ISSN 0859-600X

Volume XIX No. 3 July-September 2014

AQUACULTURE ASIA

Tilapia taking off in Fiji

Pearlspot breeding and cage culture

CBF in Cambodia

Inbreeding and shrimp

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Labour issues

You may have noticed some recent stories in the media about abusive or exploitive labour practices in the fisheries and aquaculture industries. It's not a new issue actually, it's something that has cropped up periodically for at least as long as I've been working in the field (nearly 20 years), but recently the media has been ratcheting up the pressure. And probably with good reason.

The allegations have covered many issues from use of child labour, use of undocumented migrant workers, use of forced, bonded or captive labour, inadequate or non-existent safety standards, physical abuse of workers and worse. The fishing industry has borne the brunt of the complaints, although issues have also been raised with aquaculture.

I do not want to tar the entire industry with the same brush, let's be very clear about that. I do not want people to get the idea that such practices are "normal", because they are not. Nor do I want people to think that practices in the aquaculture and fishing industries are the same, because they aren't.

But by the same token, if you look hard enough around the region you will certainly be able to find examples of at least some of these things, at least in the fishing industry. The use of undocumented migrant workers – who have practically no legal protection or recourse - on fishing vessels, in particular, is commonplace in some areas.

Which brings me to the point of this column: There are significant rumblings coming from major trading partners, notably the US and the EU, about cracking down on the importation of seafood produced illegally or through unacceptable labour conditions, which usually go hand-in-hand. It has all the hallmarks of a large and very serious trade barrier in the making.

Serious not just because there are legitimate labour rights issues to be addressed, but also because the legion of farmers and fishers that are doing the right thing are also going to be swept up in the net. If controls are introduced by trade partners, it is inevitable that all fisheries products will be required to provide documented proof of origin and production conditions. Not just wild-caught products, but the farmed ones as well.

Few people in government want to talk about these issues, but in my view they are going to be having plenty of conversations about them soon, whether they like it or not. It would be far better for governments to address these issues proactively than to wait for the ban hammer to be dropped from on high.

Simon Wilkinson

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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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Submit articles to:
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Printed by
Scand-Media Co., Ltd.

AQUACULTURE ASIA

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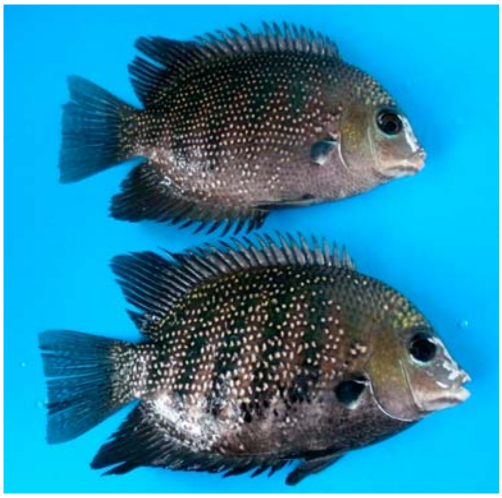
NACA Newsletter 19



Peter Edwards writes on

Rural Aquaculture

Commercial tilapia farming at 'take-off' point in Fiji

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I was delighted to receive an invitation to attend a workshop on aquaculture extension in Fiji for two reasons: it would serve to fill in a gap in my experience of global aquaculture as I had yet to visit a Pacific island country, except for the large island of Papua New Guinea (reported on in my 2009 column, 'Promoting small-scale inland aquaculture in Papua New Guinea', Aquaculture Asia 14, 3: 11-17); and I had never taught aquaculture extension although I have been involved in it ever since I started working in aquaculture in Asia, mainly because it was covered by another member of the Asian Institute of Aquaculture (AIT) aquaculture team, Harvey Demaine, with specific expertise in extension. Revisiting the AIT experience in extension and reviewing that of others in Asia was a pleasure, facilitated to a large extent by drawing on the writings of Harvey on the topic for which I am indebted to him.

On arrival in Fiji I was taken on a rather gruelling but highly enjoyable hike in the Koroyanitu National Heritage Park, Fiji's only unlogged tropical montane forest, by Tim Pickering from the Secretariat of the Pacific Community (SPC) who kindly met me at the airport in Nadi. As there should be a perk in every job, I had requested to visit the park to pander to my interest in tropical botany although it was also a great way to start the recovery from jet lag after a 24 hour door-to-door journey from Bangkok. Later in the day we visited the first modern tilapia hatchery in the country

Jiosese (left) and farm assistant (right) at Kerry's Farm, the first modern tilapia seed farm in Fiji.

Above: Close up of incubating tilapia eggs. Below: Tilapia breeding hapas suspended in a grow-out pond at Kerry's Farm.

before driving across the main island of Viti Levu to the capital city , Suva, where the workshop was to be held.

The ‘SPC Capacity-building Workshop for Aquaculture Extension Officers’, held for 5 days from 2-6 March, was organised jointly between SPC (an associate member of NACA) and the Fiji Ministry of Fisheries and Forests (MoFF). It wasattended by an enthusiastic group of about 30 aquaculture and fisheries extension officers from throughout Fiji as well as government tilapia hatchery staff and progressive fish farmers. The third day was a field trip to visit tilapia farms of varying scale.

An intense group discussion at the aquaculture extension workshop.

Workshop

The meeting was a participatory training workshop with the national participants who had experience of aquaculture and its extension in Fiji, and myself as the resource person with experience in the development of aquaculture technology and its extension in mainland tropical Asia. It was facilitated by Tim Pickering, Aquaculture Specialist, SPC.

Above: The findings of group discussions were reported back to all participants. Mr Sashi Karan of Ba hatchery MoFF reporting back as spokesman for his group.

The goal of the workshopwas to increase the capacities of Fiji aquaculture extension officers to carry out extension and advisory services and to provide farm development assistance, and assist them to scope out the key issues, skills, tools and techniques for effective discharge of their duties.

Following a brief presentation of meeting purpose and objectives, the participants were allocated to three groups to discuss and report back on their vision, roles, functions and responsibilities as aquaculture extension officers. The exercise was also to identify the aims and current capacity of the participants so that these could be addressed during the workshop. The participants were asked to discuss four themes: the main aquaculture systems in Fiji and the main constraints to their expansion and intensification; the human resources involved in aquaculture development and extension; what had extension officers been trained in, and what were their perceived gaps in knowledge; and what were their aspirations for the further development of their country’s aquaculture?

Tim and I had planned for me to ‘kick off’ my PowerPoint presentations with background theory on sustainable aquaculture development but we thought that

this would not have generated too much excitement at the start of the workshop among extension officers who spend much of their time in the field. Instead I first presented well illustrated case studies of the development and extension of Asian aquaculture (remember the saying, 'a picture is worth a thousand words'). Subsequently, I present more theoretical topics to complement the case studies: sustainable development; the history, basics and methodologies of extension; the sustainable livelihoods framework; the ecosystem approach to aquaculture; and finally policy and the specific role of national institutions in extension.

