016 from the former Inland Aquatic Animal Health Research Institute and Coastal Aquatic Animal Health Research Institute. The new division would assume responsibility for approval of fish farm standards for the import and export of live aquatic animals, surveillance and monitoring programmes for OIE-listed diseases in wild and farmed populations, issuance of health certificates and provision of diagnostic services for farmers.

A special session was held on addressing the use of anti-microbial substances in aquaculture and the development of anti-microbial resistance. This is an issue of global concern for both human and animal health, and it had been addressed by a resolution at FAO's Thirty-ninth Conference in June 2015. FAO had developed an Action Plan on Antimicrobial Resistance, which would address awareness, development of capacity for surveillance and monitoring of resistance, governance related to prudent use of antimicrobial substances in food and agriculture and promote good practices. The plan would support the World Health Organization-led Global Action Plan on Antimicrobial Resistance, highlighting the necessity of adopting a "One Health" approach involving cooperation between human and veterinary health authorities, the food and agriculture sectors and consumers.

A regional projected funded by USAID and coordinated by FAO had been commissioned Addressing Antimicrobial Usage in Asia's Livestock, Aquaculture and Crop Production Systems. The project aimed to promote a more prudent use of antimicrobial substances in livestock industries and the crop production sector to minimise the development and spread of resistance. The project will document antimicrobial usage and resistance in livestock industries including aquaculture, improve awareness of impacts and best practices, establish a platform for the promotion of antimicrobial stewardship in Asia and strengthen capacity in surveillance and monitoring.

The meeting reviewed in detail the status of aquatic animal disease in the region. Issues included:

- Developments in acute hepatopancreatic necrosis disease (AHPND) and hepatopancreatic microsporidiosis (HPM) of shrimp, caused by *Enterocytozoon hepatopenaei*.
- Reports of tilapia lake virus (now confirmed – Ed.) in Thailand and *Streptococcus* outbreaks affecting tilapia.
- A detailed analysis of amphibian and molluscan diseases in the region, including the impact of chytrid fungus, which had recently been found could be hosted by crayfish (*Procambarus* spp.) which could transmit the pathogen to amphibians.

For full details of the technical sessions please download the report of the meeting is available from the NACA website at: http://enaca.org/?id=619.

Consultation on responsible production and use of feed

FAO, NACA and the Thai Department of Fisheries convened a Regional Consultation Responsible Production and Use of Feed and Feed Ingredients for Sustainable Growth of Aquaculture in Asia-Pacific in Bangkok, 7-9 March 2017.

The objective of the consultation was to review the current status of aquaculture feed production and use, demand and supply, sourcing of ingredients, government policies and institutional support, ongoing progress and development gaps. The consultation also aimed to put forward regional strategies and a plan of action to promote responsible utilisation of feed and feed ingredients through sharing of available knowledge, technological innovations and scaling up successful practices and further research and technology development.

Aquaculture has been one of the fastest growing food production sectors over the last thirty years, globally, with annual production increasing an average of 8 percent per year. Currently, Asian aquaculture supplies some 60 percent of global food fish needs while contributing significantly to the livelihoods for rural and urban populations. As the industry has intensified it has become increasingly dependent on the use of artificial feeds (as opposed to natural productivity) to increase yield. As a result, the proportion of aquaculture production dependent on artificial feeding has increased by 97.9 percent over the last ten years alone.

The rapid growth of "fed" production systems has resulted in a drastic increase in demand for commercial feeds. As a result, the aquaculture feed industry has also grown rapidly in the past two decades, with total production of industrial compound feed increasing from 7.6 million tonnes in 1995 to 40.2 million tonnes in 2010. The increased use of feed has greatly contributed to production efficiency and quality of products, and enabled farmers to better meet market requirements.

On the other hand, rapid increase in use of feed in aquaculture has also caused a number of issues which may threaten the sustainable growth of the industry. The major issues include the following:

- Increased feed cost has caused significant reduction of profit margin in production of many important aquaculture commodities. Feed cost often accounts for 70 percent for commodities that entirely depend on artificial feed. This problem is largely caused by high cost of feed that is often non-locally produced and utilised with poor efficiency. This problem has been exacerbated by the steady decline in the market price of aquaculture products, which are in predicted to remain in decline until 2020.

- Asian feed production has become overly dependent on externally sourced feed ingredients, and this has resulted in significant problem in supply and costs.

