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AQUACULTURE ASIA

Reducing rabbitfish grazing on seaweeds

Exploring the fisheries of Wular Lake, Kashmir

Rice/crayfish farming

Golden mahseer

Aquaculture Asia

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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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Domestication programmes and disease emergence

In December I covered, albeit briefly, an upcoming special session that NACA would convene at the World Aquaculture Society Conference in Adelaide, 7-11 June 2014. The session will touch on several issues but I'd like to bring your attention to one in particular, based on a hypothesis from Prof. Roger Doyle, which concerns a possible link between domestication programmes and disease emergence in aquaculture.

We have known for a long time (and it has been covered often in this column) that inbreeding is a problem in the aquaculture industry. There are various reasons for this, not the least of which is that aquaculture as a science is only a few decades old and awareness of genetic issues amongst practitioners is clearly not what it should be. However, the enormous fecundity of most aquatic animals (relative to terrestrial livestock) is probably also a factor. In most cases, a handful of fish can produce all the seed that even quite a large farm would need, so it's easy to see why founding populations are often small and how people could think maintaining more broodstock would be unnecessary.

Many of the spawning techniques used in hatcheries, such as group spawning also yield surprisingly uneven results when the genetic contributions of the parents to the resulting progeny are investigated, with a small number of males responsible for the majority of fertilisation. Then we get into practices that are just flat out bad and where people really should (and often do) know better: Recruiting new broodstock from their own seed production leading to inbreeding (in some cases, for decades on end), using common spawning pools with mixed species leading to hybridisation, deliberate hybridisation for the sheer expediency of producing "more fish", and "copy hatcheries" that buy improved or SPF seed from a reputable producers, breed it locally without any controls on-sell their non-SPF and unimproved product as the real thing.

Inbreeding increases the susceptibility of an animal to disease. This is based on the observation from published studies across a wide range of taxa showing that inbreeding depression generally reduces survival against pretty much any kind of environmental stress you care to look at. Prof. Doyle's hypothesis, which you can read about in more detail from the paper linked below, is that shrimp may be particularly susceptible to the effects of inbreeding depression. It follows then that the poor broodstock management practices that are rife within the aquaculture industry may be a factor contributing to the frequent disease outbreaks that are observed.

The take aways are that genetic management of aquaculture broodstock is important, and that if you are buying improved or SPF seed it is probably a good idea to get it from an offical supplier, otherwise there's a good chance you are not getting what you paid for. You could be getting something much worse, actually.

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Simon Wilkinson

AQUACULTURE ASIA

Sustainable aquaculture

Research and farming techniques

NACA Newsletter 29

Peter Edwards writes on

Rural Aquaculture

Peter Edwards writes on rural aquaculture: Integrated rice/crayfish farming in Hubei Province, China

Professor Wang Weimin, Dean of the College of Fisheries of Huazhong Agricultural University in Wuhan, China, invited me to give a 16 hour course on integrated farming for their undergraduates, no doubt recalling taking such a course when he was a Masters student at the Asian Institute of technology (AIT) about 20 years ago. I confess to initially having been reluctant to accept his kind invitation as I felt that the topic would have limited relevance for the students as Chinese aquaculture has changed drastically over the last few decade. Modern pellet-fed aquaculture dominates aquaculture in the main inland fish farming areas of the country such as Hubei Province in the Yangtze River region today, with a marked decline in traditional integrated practice which contributes relatively little to total production.

However, on reflection, I decided to accept as I thought that it would be useful for Chinese students to be taught about traditional integration as well as being introduced to more modern interpretations of 'integration'. I dusted off my old AIT lectures, essentially rewrote two thirds of the course I presented to make it more relevant for today's aquaculture farming practice, and renamed the course 'Integrated farming: traditional and modern principles and farmer practices'. After covering traditional integrated farming in China and elsewhere, I presented current

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Integrated rice - swamp crayfish system in Ezhou City.