The final third of the workshop, following the field trip which also highlighted some key issues, was another division of the participants into three groups to discuss and report back on the topics in the workshop that they had found most useful, which topics did they need more in-depth knowledge of and skills in, and how should these be acquired? A wide range of topics was raised by the three groups but those standing out as being mentioned by all three groups were pond design and construction as commercial aquaculture in ponds has only recently started to increase in the country (I was asked to make a special presentation on this topic), advanced nursing of tilapia as mostly fry are stocked with resulting low survival, and cage culture which remains to be introduced to Fiji.

Field trips

Pre-workshop farm visit

Tilapia was introduced into Fiji decades ago but only recently had interest grown in tilapia as a commercial-level business, rather than a subsistence-level, small-scale farming activity which had been promoted in the past. There is increasing demand in Fiji for tilapia due to declining supplies of wild reef fish, which have been the major source of food fish, because of overfishing. Furthermore, there are concerns about the toxicity of reef fish from ciguatera, a food-borne illness, caused by eating reef fish contaminated by ciguatera toxin that is produced by dinoflagellates and accumulated in the fish.

A major constraint to the development of commercial tilapia aquaculture in Fiji prior to the development of the above hatchery was the lack of a good quality tilapia seed. The government hatcheries still produced tilapia seed using the dated method of collecting swim-up fry which can be anywhere from 10 to 40 days old.There is an advantage of the swim-up fry method, that it is easier to operate and does not require such a high level of daily care and attention, but a more efficient method is required to provide seed for commercial level aquaculture. The MoFF also packed tilpia fry for delivery to farmers at a miniscule 0.1 - 0.2 g size. Previously the stations did supply fry nursed for 15-20 days until they were fingerlings of a more suitable 1-3 g size for stocking in ponds but fry of only 0.1- 0.2 g were now being supplied to the farmers because of the increased demand for tilapia seed.

The workshop particpants arrive at the 'subsistence' level farm.

A small pond on the 'subsistence' level farm was fertilised by manure from a handful of ducks.

Tim was keen for me to visit the first modern tilapia hatchery in Fiji, Kerry's Farm, managed by Jiosese Vodowaqavuka, a Fijian farmer who had attended the regular short course, 'Training on Tilapia Hatchery and Grow-out Technology' at AIT in 2013. SPC had recognised that the development of a commercially viable tilapia farming industry in Fiji would depend on private sector hatcheries producing good quality tilapia seed. SPC had recently assessed the potential of existing small-scale tilapia farm sites and farmers to develop a specialised tilapia hatchery and had selected Jiosese to attend the course to obtain the necessary knowledge and skills to pioneer its introduction into Fiji.

The 16 ha farm, owned by an ethnic Chinese medical doctor, Dr Zen, mainly cultivated cassava but 4 ha of ponds been built in 2005. Giant river prawn, Macrobrachiumrosenbergii, was farmed initially but the water supply, pumped from a nearby river, was insufficient to permit water exchange, so tilapia has been farmed since 2008 instead.

The farm had set up a scaled-down AIT hatchery and nursery system to produce MT (methyltestosterone) -treated seed. MT-treated fry fed fish meal took 21 days to produce after which they were nursed in hapas suspended in a pond and fed fishmeal for 2 weeks until they reached 5 g. They were then stocked in ponds at 3/m^2. The seven 2,100 m^2 ponds were fertilised once with a single 25 kg sack of feedlot chicken manure and the fish were then fed with locally produced sinking pelleted feed with a 25% protein content costing FJD 31/25 kg sack (US$1 = FJD 2 approximately). The pond water was usually green except during rain. The fish reached a marketable size of 250 g in 6 months withan FCR of 2:1.

There was a good market for the fish which were sold at the high price of FJD10/kg, about US$5/kg. A floating pellet purchased from China was to be tested and compared soon with the locally manufactured sinking pellet which had poor water stability, the first such trial in Fiji. Last year the farm produced 30,000 fingerlings in 3 months, enough to stock all the grow-out ponds on the farm and have a surplus for sale to other farmers.

The tilapia seed produced at Kerry's farm were in-demand by other farmers because they came in uniform batches that were aged +/- 5 days of each other, were all male from MT treatment, were nursed on tuna fish meal for a further 30 days after completion of MT treatment, were size-graded before packing, were visibly strong fit and active swimmers compared to MoFF fry, and had been accurately counted by the AIT scooping technique (MoFF counts were by

A well managed pond on the 'semi-subsistence' level farm.

scooping beakers of water from a strongly aerated tank for counting so were wildly inaccurate), and farmers who had tried them already were telling other farmers that they did not see tilapia breeding in ponds at the time that they would normally expect to see offspring appearing.

Workshop farm visits

The purpose of the field trips was to instruct the extension officers in how to best conduct farmer interviews. The extension officers explained that there were two main purposes in visiting farms: to collect statistical data on aquaculture for the government; and to help the farmers to improve their aquaculture practice. Tim and I requested the extension officers to recommend three tilapia farms at varying levels of scale for the workshop participants to visit for the mid-workshop, one day field trip: 'subsistence' level with tilapia raised only for domestic consumption; 'semi-subsistence' level with fish being consumed by the farm household but mainly sold but with other sources of household income; and 'commercial' level with the farm household selling fish as their sole livelihood activity.

The first farm we visited, the 'subsistence' farm, had a small 100 m^2 pond constructed for the farmer's dozen or so ducks. The pond received only duck manure and no other fertilisers or feed were provided for the fish. Five hundred 2-3 g tilapia fingerlings supplied by the MoFF had been stocked once the previous year at a density of 5/m^2. The farmer claimed that 400 fish of 200-300 g had been harvested for domestic consumption over the last 6 months, giving a highly unlikely extrapolated production of 10 tonnes/ha for the period, even though the water was plankton-rich as indicated by the green coloured water.

The 'subsistence' farmer on further discussion turned out to be far from poor as he was a partner in a logging business so he was a 'subsistence' farmer from only an aquaculture

Tim Pickering (SPC), Mr Mohammed Saddiq ('commercial' level farmer) and Mr Tomasi Cama (Fisheries Officer for Bua Province of Vanua Levu Island) behind a recently constructed tank.

technical point of view. I was thus unable to explore the social issues of relatively poor crop farmers becoming involved in aquaculture as a possible diversification of farm activities. The farmer explained that the small-scale pond was a trial pond to gain experience in aquaculture as he intended to construct a larger pond to raise pellet-fed fish for sale. He explained that the farm gate price for large tilapia was an attractive FJD 8/kg with a production cost of only FJD 3/kg. He had already received permission from the clan to which he belonged to lease land to construct a larger, 30 x 40m, 1,200 m^2 pond. Most of the land in Fiji is communally owned by clans. He had also requested assistance from the MoFF to construct the pond.