- In order to sustain capture fisheries and maintain marine ecosystem functions and services, there has been increasing effort to combat IUU fishing globally. It is believed considerable proportion of products from IUU fishing is used for aquaculture purpose in the region. Responsible sourcing of feed ingredients free from IUU fishing is likely to become a certification requirement in international trade of aquaculture products.

The main issues discussed in the consultation were:

- Development and use of alternatives of fishmeal and other high cost feed ingredients in aquaculture.

- Traceability of aquaculture products in relation to feed and feed ingredients.

- Promote cost-effective aquaculture feed made of locally available feed ingredients.

- Innovation in aquaculture farming and feeding practices for reduced feed costs and environment impacts at farm level.

Audio recordings of the technical presentations made at the workshop are in preparation, and will shortly be available for download or online access from the NACA website, www.enaca.org. The technical proceedings are in preparation and will be published in coming months.

Giant Prawn 2017

The fourth major international event on giant freshwater prawns (*Macrobrachium* spp.) was organised by the Asian Institute of Technology from 20-24 March 2007. The conference was co-hosted by the Thai Department of Fisheries and the Can Tho University, Vietnam. NACA was a sponsor of the event.

Speakers included Peter Mather (Australia), Md Ayaz Hasan Chisty (Bangladesh), Fatima Ferdouse Razeghpanah (Bangladesh), Patricia Moraes Valenti (Brazil), Wagner Cotroni Valenti (Brazil), Yang Guoliang (China), Zhang Tai-Zhuo (China), C. Mohanakumuran Nair (India), Endhay Kusnendar (Indonesia), Amir Sagi (Israel), Assaf Shechter (Hong Kong), Ilan Karplus (Israel), Mohd Fariduddin Othman (Malaysia), Nyan Taw and Soe Tun (Myanmar), Timothy Pickering (Pacific Islands), Nikolina Kovatcheva (Russia), Rohana Subasinghe (Sri Lanka), Philip T. Cheng (Taiwan, tbc), Amararatne Yakupitiyage (Thailand), Donghuo Jiang (Thailand), Rapeepun Vanichviriyakit (Thailand), Uthiarat Na-Nakorn (Thailand), Natthapong Wannapat (Thailand), Nitikorn Piwpong (Thailand), William Daniels (USA), James Tidwell (USA), Nguyen Thanh Vu (Vietnam), Patrick Sorgeloos (Belgium) and Tran Ngoc Hai (Vietnam).

The conference was preceded by an optional three-day intensive Workshop on Advances in Prawn Hatchery Management. A special session on gender issues was included.

The conference, organised by Salin Krishna (AIT) and Michael New, built on a series of highly successful events that trace back to the very beginnings of the industry. The first conference, Giant Prawn 1980 brought together all those involved in freshwater prawn research and farming for the first time and set many priorities for future research and development. A comprehensive volume of proceedings that summarised the latest research on *Macrobrachium* at that time was published by Elsevier.

In 2003 the second major *Macrobrachium* conference (Freshwater Prawn 2003) was organised by C. Mohanakumaran Nair at the College of Fisheries, Kerala Agricultural University, Kochi, the southern Indian city in the State of Kerala. Michael New presented the keynote address in this Conference. This meeting was attended by nearly 500 delegates from all over the world and was a major boost for freshwater prawn farming development in India. Selected papers from this conference were published as a special edition of the international journal, Aquaculture Research. Full proceedings of the meeting were also published by Allied Publishers, New Delhi, India.

In 2011 Michael collaborated with Kerala Agricultural University in India and the World Aquaculture Society to organise the Giant Prawn 2011, the second conference in the series, which was also held in Kochi. This event was held in conjunction with Asian Pacific Aquaculture 2011, the annual conference of the World Aquaculture Society - Asia Pacific Chapter. Selected papers from this conference were also published as a special volume of the Journal Aquaculture Research.

The technical sessions of Giant Prawn 2017 were excellent, wide-ranging and thoroughly enjoyed by all; it is evident that *Macrobrachium* farming has come a long way since its humble beginnings and has now reached a considerable level of sophistication. Unfortunately Michael New could not attend the event due to unforeseen circumstances at the last minute, but we are assured he was in there in spirit!

Selected papers presented at GIANT PRAWN 2017 will be published in a special edition of the Journal of the World Aquaculture Society. The proceedings of the conference will also be published in due course.