Swamp crayfish broodstock.

research and development in 'modern integration' in which the principles of traditional aquaculture are being used to reduce the adverse environmental impact of modern, pellet-fed aquaculture. I also lectured on aquaculture in relation to the most efficient or alternative use of land, freshwater and the sea, and integration of aquaculture into inland and marine ecosystems and agro-ecosystems. Thus the theory and farmer practice of traditional integrated aquaculture farming systems were relegated to only about one third of the course. I was ably assisted in presenting the lectures, in English of course, by Cao Xiaojuan, a lecturer in the Fisheries College; although the undergraduates' English comprehension ability was impressive, Xiaojuan helped by explaining some of the more complicated issues in Chinese.

I took the opportunity after giving the course to witness the remarkable recent development of an integrated rice/crustacean system. Professor Wang took me on a two day field trip to visit farmers practicing rice/swamp crayfish (*Procambarus clarkii*) integration. We visited farms in two different areas of Hubei Province: Ezhou City and Jingzhou City. Integrated rice/fish (fish used in the broad sense to include crustaceans) farming has expanded rapidly over the past decade in China with the integration of rice with high-value crustaceans such as swamp crayfish and Chinese mitten crab (*Eriochir sinensis*) rather than mostly lower-value finfish.

The recent development of integrated rice/crustacean farming in China was brought to my attention by Miao Weimin who presented a seminal paper on its recent expansion in China at the workshop on 'Research Needs to Sustaining Aquaculture to 2025 and Beyond' in Rayong, Thailand in 2007. I was keen to see this remarkable new development myself. The papers were subsequently published as a book, 'Success Stories in Asian Aquaculture', De Silva and Davies (2010), which can be downloaded for free on the internet.

Extension officer trying (unsuccessfully) to retrieve a swamp crayfish from its burrow.

Swamp crayfish was introduced into China from the southern USA in the 1930s and quickly became established. Feral stocks were adequate to support relatively low initial consumption for decades but it became popular more recently so there was a need to farm the species.

Ezhou City

We visited Wanmu Lake Farm in Zelin Town, with Xu Xin Chuan, General Engineer of the Ezhou Fisheries Bureau and a group of extension officers and farmers. Like most farms in China today, the farm used to be a commune but now the 122 farmers farmed the 734 ha of the former commune individually although as a group they cooperated on input supply and marketing and received technical assistance from the local government extension service.

The individual rice farms varied in area from 1.3-11.3 ha but most were close to the average of 4.0 ha. All were integrated with crayfish from 2007. The average size of individual rice fields was 0.4 ha. Only just over a decade ago the farmers were poor because they could only harvest a single crop of rice as the climate is temperate with cold winters. The farmers could still only grow a single crop of rice, for 3 months from mid-June to mid-October because of the low temperature constraint but crayfish were farmed year round. A 3-5 m wide and 1 m deep ditch or trench surrounded each rice field. Furthermore, a small earthen dike was constructed on the inside of the ditch to enable the crayfish to tunnel into the ground. The low-lying area was well supplied with water as it was also irrigated, with excess water being pumped out. Water was pumped in following the rice harvest.

Good water supply from irrigation canal.

Screen to prevent loss of swamp crayfish through water drain (bottom of photo).

Ezhou farmers and extension officers.

Details of integrated rice swamp crayfish integration.

Promotion of swamp crayfish.

Lunch with Ezhou farmers and extension officers, Professor Wang left foreground.

Rice yields were very high, an average of 9.8 tonnes/ha with some farms producing 11.3 tonnes/ha, due in part to fertilisation from crayfish faeces. No pesticides were being used on the rice which was reported to be organic.

The farm specialised in crayfish seed production although some larger crayfish were sold. The technology was developed in Jingzhou by local farmers in cooperation with scientists in 1986. The crayfish grew from March to November with breeding taking place from September to November. No feed was intentionally given to the crayfish as this would induce earlier moulting and maturity with lower seed quality as documented by a local university study. Feeding was mainly extensive on weeds and insects present in the rice field, including insects trapped in nocturnal light traps which were also used to reduce the incidence of rice insect pests.

Crayfish were caught by sein net to give a yield for grow-out of 525 kg/ha of 30 individuals/kg with a 90% survival rate. Seed was sold in March for $4.3-5.0/kg and comprised 200-400 individuals/kg. Prices for grow-out ranged from $11.7 early in the season from late March to early April to $3.3/kg after July (US$1 = Yuan 6.0).