The second farm we visited, the 'semi-subsistence' farmer, had a truck transport business delivering mainly chicken feed but also tilapia pelleted feed. He got the idea to farm fish from observing other fish farmers who he visited delivering fish feed. He started with a single 30 x 40 m^2 pond on his 2.5 ha farm which he had purchased using his savings. Water had to be pumped a distance of 100 m from a nearby river although it was supplemented with heavy rainfall. He was on his third cycle of fish in the pond. He stocked 4,000 fry or 3.3. fry/m^2. The first harvest in the 1,200 m^2 pond was 1.2 tonnes, an impressive extrapolated harvest of almost 10 tonnes/ha, of 200-250 g fish, which he sold at FJD 8/kg, a total of FJD 9,800; the second harvest was 1.1 tonnes sold at FJD 7/kg for a total of FJD 7,800. He had built two other ponds which had been stocked with fish and a third was under construction. A pond cost FJD 3,000 to build with a FJD 4,500 operating cost for a tilapia crop (feed, transport, fuel) of which feed, costing FJD 1.26/kg, comprised 84 % of the total operating cost. Ponds were being constructed using a revolving fund from the profits of fish culture. The farmer was also raising ornamental goldfish. A major issue was poaching of fish by herons.

Mr Mohammed Saddiq had diversified into ornamental goldfish.

The third and final farm visit was to a fully commercial farm established in 1992, over 20 years ago. The farmer had previously worked for the MoFF until 1976 from whom he learned

An undrainable pond on the 'commercial' level fish farm.

basic fish culture. The 3 ha farm consisted only of fish ponds: a total of six ponds, one of 30 x 40 m (curiously the same size as the ponds the other two farms visited either had built or intended to build), two of 25 x 28 m; two of 17 x 28 m; an 1 of 20 x 30 m. The earliest two ponds constructed had never been de-silted because their bottoms were lower than that of the drainage ditch and had become very shallow and highly eutrophic. Pond preparation for the drainable ponds consisted of sun drying the bottom and adding 100 kg lime to kill young tilapia and Gambusia fish. The pond was filled with water and then fertilised with 100 kg of feedlot chicken manure in 25 kg sacks floating in the water which could be removed if the water became too fertile. Fish were stocked 3 weeks later and fed with a farm-made mixed powder of fish meal, copra and mill mix. A total of 4,000 fry were stocked in a 1,200 m^2 pond or 3/m^2. According to the farmer, until 10 years ago 1,000 fish of 200 g size were harvested in each of four successive weeks starting after 5 months of growth in the two undrainable ponds, the first ponds constructed on the farm at the bottom of a valley. The total of 800 kg of fish from the four harvests, assuming an unlikely zero mortality although some tilapia may have survived from the previous harvest in the undrainable pond, gives a realistic extrapolated harvest of 6.6 tonnes/ha. However, the production had declined by 50% as the pond had become shallow. The local price was FGD 8/kg. A major issue was harvesting and marketing the fish depended on the MoFF. The farmer had been waiting for 4 months for his fish to be harvested for live sale and last month 500 large fish had died from lack of night-time dissolved oxygen because of the highly eutrophic status of the pond. The pond was being oxygenated by an electric pump driven aeration system that had been observed on a training programme at AIT. The farmer had recognised the advantage of nursing fry supplied by the MoFF as he had built a concrete tank for the purpose. This farmer was also raising ornamental goldfish as was the second farm visited.

The River Rewa, a potential site for tilapia cage culture.

Suva Fish Market - the major fish sold were small reef fish.

Prospects and remaining issues

The development of commercial farming of tilapia in Fiji was clearly underway. A major development was the introduction of modern seed production through a Fijian farmer attending a training programme at AIT sponsored by SPC so that monosex, uniform size and age, seed of tilapia were becoming available for the first time in the country.

Farmers were stocking mostly very small 0.2 - 0.3 g fry which had a high mortality when stocked directly in grow-out ponds. There is a need to introduce advanced nursing, either in specially designed tanks or nursery ponds, or better still in hapas suspended in grow-out ponds, to produce larger and stronger fingerlings which have a better survival rate as well as requiring a shorter period to reach marketable size.

The only pelleted feed available in the country was a locally produced sinking pellet. However, SPC was funding a trial to compare the performance in tilapia grow-out of an extruded floating pellet imported from China with the locally produced sinking pellet. Feed mills in Fiji would only start to manufacture floating fish pellets if the production volume warranted investment in the machinery required to produce the improved pellets.

Tim also informed me that a major unexploited issue in Fiji was the absence of cage culture of tilapia. During the field trip we drove along the bank of a major river, the River Rewa, which may be suitable for tilapia cage culture and which struck me by their absence. During the workshop I also gave a special session on cage culture as it was of interest to the participants.

The field trip revealed a major constraint to the commercialisation of tilapia in Fiji, the limited marketing system. I informed the participants that provision of input supply of fish seed and feed, and harvesting and marketing fish, from farms was a major business opportunity. One of the workshop participants expressed interest in pursuing this as he had a pick-up truck, an essential item to begin to set up a tilapia marketing network.

Live tilapia in aerated tanks, Suva Fish market.

Both the MoFF and SPC had clearly recognised that commercial tilapia farming was at 'take-off' point in Fiji, hence holding the workshop on extension of aquaculture.

Close up of live tilapia, Suva Fish Market.

Tank based captive breeding and seed production of the pearlspot (*Etroplus suratensis*)

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Shrimp farming industry throughout Asia has witnessed havoc in the 1990s due to viral disease problems (notably white spot syndrome virus), which is still persistent. Therefore, species diversification has been an urgent need for sustainable brackishwater aquaculture development. As a high value species, the pearlspot, *Etroplus suratensis* (Bloch) is considered one of the most suitable candidates for diversified coastal aquaculture in south Asia. E. suratensis or green chromide is one of the only three cichlid species native to southern Asia including peninsular India and Sri Lanka (the others being *Etroplus maculatus* (Bloch) and *Etroplus canarensis* Day). In India, it is widely distributed and traditionally cultured in the backwaters and freshwaters along the coastal regions from South Canara to Thiruvananthapuram on the west coast and later introduced to the east coast regions, such as Chilka Lake, Orissa and Kakdwip, West Bengal. Owing to its palatability and flesh quality the pearlspot has high consumer preference. This fish is compatible to be farmed in brackishwater and freshwater polyculture with carps, mullets, milkfish and shrimps due to its euryhaline nature and omnivorous feeding habit. However, seed availability for aquaculture has become limited due to depleted natural stocks resulted from over exploitation. Captive breeding and seed production of this species seem to be complicated and unsuccessful as it is difficult to manage their unique reproductive behaviour including pairing, nest building, courtship and parental care1. Although self-recruitment in earthen ponds has been practiced by farmers employing broodstock management

Figure 1: Fired clay tiles served as artificial nesting substrates.

strategies, recovery of seed from pond systems is problematic and time consuming; also the substantial disturbances during seed collection hamper the breeding activity of already paired brooders. Previous work at the Central Institute of Brackishwater Aquaculture showed promising results in controlled breeding of this fish in 20 tonne RCC tank provided with soil base, fired clay tiles as substrates for egg laying and water flow-through2. More recently, successful effort3 has been undertaken for captive breeding and seed production in specially designed artificial raceway tank provided with spawning substrates and cement slabs with artificial pits for larval brooding. However, this system remains different from their natural counterpart in term of brooding pits, which are generally excavated by the parents on the muddy ground near the nest before the eggs hatch out. Moreover, the said system seems to be expensive to install and operate. In this context, we have endeavoured to produce pearlspot seeds employing improved and simplified resource and cost-efficient techniques that can easily be adopted by farmers.