New NACA website preview

As foreshadowed, a new NACA website has been in development for some time and it's finally just about ready to put into production. Most of the content from the old site has been transferred across, subject indexed and in most cases edited or re-written from scratch. For the moment, you can preview the new site at http://www.enaca.org/tuskfish/.

Keeping up to date is far easier on the new site as it has been restructured into a single newsfeed. "Sections" have been done away with and all content, regardless of type, now appears on the home page. You need look no further to see what has been going on.

All content has also been subject indexed. By selecting a tag from a drop down list on the home page you can filter out all content on the site that relevant to a particular subject – everything that we have ever published. If you have specific needs, an improved search engine is also available.

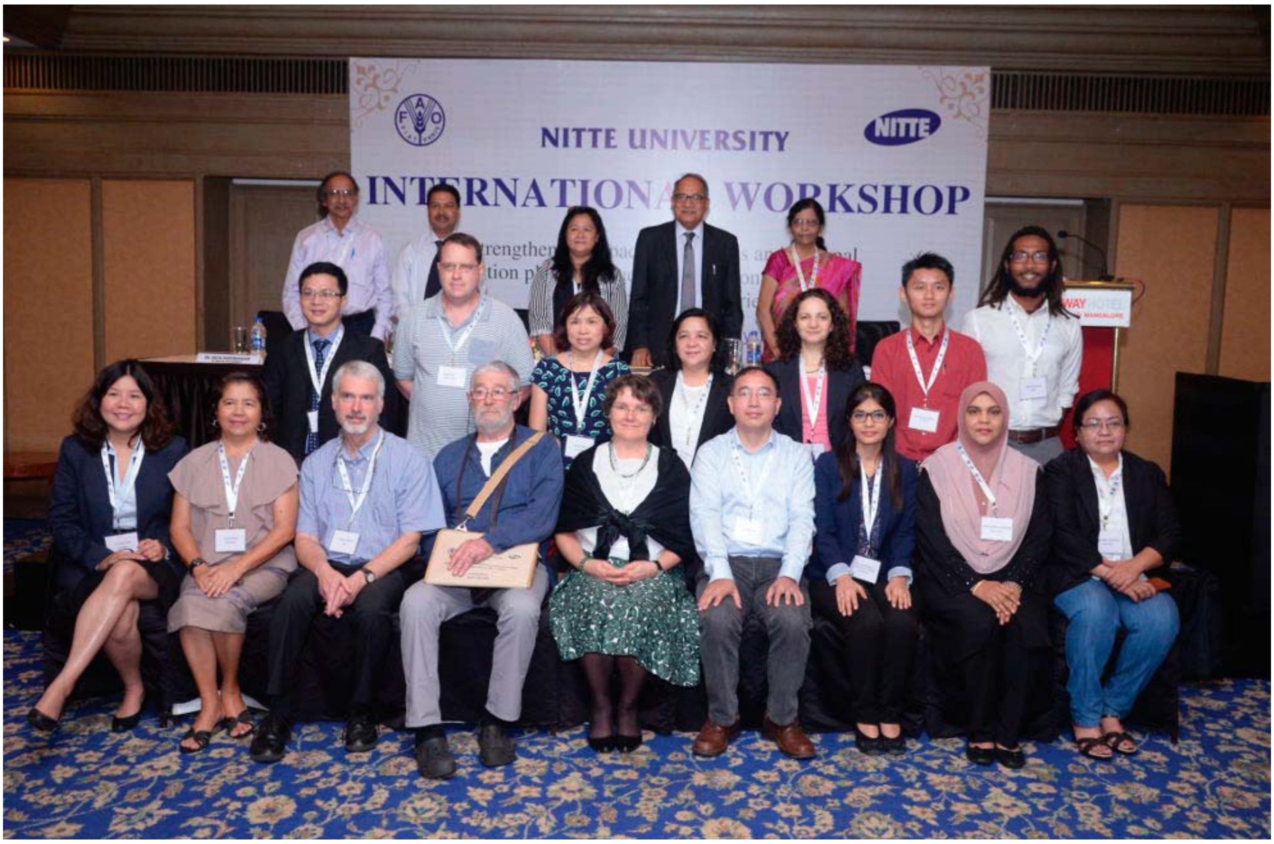
Content has also been organised into collections. If you access a single magazine article, for example, you will also be offered a reference to the full issue. If you access the full magazine you will also be offered a reference to the collection of all magazines, and so on. In this way you will be guided towards related content, if you want it.