Profit for rice was only $1,000/ha whereas crayfish seed made a much higher profit of $6,500/ha. Grow-out as practiced on other farms was reported to make a profit up to $7,500/ha although requiring a much higher input, primarily pelleted feed. Prior to the introduction of crayfish, farmers either worked part-time or full-time in the city but integrated rice/crayfish farming now provided full-time on-farm employment.

The farmers reported no problems with the integrated system. They asked me the inevitable question, how I thought they might improve their system? I replied, in general of course as an 'instant expert', that they needed to work out what were the production rate limiting factors and how to overcome them if possible e.g. climate, feed, space, water? Then they told me that they were satisfied with current production but were concerned about how to maintain it. While genetic deterioration leading to a decline in broodstock size was a worry, it had not yet occurred on this farm although it had been reported elsewhere. Disease and inbred stock leading to a decline in crayfish size and production were reported to be occurring in Jiangzhou where crayfish farming was first developed.

Integrated rice/crayfish farming was reported to be spreading to other areas. However, it was pointed out that optimal production required low-lying rice fields with a good water supply. The extension officers told me that currently there was less than 3,333 ha of rice/crayfish farming in Hubei Province, but with a potential area of 0.4 million ha or 24% of the province's total area of 1.7 million ha of rice fields.

Swamp crayfish plate at the lunch.

Jingzhou City

Taihu Farm in Jingzhou City was the second farm we visited. It comprised a total area of 200 ha belonging to 100 farmers who worked together as a modern communal farm as on the Ezhou City farm. Again only one crop of rice could be grown, with crayfish integration starting in 2006. In contrast to the previous farm, the farmers here were involved in crayfish grow-out although they produced their own seed. Furthermore, a more recent model of integration was being carried out in some former rice fields, integrated lotus/crayfish culture.

Rice was planted in June and harvested in October with a production of 6 tonnes/ha. The rice was fertilised with only 50% of the usual rate of chemical fertiliser because of the residual fertilising effect of the integrated crayfish; and again no pesticides were used. The rice production was reported to be more or less the same as before crayfish were integrated, with the small increase in unit area production of rice following integration with crayfish compensating for the loss of rice field production area through construction of the peripheral trench.

The peripheral trench was smaller than that of the previous farm, 1.5-2 m wide and 0.6 m deep. Broodstock with a size of 40 individuals/kg derived from the harvest were stocked at 150 kg/ha from the end of February to the end of May although the earliest that the crayfish started to breed was October to November. About 50% of the crayfish stocked each year were newly introduced broodstock to avoid genetic deterioration.

No feed was given to the crayfish. Crayfish production of 20-40 individuals/kg ranged from a minimum of 1.1 to a maximum of 3.8 with an average of 2.3 tonnes/ha. Farm gate price ranged from $0.4-1.7/kg, with the highest prices early in the season as well as for large-sized crayfish harvested later in the season.

The main problem being experienced by the farmer we interviewed was a viral disease causing 100% crayfish mortality under crowded conditions when the water temperature rose in mid to late May. Rice fields stocked with crayfish at low density were reported not to be affected.

The communal farm visited was reported to be the only one in the area with integrated rice/crayfish culture because it was the only low-lying land and also had a good water supply, from a nearby reservoir.

Crayfish were also reported to be farmed in another area in Gong An County under the administration of Jingzhou City, on 2,000 ha but in ponds. The crayfish were reported to be fed with pelleted feed, fresh grass shoots, and leaves and tubers of sweet potato and pumpkin and. At least 70% of the pond area needed to be planted with submerged aquatic macrophytes to provide a suitable habitat for crayfish. Production was relatively high compared to integration with rice, 4.5 tonnes/ha.

A fairly new model of integrated crayfish culture was also observed on Taihu Farm, lotus/crayfish integration with rice fields converted to raise lotus to produce seeds for human consumption. The design and profitability of this system were reported to be more or less the same as for crayfish integration with rice. Production of lotus seeds was 0.75 tonnes/ha which were sold for $0.7/kg. According to Professor Wang, lotus farmed for edible seed has red flowers while that farmed for edible underground stems or rhizomes has white flowers.