Breeding tank set up

Captive breeding of this fish was undertaken in specially designed circular cement cistern under simulated natural conditions. The flat bottom circular cistern of 10 tonne capacity had an outlet pipe. Artificial nesting materials comprising of fired clay tiles (9 pieces) were hung 1.0-1.2 m apart from the top of the tank keeping 50-60 cm inside from the tank wall and 45-50 cm above the bottom (Figure 1). Nine circular plastic tubs (55 cm in diameter × 35 cm deep) were filled up to 30 cm with bottom soil collected from a pearlspot broodstock pond (Figure 2). The tubs were placed at the tank bottom just under the tiles to facilitate the parental care. The tank was filled to a depth of 1.2 m, with dechlorinated filtered brackishwater (10-12 ppt salinity). Three feeding pots made of fired clay were placed hanging in the tank at 50 cm water depth. Oxygen supply in the tank was maintained using compressed air (Figure 3).

Figure 2: Plastic tubs provided with clayey soils for making brooding pits by the parent fish for hatched out larvae.

Figure 3: Aeration in the breeding tank.

Table 1. Economic analysis of the tank breeding system of pearlspot. Calculation was for 120 days of a breeding cycle. Currency mentioned is Indian Rupee (100 INR = 1.90 US$).

Items	Amount	Price rate (in INR)	Total (INR)
Pearlspot brooders	12 pairs = 2.5 kg	100 kg^{-1}	250
Feed	6 kg	20 kg^{-1}	120
Fire clay tiles	9 pieces	15 piece^{-1}	135
Fire clay pots	3 pieces	10 piece^{-1}	30
Plastic tubs	9 pieces	80 piece^{-1}	720
Aeration facility			2,500
Labour	30 man-days	140 man-days	4,200
Miscellaneous expenses		1,045	
Sub-total (for cycle 1)		9,000	
Pearlspot fry sale	6,800	2 fry^{-1}	13,600
Net-return from cycle 1	4,600		
Operational costs for cycle 2 & 3 (excluding expenses on tiles, pots, tubs & aeration facility)	11,230		
Total operational cost (in 3 cycles)	20,230		
Total return on fry sale (in 3 cycles)	40,800		
Net-return from cycle 2 & 3	15,970		
Total net-return (in 3 cycles)	20,570		
Benefit-cost ratio (BCR)= total return/ total operational cost	2.02		

Selection and stocking of brood fish

The pearlspot is heterosexual and females outnumber males in sex ratio in the natural population. The fish becomes sexually mature within a year of age with over 10 cm size. Pearlspot breed in both brackish and freshwater throughout the year with two peaks in February-April and June- October3. Pearlspot brood fish were raised in separate broodstock ponds. Mature males and females were selected based on their secondary sexual characteristics developed during breeding season. In males, the colour bands on body surfaces become darker and conspicuous, the greenish-blue iridescence and the pearly white spots are very prominent, ventral part of the body is covered with numerous dark pigmentations and overall the male turns gorgeously darker. The female is generally smaller in size with muddy yellowish darker colour (Figure 4). The mature male and female can also be differentiated by the presence of a projected genital papilla. In mature male it is slender and pointed, whereas in female it is broader, swollen with tip blunt and reddish (Figure 5). Altogether 12 pairs of selected brood fish of size 14-18 cm (80-120 g) were released in the breeding tank with 1:1 sex ratio.

Post-stocking breeding tank management

Pellet feed with 30% protein content4 was provided in the feeding pots at 2% body weight twice daily. Fifty per cent of water in the breeding tank was replaced at weekly intervals with fresh treated brackishwater (10-12 ppt) and care was taken to keep the substrate tiles submerged during water