The new site offers improved visibility into the network with direct links to our work programmes, participating research centres, the Technical Advisory Committee and representatives of member governments. In the coming months, we will also launch a database of scientific expertise available in the network.

The site is also mobile friendly, and will adjust itself to display easily on any device you care to use whether it be a phone, tablet, lap top or desktop display.

The website has been developed using a purpose-built content management system called Tuskfish, developed in house. Tuskfish has been specifically designed to be lightweight, easily maintained and robust. Use of external libraries has been avoided as far as possible and it does not require a separate database server, making use of SQLite. We have some work to do to polish the system for use by others, but in the coming months a public release will be issued along with a manual, to assist others who may find it useful for developing their own sites.

Reducing health risks from anti-microbial resistance in aquaculture



Participants in the workshop held at Nitte University, Mangalore, India, 10-12 April 2017.

The development of resistant strains of disease-causing microorganisms is an important health issue of global concern. When microbes such as bacteria, fungi, parasites, and viruses become resistant to antimicrobial substances, the diseases they may cause become more difficult or impossible to treat. Resistance is developed by the indiscriminate use of antimicrobials and places human health at risk.

The discovery of antibiotics revolutionised medicine, creating a belief that a 'magic bullet' had finally been found to control bacterial diseases. Antibiotics, a class of antimicrobial agents, kill or inhibit the growth of bacteria, but they have no significant effect on other types of microorganisms such as viruses.

"Bacteria, the oldest life form on this planet have survived 4 billion years due to their remarkable ability to adapt to changes in their environment... any 'resistance' gene present in any member of any species in the microbiome has the potential to transfer to any other species" says Dr Peter Smith of Ireland.

National delegates representing China, Malaysia, the Philippines and Viet Nam; fish health experts from India, Ireland, the Netherlands, the Philippines, Viet Nam and the United States; and representatives of the Government of India, Nitte University, FAO, NACA and the OIE are participating at an international workshop to address antimicrobial use (AMU) and AMR in aquaculture, convened by FAO and Nitte University, in Mangalore, India, 10-12 April.

Dr J.K. Jena, Deputy Director General of the Indian Council of Agricultural Research, highlighted the importance of aquaculture and the need to address issues related to diseases and the irresponsible use of veterinary drugs. "Strengthening laboratory networks and increasing AMU/AMR awareness as well as research on safety, efficacy and withdrawal period, resistance mode and process of transfer of resistance for different antimicrobials are needed", he said.

In his Presidential Address, the Vice-Chancellor of Nitte University, Professor Ramananda Shetty, urged interdisciplinary studies to be undertaken as all sectors have a responsibility towards this burning problem. He emphasised the need for regulation of antibiotic sales, responsible implementation of treatment regimens by the doctors and diligent attention to medical advice by the patients.

The complexity of the issue calls for a "One Health" platform involving both human medicine and the agriculture sector in an interdisciplinary and integrated approach to tackle what is very much a common problem. This approach combined with concerted actions at the national level that span policy and regulatory spheres, preventive actions and engagement with producers and other food value chain stakeholders are needed to prevent and reduce AMR.

Detailed guidance was provided on developing the aquaculture component of the National Action Plans on AMR covering the four focus areas of FAO's Action Plan on AMR: awareness, governance, evidence (usage and surveillance) and practice (prudent use). National delegates will further develop the action plans, disseminate the scientific information delivered during the workshop and create awareness of AMR issues among national stakeholders.

NACA has recently commenced a project, funded by FAO, to investigate document and characterize antimicrobial use in the aquaculture sector including current and proposed practices in aquaculture and aquatic disease status in Asia. The project will operate on freshwater fish aquaculture in Myanmar, shrimp aquaculture in Thailand and *Pangasius* aquaculture in Vietnam.

Network of Aquaculture Centres in Asia-Pacific

Mailing address:
P.O. Box 1040,
Kasetsart University
Post Office,
Ladyao, Jatujak,
Bangkok 10903,
Thailand

Phone +66 (2) 561 1728
Fax +66 (2) 561 1727
Email: info@enaca.org
Website: www.enaca.org

NACA is a network composed of 19 member governments in the Asia-Pacific Region.