As a botanist at heart I could not resist adding that China has over 600 cultivars of lotus (*Nelumbo nucifer*), not to be confused with water lily (*Nymphaea* species) which are classified in different plant orders as well as families (Wang and Zhang, 2005). The day before teaching the course on integrated farming I spent a most pleasant afternoon being guided around the Wuhan Botanical Garden by two lady aquaculture students, Luo Weimin and Xu Xiuwen, and was able to see several of lotus cultivars in flower as the garden maintains a lotus cultivar gene bank.

Future prospects for rice/fish integration

As I wrote in a review of traditional integrated aquaculture practice, the importance of rice/fish integrated farming has been grossly overestimated (Edwards, 2009). While capture of wild fish in rice fields is surely as old as rice farming itself, culture of fish in rice fields has never been a significant widespread practice although it has been common in some areas in the past. There have been numerous attempts by development agencies over the last 20-30 years to promote the practice in both irrigated and rainfed areas where poverty was highest but sustainability has generally been limited. While rice/fish integration is technically feasible in most rice farming areas, it is mostly not attractive to farmers in terms of return to labour as yields without supplementary feeding range from only 100-250 kg/ha of usually relatively small low-market value. I recall some 20 years ago interviewing a farmer in Northeast Thailand who had a small plot of integrated rice/fish. On enquiring why he had not expanded the practice throughout his farm, I received a withering look. With some exasperation after encouraging him to explain why, he replied: ‘I struggle to maintain adequate water for the fish in the dry season; and in the rainy season I have difficulty preventing fish from escaping from the field in the flood water’.

There are always exceptions to the ‘golden rule’ as indicated by raising high-market value species in integrated rice/fish systems such as red common carp in what is now a World agricultural heritage site in Zheijiang province as I reported in an earlier column (Edwards, 2006). Giant river prawn (*Macrobrachium rosenbergii*) is being successfully farmed in rice fields in low-lying areas of Southern Bangladesh and in the Mekong Delta in Southern Vietnam; and Chinese mitten crab (*Eriochir sinensis*) in the lower Yangtze River region, especially in Jiangsu province, as described by Miao (2010). These areas are mostly low lying and/or have a very good water supply which is an absolute prerequisite for being able to successfully raise fish or crustaceans in rice fields as reported by the farmers interviewed here as well as by Miao

Integrated rice swamp crayfish system in Jiangzhou City.

Integrated rice lotus system in Jiangzhou City.

Dish of lotus seeds (whitish coloured spheres), lotus rhizomes (elongated white pieces) as well as water chestnut (brownish white pieces).

(2010). An additional factor contributing towards success is the production of a high-value species such as swamp crayfish in Hubei Province as indicated by this column and also by Miao (2010).

The area of rice/fish culture has expanded over the last decade in China to 1.2 million ha (MOA, 2012). While this currently takes place on only 4% of all rice fields in the country and with an average yield of only 1 tonne/ha, there appears to be great potential for expansion of the practice in China as it leads to more than doubling farm household income with rice alone. Miao (2010) pointed out that rice/crustacean integration led to a significantly increased economic return even though unit production of fish was more or less same as in the past or even slightly lower; he reported a rice maximum net income of US $1,500/ha but also $2,000-4,000 from aquaculture on typical small-scale 0.2-1 ha (average 0.5 ha) farms. The contribution of swamp crayfish to farm income was even higher according to the interviews conducted for this column.

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Improvement of seaweed *Kappaphycus alvarezii* culture production by reducing grazing by rabbit fish (*Siganus* spp.)

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Kappaphycus (*Kappaphycus alvarezii*) is a tropical red seaweed distributed naturally in some Asian countries, especially in Philippines and Indonesia. This is an important resource for extracting carrageenan (Ohno, Nang and Hirase, 1996; Trono, 1992). Imported into Vietnam since 1993, Kappahycus is the most popular cultured seaweed in coastal South-Central provinces of Vietnam, such as Phu Yen, Khanh Hoa and Ninh Thuan (Nang and Dinh, 1998; Ohno, Nang and Hirase, 1996). Culture of this species has successfully contributed to livelihood improvement of many coastal communities in this region (Ly, Nang and Dinh, 1998; Nang and Dinh, 1998). Kappaphycus farming has high potential to be developed in culture area as well as production in South-Central provinces of Vietnam. However, the farming of this species recently faces some difficulties in seed supply, market price, disease and grazing by herbivores (Nang and Dinh, 1998).