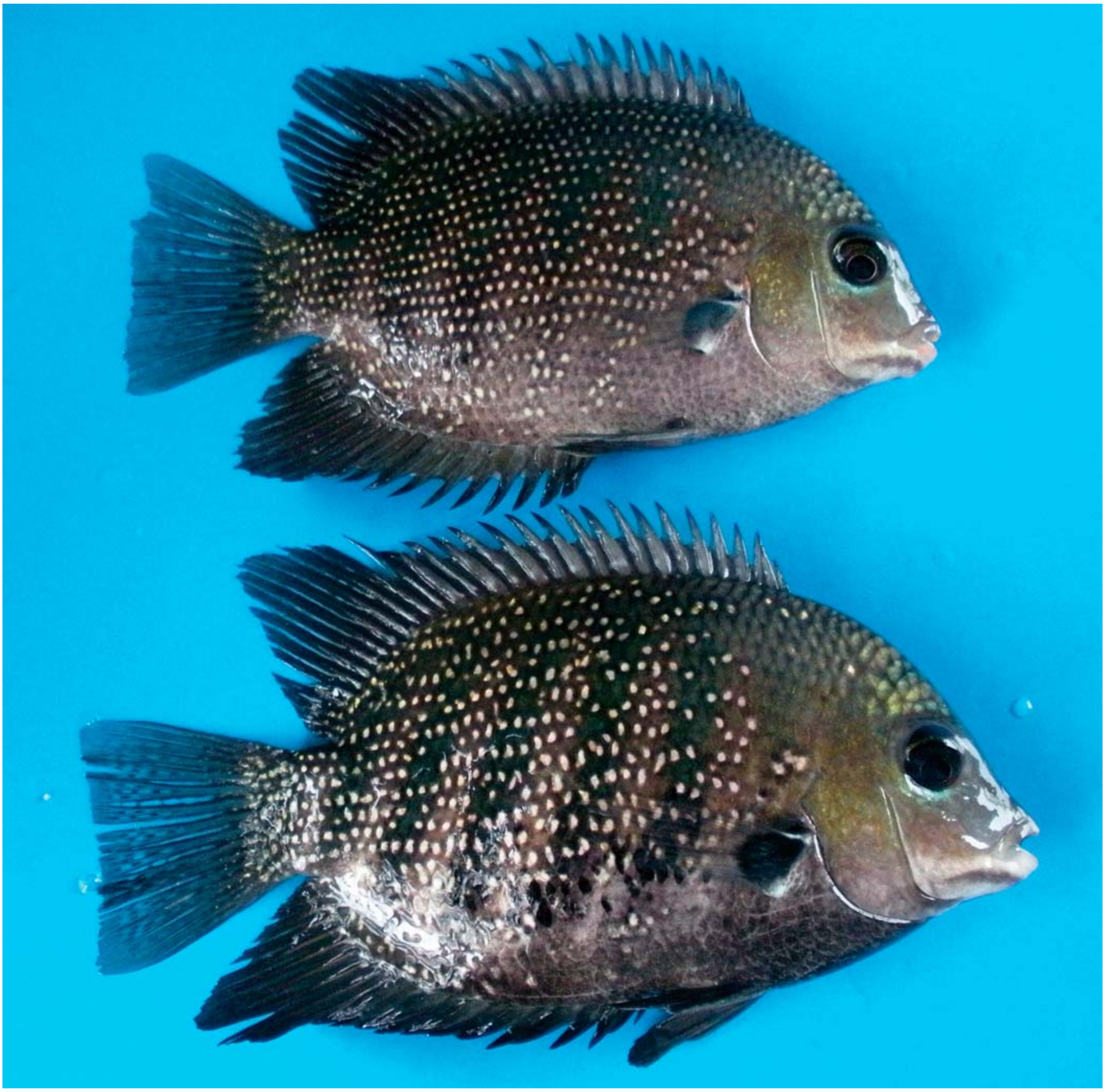

Figure 4: Mature female (upper) and male (below) pearlspot.

exchange. Mostly the bottom water was exchanged to remove the accumulated feed wastage and faecal matter in order to prevent water quality deterioration. Aeration for 2 hours was alternated with 2 hours non-aeration in the tanks.

Reproductive behaviour, spawning and larvae production

In the breeding tank, captive seed production was facilitated by promoting parental care of the paired spawners. During the breeding season, after pair formation both male and female participate in nest making with the male contributing more to this activity. In nature, for nest making they utilise submerged stationary solid objects such as coconut leaves, coconut husks, wooden logs and stones placed 11 to 45 cm above the tank bottom5. Within 2-3 days after release in the breeding tank, breeding pairs were formed. Then the pair started making nest by cleaning the tile surfaces and was seen to indulge in spawning acts within a month. The female was observed to lay flat on the spawning nest and gently move from one side to the other, attaching their eggs carefully on to the substratum with the help of its tubular and fleshy ovipositor and ventral fins. The male fish with a slow and quicker movement fertilized the deposited eggs instantly by releasing a spray of milt. This process of repeated egg laying and fertilization was continued for 2-3 hours and the eggs were placed closely in a patch without touching each other in a single layer. A distinguished parental care of eggs and hatchlings was seen after the eggs were laid, the female brooded with their rhythmic fanning and mouthing activity and the male guarded the territory preventing entry of intruders. Formation of pits (6-8 cm diameter and 2-3 cm deep) for larval brooding on the mud of plastic tubs was also found (Figure 6). The eggs hatched out in 80–90 hours and the hatchlings were picked up by the brooding mother in her mouth and transferred to the pits. During this period also, fanning and mouthing of the female continued. After absorption of yolk sack in a week, the hatchlings became free swimming and gradually moved out of the pits to the open waters led by the parents. Natural food in the form of zooplanktons collected from brackishwater culture ponds was supplied in the tank as preferred food for larvae. Initially the larvae were devoid of body pigmentation and as they grew, they became free swimming and body pigmentation developed.

Collection of seeds

Within a month the seed resembled adult form with a size of about 2.0-2.2 cm (Figure 7). Seeds were collected by opening the outlet fitted with a net cage in a sump filled with brackish-water. Thus, in a breeding season of 4 months from this tank breeding 5000-10,000 pearlspot seeds could be produced. Therefore, 3 cycles could be accomplished in a year with a lucrative benefit-cost ratio (BCR) of 2.02 (Table 1).

Captive seed production in tanks is advantageous to the natural breeding in ponds as it is easily managed and requires less space and capital investment. Furthermore, fry yield under tank breeding is higher compared to earthen pond system and year round spawning can also be achieved. Seed recovery is better as complete capture of juveniles is possible with less effort in controlled tank breeding. This tank breeding

Figure 5: Sex differentiation by the presence of a projected genital papilla, which is broader, swollen with tip blunt and reddish in female (upper) and slender and pointed in male (below).

Figure 6: Formation of pits for larval brooding on the mud of plastic tub.

Figure 7: Collected pearlspot seeds from breeding tank.

method with further improvement may become a cost-effective simplified technique which can produce significant amount of pearlspot seeds much needed for brackishwater aquaculture diversification.

Acknowledgements

During this study, support and help received from the field and laboratory staffs of the Kakdwip Research Centre of CIBA are duly acknowledged.

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Cage culture of the native cichlid, *Etroplus suratensis* (pearlspot) in Kerala, India; A laudable initiative towards emergence of small scale cage culture

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The state of Kerala, a focal centre of tourism in India, is fondly called “Gods own country”. Memories of serene houseboat cruises along winding estuaries and savouring freshly prepared karimeen delicacies onboard are treasured by most tourists among their nonpareil experiences in Kerala. Alluring images of locally prepared karimeen served on a traditional platter are an integral part of the hoardings and tourism advertisements for house boat cruises and local restaurants. Thus the fish has come to occupy an integral part of the tourist’s cuisine, the ethos of which is well echoed in the statement “Kerala’s icon in the minds of gourmets” by courtesy of a leading Indian daily.

Etroplus suratensis, commonly known as “green chromide” or “pearlspot” and colloquially referred to as ‘Karimeen’ has evolved from the local household cuisine to a major highlight of the tourism industry. This species is native to Indian and Sri Lankan waters and contributes to a major fishery in the inland waters of Kerala. Traditionally, pearlspot is caught using gill nets, cast nets, hand picking or by stunning the fish using light at night. The fish has a year round market and fetches a price of Rs. 400-600/kg, which is at par or above the price of any other food fish in the state. The commercial importance and the local preference led the state government of Kerala to declare pearlspot as the State Fish in the year 2010 and the year 2011-12 was declared as ‘Karimeen Varsham’ or ‘The Year of Pearlspot’ with an all out effort to conserve the valuable resource and sustain the fishery. The effort by the state is truly laudable since it provided the necessary impetus for conservation initiatives in its home ground - the brackish water lakes of Kerala, and an increase in production through aquaculture.

The species grows well in a wide range of salinities and hence is suitable for farming in a variety of water bodies, providing opportunity to a relatively large number of farmers to take up its farming. High market demand coupled with assured economic benefits and easily adoptable technology makes the species an ideal candidate for small scale fish

Cages fixed in brackishwater lagoon in Kollam, Kerala.

culture in Kerala, using locally available inputs. Traditionally, pearlspot is grown as a component in polyculture systems with other brackishwater fishes (milk fish, mullets, tilapia etc.) and shrimps in brackishwater aquaculture ponds, where seeds from natural water sources are allowed to grow in confinement utilising the natural productivity of the water body. Being an omnivorous fish, the culture of the species is supported by low cost farm made feeds and no special skills or interventions are required at any stage of culture.

Since the declaration of pearlspot as the "signature fish of Kerala", the state government has been promoting its culture in traditional culture ponds, homestead ponds, kitchen ponds and cages through the 'The Year of Pearlspot' project. To overcome seed scarcity, establishment of small scale hatcheries has been envisaged. Cage culture of pearlspot is now being initiated through various self-help groups (SHGs) in all the coastal districts of Kerala such as Trivandrum, Kollam, Alappuzha, Ernakulam, Thrissur, Malappuram, Kozhikode, Kannur and Kasargod.

People with ample access to open brackishwater bodies are selected as beneficiaries of the project. Activity groups consisting of 4-5 farmers are formed and then trained on the different aspects of cage culture like cage fabrication, installation, stocking, feeding, cleaning etc. The government provides support in the form subsidies for seed and feed, technological inputs from experts and encouragement through recognition in the form of awards.

The cages are usually installed in open brackishwater bodies and the major criteria used for site selection is the absence of pollution and the water depth in addition to proximity to farmer's house-holds to ensure security. Areas abundant in oysters and fouling organisms are avoided. No alteration is done to the local ecosystem for installing the cages. Cages are set up in areas with more than 75-90 cm clearance from the bottom. Double walled fixed cages with an inner nylon net of 16-18 mm mesh size and an outer HDPE net of 28-30 mm mesh size, with dimensions of 2.0 x 1.5 x 1.5 m supported by PVC framework are used. Some farmers provide additional protection with used nets around the area to keep away rodents and crabs. The cages are fabricated mostly by the farmers themselves with materials supplied by the agencies (average cost of about Rs. 5,000 per cage). Setting up of the cages usually requires 2-4 person-days and with proper maintenance the cages are found to last for 2-3 culture cycles. The main labour component goes in for cage fabrication, installation of cages and final harvesting. Activities like feeding and cleaning of net cages are usually managed along with other routine activities by the farmers themselves, most of whom are traditional fisher folk depending on the same water body.

Majority of the seeds used for culture are collected from these natural water bodies, either by the farmers themselves or procured from breeders and wild seed collectors. Various government agencies also procure stocking material from private entrepreneurs and distribute them to farmers. Seeds trapped in Chinese dip nets and other gears have also been used for cage culture. The seeds are currently sold at Rs. 4-6/seed depending on the size. Stocking density usually varies from 150-800/m3 and is primarily decided by seed size and availability at the time of stocking.

Farmer inspecting cages after a culture cycle.

Prior to stocking of fish seed, the cages are immersed in culture system for a period of seven days to permit periphyton colonization which forms the initial feed for the stocked fishes. From experience, farmers have noted that copious periphyton availability enhances growth and survival of the seeds. The inner net of the cage is removed when the seeds attain an average body weight of about 50 g. Few farmers have further noted differential growth in pearlspot when reared from the fry stage onwards but not so when fingerlings were used for initial stocking.

Feed components primarily consists of locally available ingredients such as groundnut oil cake, rice bran, tapioca, fish meal, boiled mussel meat, cooked rice, vegetable waste, wheat flour, cattle feed, etc. Few innovative farmers collect locally available algae to be used as feed. Commercial pelletted fish feeds were rarely used. Feeding is usually done twice daily @ 10% of the biomass. The feed is dispensed using a PVC pipe to feeding trays suspended within the cages. Most of the farmers have observed that the cages were devoid of algae or other periphytic organisms as pearlspot actively consume these, and hence problems related to clogging of nets are usually not encountered.

Fishes are harvested after 6-8 months culture period by which time they attain about 150-200 g in body weight. Marketing of farmed pearlspot is never an issue due to the exceptionally high local demand. Partial harvest is practised by many successful farmers, so that the larger fish can be disposed according to demand and allow the smaller ones to grow. Seasoned farmers are adept at clubbing marketing with festival seasons or trawl ban period so as to realise maximum profits. Often, local restaurants are willing to take up the total production of a single cage. Since pearlspot is a “table fish”, restaurants also prefer smaller sized fish to get more units of fish per kilogram. Thus depending on the clientele, it may be actually possible to shorten the culture duration. Another interesting aspect is the higher demand for pearlspot produced from the natural waterbodies of Kerala. The local customers hold the perception that these fish have superior organoleptic qualities and therefore command better price against fishes brought from other states.

Seed shortage has led many farmers to adopt continuous stocking and harvest thereby making it difficult to assess the economics. The highest production achieved by cage culture currently is 50-60 kg per cage unit. Some of the most successful farmers have reported an income of Rs 10,000 per cage indicating ample potential for small scale cage culture of pearlspot as a supplementary source of income and employment.

Constraints that deter expansion of pearlspot farming relate to certain inherent biological characteristics of the species such as low fecundity coupled with the absence of an optimized induced breeding technology, complexities in pair formation, nest building and parental care of the young. These factors make mass scale seed production challenging and discourage entrepreneurs from venturing into more intensive forms of culture, despite the excellent demand for the species.

Another constraint is the absence of a viable formulated feed for the species, suitable for use in cages. Farmers use a variety of materials depending on local availability and cost effectiveness, irrespective of the nutritional requirement of the species. An appropriate formula for farm made feed is the need of the hour to tackle the co-existing problems of nutritional requirement of the species and cost of feed. Absence of an appropriate nutritional strategy may be one of the reasons for the long culture periods currently encountered. Loss of fish due to algal blooms, predation by rodents, birds, snakes, crabs, otters and poaching are of serious concern to farmers. Biofouling on cage frames is another reported issue. Settlement of waste materials from cages to the lake bottom has so far not been observed in the areas used for cage culture.

Farmers who have taken up pearlspot cage culture are mostly traditional fisher folk than seasoned fish culturists and exhibit keen interest in taking up fish farming to supplement their income. The initiation of pearlspot cage culture has opened the possibility of cage culture of other fish species like mullets, milkfish etc. The success witnessed in the cage culture of pearlspot has instilled confidence among these farmers to adopt this approach for other fish species as well. Successful cage culture of multiple species by farmers previously involved in pearlspot culture is being reported. An interesting case is that of a Chinese dip net fishers maintaining cages in the vicinity of the nets for temporary holding of smaller sized economically important fish species prior to sorting and stocking into grow-out cages. This approach has resulted in initiation of small-scale cage culture of species like grey mullets, milk fish and scatophagus in these open water bodies.

Clay pot used as feed tray in the cages.