Since the seaweed is cultured in the open sea, preventing herbivorous fish, especially rabbit fish (*Siganus* spp.) from harming the crop is not easy. Solving the problem could improve the seaweed productivity and farmers' income (Ly, Nang and Dinh, 1998). Farmers have applied some methods to prevent rabbit fish, such as site selection and net-fence installation; however, the benefits were low and the best net mesh-size was not tested and reported (Nang and Dinh, 1998).

In that case, improving kappaphycus culture performance by using proper net-fence or co-culture of carnivorous fish to prevent rabbit fish could be an option for research. As seaweed farm-gate price reduces recently, effectively preventing rabbit fish to improve kappaphycus productivity is necessary to ensure the stable income of seaweed farmers.

Research team members at a seaweed watch house.

A simple hapa system for testing the hunting ability of seabass.

This research was conducted in order to improve the productivity and profit of kappaphycus culture, and to determine proper technique of preventing rabbit fish from grazing the seaweed.

Experimental design

The research was conducted in Cam Ranh bay from April to August using *Kappaphycus alvarezii* as cultured species. The trial included four treatments with three replicates for each treatment. The experiment was organized using completely randomized design (CRD) on a culture area of 10x150 m^2. Each replicate was constructed on an area of 10x10 m^2 with a seaweed stocking density of 1kg/m^2.

Each replicate was located at 5m distance from the next one. Since the experimental area was narrow and perpendicular to water flow (tidal) direction, the replicates with net-fence did not affect the others. The treatments were as follows:

- Treatment 1: culture the seaweed inside a net-fence of 2 cm mesh size.
- Treatment 2: culture the seaweed inside a net-fence of 3 cm mesh size.
- Treatment 3: co-culture the seaweed in net-fence of 5 cm mesh size with seabass *Lates calcarifer* stocked at 1kg fish/10m^2 with fish size of a size of 420 ± 26g/fish. Seabass were not fed so that they depended on rabbit fish as natural feed.
- Treatment 4: control treatment without net-fence and seabass.

A net-fence system for treatment 3.

Two-week stocked kappaphycus taken for measurement.

The experiment was conducted twice within 12 weeks at the same time as the local kappaphycus culture crops. All techniques for handling and management, such as catching rabbit fish and seaweed cleaning were the same between the treatments.

Sampling kappaphycus were measured in the watch house for fresh weight.

Data collection

Environmental parameters

Some important environmental parameters were determined weekly with the methods or equipments listed in Table 1.

Growth performance

Every week, 30 seaweed thalli were randomly collected from each replicate to determine weight for daily weight gain (DWG) and specific growth rate (SGR) as below equations:

- DWG (g.day-1) = $(W_2 – W^1) / (t_2 – t_1)$
- SGR (%.day-1) = $100 \times \ln(W_2/W_1) / (t_2 – t_1)$

Where W_1 is thallus weight at cultured day t_1, W_2 is thallus weight at cultured day t_2.

Around 1kg fresh weight of the seaweed taken from each replicate was dried at 105°C for 24 hours to determine dried-fresh weight ratio.

Data analysis

Data are presented as mean ± SD. Results were compared by analysis of variance (oneway ANOVA) followed by the Turkey's test when significant differences were found at the $P < 0.05$). Data analyses were performed with SPSS 20.0 for Windows.

Results

Range of some environmental parameters

Most of the environmental factors in the culture area was similar between the different experimental units. During the trial period, the temperature ranged from 25 – 32°C consistent with the adaptation of both the seaweed (Muñoz, Freile-Pelegrín and Robledo, 2004; Trono, 1992) and the seabass (FAO, 1989; Katersky and Carter, 2007). The pH occasionally reached high values, almost 9.0 in the evening. Salinity was quite stable, ranging from 28 - 33ppt. The most variable factor was transparency, ranging from 65 - 120cm due to the influence of tide and algae discharged from shrimp farms nearby. Transparency can affect to the seaweed growth performance as it indicated the amount of light usable for photosynthesis process of kappaphycus. However, the period of high water turbidity was not last long during the trial.