In the case of women, cage culture has been a source of income without affecting routine household chores. SHGs were initially promoted to take up cage culture, however, not all the SHG’s successfully completed the first culture cycle. Some of the commonly cited reasons relate to the long culture period, loss of enthusiasm due to poor growth rate of the species and poor coordination between members in sharing responsibilities. Unlike many brackishwater species pearlspot exhibits slow growth rate in the initial phase of culture and quite understandably this was a major discouraging factor for farmers who took to fish farming for the first time. Sucessful culture of pearlspot by such SHG’s was possible in cases where the group members sustained their enthusiasm till the end of the culture period despite the initial slow growth rates. Success witnessed in case of these groups or individual farmers has changed the perception towards pearlspot culture and re-initiated cage culture activities. Since cage culture of this omnivorous species does not require very high level fish farming expertise and has proven economic viability, one can foresee the bright prospects of such small scale aquaculture initiatives in open waterbodies particularly suitable for landless people interested in aquaculture.

In this first endeavour by the state, adoption of cage aquaculture by farmers have resulted in varying degree of success depending on their experience, involvement in the activity and site specific culture conditions. The significance of such an effort lies in the opportunity now available for poor families or people previously unconnected with aquaculture to enter fish culture and become part of the food production sector, something fundamental in ensuring food security in the years to come. Entrepreneurial models such as these are worth emulating for other species as well depending on the local feasibility in different regions of the country. The joint effort in Kerala from the policy makers, state machinery, researchers and farmers may find a place in the history of Indian aquaculture as the first of its kind to push across systematic small scale cage culture practice in any state in India.

NACA Newsletter

ISSN 0115-8503

Published by the Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

Volume XXIX, No. 3-4
July-December 2014

Culture-based fisheries exchange visit from Lao to Cambodia

Community representatives (right) with the project team (left), Kompong Tom Province, Cambodia.

A team of Lao researchers, government officers and three community representatives visited Cambodia from 25-29 May 2014 to observe local culture-based fisheries practices and to share experience. The exchange was conducted as part of the ACIAR-funded research project *Culture-based Fisheries Development in Lao PDR and Cambodia*, which has been running since 2012. This was the second such exchange under the project; in 2013 participants from the Cambodian side had visited Lao PDR.

The Lao team began their visit, which would circumnavigate the Great Lake by road, in Phnom Penh after a long drive from Vientiane. After meeting their counterparts at the Cambodian Department of Fisheries, they travelled to Kompong Tom Province to observe a large farm operating by an irrigation canal and reservoir. Due to favourable topography the farm was able to implement a gravity-fed flow-through system through the culture ponds, which were stocked mainly with tilapia, bighead and silver carp. The farm adopted a partial harvest regime with harvesting time and quantity determined according to current market demand. The team also observed a nearby natural lake which was one of the culture-based fisheries sites being piloted by the project. However, it was not possible to take a close look due to the condition of the road.

Irrigation reservoir used for secondary culture-based fisheries activity, Kompong Tom Province, Cambodia.

In the afternoon the team visited a community that were practicing culture-based fisheries in a community pond through the project. The community committee warmly welcomed the delegation and gave presentations on the local development initiatives in their village, which also included fisheries management and micro-credit programmes. The community expressed satisfaction with their first experiences in culture-based fisheries under the project and indicated that they planned to scale up the activity over the next few cycles as they became more confident.

On the 27th of May the group travelled to Bantaey Province and visited a fisheries conservation site. The conservation area was a deep part of a river connected to the Great Lake (Tonle Sap), adjacent to a temple. Fishing in the conservation area was forbidden and obviously this restriction was enforced, as the pool was heavily populated with large *Pangasius*, tinfoil barb and to a lesser extent carp species.

The team reached Kompong Chhang Province on the 28th, where they observed floating communities and cage culture taking place in the Great Lake. As it was the dry season the water level was low. Hundreds of boat houses were clustered together with cages beneath for fish culture, which were mainly stocked with *Mystus* catfish, which fetches a high market price of around US$8/kg. The team also observed a fishing boat landing its catch, with many species and a great variation of sizes of fish ranging from less than one hundred grams to several kilograms. In the afternoon the group travelled back to Phnom Penh and visited fish farms in the outlying suburban areas, which combined hatchery and grow-out operations. Fry and fingerlings were nursed

The trials of field work. Get out and push!

in hapas before being stocked out into the ponds. A simple compound feed paste was mixed and cooked on site into a paste for feeding.

The final day of the exchange visit was spent at the Cambodian Fisheries Administration, where Cambodian counterparts gave presentations about their culture-based fisheries activities and experiences under the project, followed by questions and answers. The Cambodian side indicated that they had found culture-based fisheries to be a very effective mechanism for improving the livelihoods of rural communities, although work was still at a relatively early stage with much learning to do. They advised that careful site selection especially with regards to the social aspects of the project were the key to success. It was important to work with communities that had both a strong commitment to the project and good local organisation and leadership, as it would be difficult to make progress otherwise.

The exchange visit highlighted differences in the operating environment between the two countries that affected culture-based fisheries activities. Aside from different styles of local government and community organisation, Cambodia differs from Lao PDR in having an open access policy with regards to fishing. In Cambodia by law, anyone can fish in a water body (excepting designated conservation areas), whereas in Lao PDR access to a water body can be controlled or restricted by the local community.

Above: Landing the catch from a well boat. Below: Sorting it on deck in a floating cage house.Tonle Sap, Cambodia.

Fish conservation area in a deep pool, Bantaey Province, Cambodia.

Usual practice in culture-based fisheries is to protect newly stocked fish for a period in order to let them reach a good size and maximise the returns on investment.

In Cambodia this is not possible due to the open access policy, which is important for food security of the poor and must be respected. However, Cambodia does designate portions of water bodies as conservation zones that are closed to fishing. Discussions are underway about the possibility of using conservation zones as nursery areas for stocking seed for culture-based fisheries activities.

NACA would like to thank the Cambodian side for their excellent support in organising and coordinating the exchange visit, in particular His Excellency Mr Srun Limsong for generous use of his time in accompanying the Lao team for the entire trip.

Lao and Cambodian teams in the Cambodian Fisheries Administration Office, Pnomh Penh.

National Fish Day, Cambodia

NACA was privileged to have the opportunity to attend the National Fish Day celebrations in Cambodia, held at the Kdol Reservoir in Kampol Chhnange Province on 1 July and organised by the Fisheries Administration. Approximately 10,000 people attended the ceremony, including many school children and villagers from surrounding areas, which was presided over by Prime Minister Hun Sen. The Director General of the Fisheries Administration gave a report on fisheries and aquaculture development over the past year. This was followed by a speech by the Prime Minister who spoke at length about recent changes to fisheries laws including the replacement of the fishing lot system with an open access fishing regime in inland waters and the need to observe conservation measures such as respecting closed seasons to allow fish to breed, the protection of conservation areas and bans on illegal types of fishing gear. The ceremony concluded with the release of approximately 1.5 million fry into the reservoir, as well as a large number of adult brood-stock of a wide variety of species.

Releasing fish seed into the Kdol Reservoir.

WAS Adelaide: Special Session on Regional Cooperation for Improved Biosecurity

Raising awareness of the link between genetics and disease was be addressed by the global aquaculture community at a special session on regional cooperation for improved biosecurity held at the World Aquaculture Adelaide 2014 conference on 11 June.