The environmental parameters were fluctuated over time. The results showed that temperature had a trend of increasing gradually. Salinity fluctuated based on tide and rain effects. During the trial, ammonia nitrogen (TAN) concentration slightly decreased and total suspended solid (TSS) concentration increased in all experimental units while ortho-phosphate concentration was relatively stable. These changes may caused by the total effects of season, tidal fluctuation and water discharged from shrimp farms. The concentration of TAN normally accounts for over 55% of total nitrogen in seawater (Muñoz, Freile-Pelegrín and Robledo, 2004). Thus, total nitrogen content in experimental water should higher than 0.1 mg/L, met the requirement for the cultured seaweed to grow sustainably.

Table 1. Some environmental parameters to be measured.

Parameter	Method (equipment)	Accuracy
Water temperature	Mercury thermometer	1°C
Salinity	Refractometer	1ppt
pH	pH test	0.5
Transparency	Secchi disk	5 cm
Total ammonia nitrogen (TAN)	Phenate method	1 µg/L
Dissolved orthophosphate (PO_4-P)	Ascorbic acid method	1 µg/L
Total suspended solid (TSS)	Oven dried at 103°C, 24hrs	1 µg/L

Table 2. Range of some environmental parameters within experimental area.

Parameter		Mean	Min	Max
Temperature (°C)	Early morning	28 ± 1.4	25	29
	Afternoon	30 ± 1.9	27	32
pH	Early morning	-	7.5	8.0
	Afternoon	-	8.0	9.0
Salinity (ppt)		30 ± 1.5	28	33
Transparency (cm)		92 ± 18.3	65	120
Total ammonia nitrogen (µg/L)		54 ± 8.7	41	70
Ortho phosphate (µg/L)		12 ± 2.0	9	16
Total suspended solid (mg/L)		19 ± 8.8	12	38

Table 3. Fresh weight (g/thallus) of kappaphycus in different treatments.

Culture day	T1	T2	T3	T4
1	$98 \pm 0.6_a$	$98 \pm 0.6_a$	$97 \pm 2.1_a$	$98 \pm 2.1_a$
9	$121 \pm 2.0_a$	$120 \pm 4.4_a$	$127 \pm 4.0_a$	$117 \pm 5.5_a$
15	$140 \pm 1.5_b$	$129 \pm 4.6_{ab}$	$158 \pm 2.1_c$	$120 \pm 7.0_a$
23	$186 \pm 3.6_b$	$155 \pm 6.8_a$	$221 \pm 13.5_c$	$142 \pm 11.8_a$
30	$233 \pm 2.6_b$	$214 \pm 9.6_{ab}$	$281 \pm 8.0_c$	$188 \pm 15.6_a$
39	$319 \pm 2.1_b$	$277 \pm 28.0_a$	$365 \pm 10.8_c$	$237 \pm 9.9_a$
47	$474 \pm 0.6_c$	$420 \pm 30.9_b$	$528 \pm 7.4_d$	$249 \pm 17.5_a$
54	$643 \pm 10.6_c$	$484 \pm 31.4_b$	$797 \pm 13.4_d$	$316 \pm 15.0_a$
61	$786 \pm 25.0_c$	$571 \pm 46.9_b$	$1077 \pm 65.0_d$	$400 \pm 41.2_a$
68	$884 \pm 43.2_c$	$687 \pm 65.4_b$	$1329 \pm 69.5_d$	$483 \pm 30.7_a$
75	$1020 \pm 56.0_b$	$746 \pm 100.4_a$	$1486 \pm 106.0_c$	$605 \pm 53.7_a$
88	$1221 \pm 40.4_b$	$916 \pm 49.1_a$	$1641 \pm 80.3_c$	$851 \pm 72.7_a$

Different letters on a row (a,b,c and d) indicate significant differences (p<0,05).

Table 4. Growth performance and dried/wet weight ratio in each treatment.