Aquatic animal health issues cause massive losses in the aquaculture industry each year. It is estimated that across the global tropical shrimp industry alone around 40% of production is lost to disease.

Much of the impact falls upon small-scale farmers, who are not equipped to deal with disease outbreaks. These often have devastating effects on their incomes and livelihoods. Larger scale commercial producers are also not immune from disease issues, often suffering major financial setbacks due to outbreaks which can also impact on international trade.

Effective health management is a shared responsibility that requires a coordinated approach from all countries. The session gave participants of the conference the opportunity to network and discuss this important issue.

The session was organised by Network of Aquaculture Centres in Asia Pacific and sponsored by the Australian Centre for International Agricultural Research, with the aim to bring together industry and scientists to discuss closer cooperation in health management and biosecurity.

The session was organised into three sub-sessions:

- Regional cooperation in aquatic animal health management.
- Dealing with emerging diseases (focussing on EMS / AHPNS as a case study).
- Domestication programs and disease emergence.

Discussion panels were be held after the sub-theme presentations to allow participants to interact with the presenters. Recordings of the presentations will be available for download or online access via the NACA website in due course, please visit the Podcast section http://www.enaca.org/modules/podcast/.

Inbreeding and disease in tropical shrimp aquaculture: a reappraisal and caution

The disease crisis facing shrimp aquaculture may be propelled, in part, by an interaction between management practices that cause inbreeding, and the amplification by inbreeding of susceptibility to disease and environmental stresses. The study describes and numerically simulates gene flow from *Penaeus* (*Litopenaeus*) *vannamei* hatcheries that employ a 'Breeder Lock' to discourage use of their PL as breeders, through 'copy hatcheries' that breed the locked PL, to inbred shrimp in farm ponds. Re-analysis of published data shows that inbreeding depression under stress is exceptionally strong in shrimp. Inbreeding is currently overlooked as a problem because: (1) procedures recommended for well-managed hatcheries do not consider their implications for the copy hatcheries that supply most farmed shrimp (estimated 70%), (2) inbreeding in hatcheries is often reported as zero even though zero is the mathematical expectation of the usual estimator (Fis, fixation index) whatever the true genealogy of the broodstock. Simulation shows, however, that inbreeding can be estimated with Wang's trioML estimator, that Fis can differentiate Breeder Locked from copy PL and that simple tests can verify the lock status of PL. The importance of inbreeding should be re-evaluated in the context of disease and environmental stress. Unrecognized inbreeding may increase the incidence, prevalence and lethality of WSSV, IHHNV, EMS (AHPND) and other diseases.

Full article by Roger Doyle available at:
http://dx.doi.org/10.1111/are.12472

Shrimp EMS/AHPND Special Session at DAA9

The organisers of the 9th Symposium on Diseases in Asian Aquaculture (DAA9) will convene a special session on shrimp EMS/AHPND. If you want to know the latest on this emerging shrimp disease and become part of the Fish Health Section (FHS) of the Asian Fisheries Society (AFS) network, don't miss this opportunity.

Prof Tim Flegel will facilitate the session in collaboration with FHS and DAH (MARD) with an opening presentation titled "EMS/AHPND: a game changer for the future development of aquaculture". This will be followed by presentations from other invited speakers and speakers selected from submitted abstracts. Prof Lightner, Dr Gomez-Gill, Dr Hirono, Prof Grace Lo and Prof Sorgeloos have confirmed making presentations at this session. We are expecting many more presentations from leading researchers from within and outside this region. The scope of the session will be broad and cover sequencing and analysis of genomic and epigenomic DNA of AHPND isolates; pathology, epidemiology and control; plus ongoing regional/international initiatives in Asia Pacific for dealing with the disease. The session will be part of the five day DAA9 event and is open to all DAA9 registered delegates.

Visit DAA9 website at www.daa9.org and register now. Submit your AHPND research for presentations as oral or poster papers.

2nd International Symposium on Aquaculture and Fisheries Education

The 2nd International Symposium on Aquaculture and Fisheries Education (ISAFE2) is jointly organised by the Asian Fisheries Society and Shanghai Ocean University. The symposium will be convened at the SHOU campus at in Shanghai from 22-24 April 2015.

ISAFE2 will bring educators, distinguished speakers and training agencies from across the aquaculture and fisheries industries, teaching institutions and education regulatory agencies to discuss many critical issues pertaining to the needs of the industry on the one hand and the issues confronting the training, academic and education regulatory agencies in ensuring a sustainable well-educated industry sector on the other in the Asia-Pacific (AP) region.

ISAFE2 will have the theme "Better education, Better professionals, Better Industry". The symposium will discuss issues highlighted during ISAFE1 and on-going issues confronting aquaculture and fisheries education in the region. It will:

- Discuss the current status of aquaculture and fisheries education in the AP countries with special reference to
- Curricula and courses.
- Accreditations, quality and certification.
- Collaboration and partnership.
- Examine the existing and future linkages between AFS and regional educators with international agencies and institutions.
- Explore the on-going development of distance education and its impacts on the delivery of aquaculture and fisheries education.

Call for papers

The symposium will be calling for submission of oral and poster papers in the near future. All submitted papers must be based on original research and have not been previously submitted for publications or presented in another conference. A comprehensive list of topics is under consideration for presentations during ISAFE2. They include:

- Current status of fisheries and aquaculture education.
- Need-based curriculum development.
- Vocational Vs Technical Vs Higher education training.
- Innovative teaching and learning methods.
- Distant / flexible education.
- Partnerships between stakeholders – academic, training and industry sectors.
- Support to young aquaculture and fisheries scientists.
- Future direction and strategy.

For more information, please visit the ISAFE2 website at: .

http://isafe2.shou.edu.cn/.

Report on Sustainable Fisheries and Aquaculture for Food Security and Nutrition

A new report addresses a frequently overlooked but extremely important part of world food and nutrition security: the role and importance of fish in seeking food and nutrition security for all. Fisheries and aquaculture have often been arbitrarily separated from other parts of the food and agricultural systems in food security studies, debates and policy-making.

The report presents a synthesis of existing evidence regarding the complex pathways between fisheries and aquaculture and food and nutrition security, including the environmental, economic and social dimensions, as well as issues related to governance. It provides insights on what needs to be done to achieve sustainable fisheries and aquaculture in order to strengthen their positive impact on food and nutrition security.

The ambition of this compact yet comprehensive report is to help the international community to share and understand the wide spectrum of issues that make fisheries and aquaculture such an important part of efforts to assure food security for all.

The High Level Panel of Experts on Food Security and Nutrition (HLPE) was created in 2010 to provide the United Nations' Committee on World Food Security (CFS) with evidence-based and policy-oriented analysis to underpin policy debates and policy formulation. The HLPE reports provide evidence relevant to the diversity of contexts, with recommendations aiming to be useful to guide context-specific policy interventions. Download the full report from:

http://www.fao.org/3/a-i3844e.pdf

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