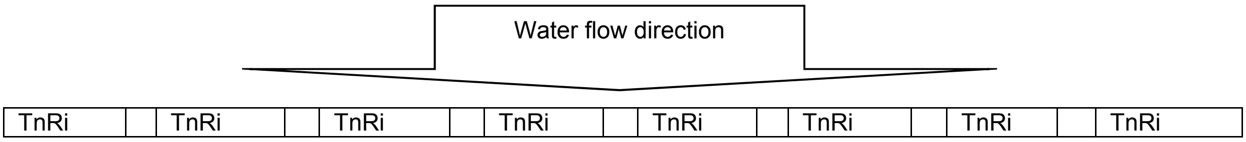
Treatment	DWG ($g.day^{-1}$)	SGR ($\%.day^{-1}$)	Dried/wet ratio (%)
T1	$12.9 \pm 0.47_b$	$2.89 \pm 0.039_b$	$8.61 \pm 0.012_b$
T2	$9.4 \pm 0.57_a$	$2.57 \pm 0.067_a$	$8.50 \pm 0.023_a$
T3	$17.7 \pm 0.93_c$	$3.25 \pm 0.072_c$	$8.74 \pm 0.010_c$
T4	$8.7 \pm 0.82_a$	$2.49 \pm 0.081_a$	$8.50 \pm 0.035_a$

Different letters on a row (a,b,c and d) indicate significant differences (p<0,05).

Growth performance of cultured kappaphycus

The results showed that the growth performance of the seaweed was different between the treatments. Within the first two weeks, the fresh weight of kappaphycus thalli was similar in all treatments. After that, there was a significant difference between treatments. Accordingly, seaweed biomass in the treatment cultured with seabass increased rapidly, followed by small mesh-size treatment then by bigger mesh-size and non-preventing treatments. This result was shown in Figure 2 and Table 3.

Figure 1. Experimental design layout. n has a value from 1-4, i from 1-3; TnRi is randomly uniquely combined).

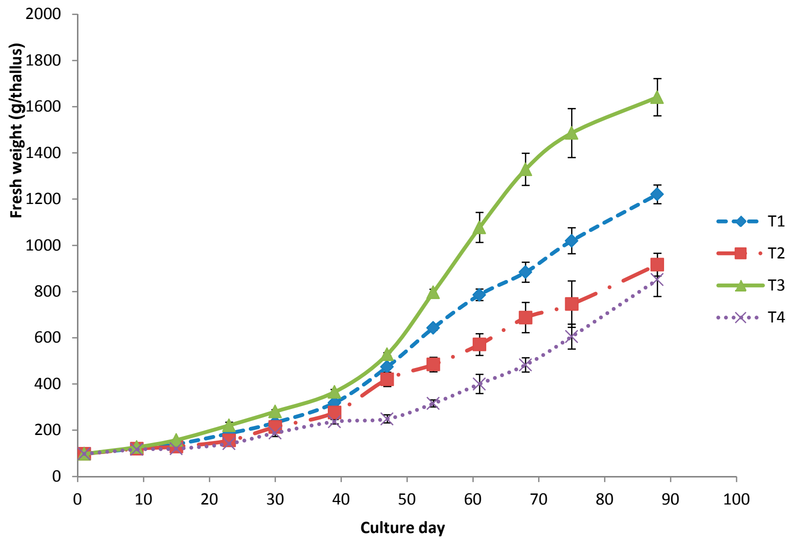


The data presented in Table 3 show that after 15 cultured days, seaweed cultured in treatment 3 showed a remarkable increase in biomass as its average thallus weight was significantly higher than that of the other treatments. This result may be caused by seabass predating upon or exluding rabbit fish from the culture area as only rabbit fish affected the seaweed crop while environmental conditions were similar among the treatments.

Between treatment T1 and T2, the usage effects of small and large mesh-size nets were only clearly after 40 cultured days. At this time a massive appearance of juvenile rabbit fish was recorded. They grazed the kappaphycus in droves with more serious effects than the rabbit fish of larger size. This is consistent with the idea that large numbers of small rabbit fish grazed seaweed shoots causing them to exhibit low growth performance. Thus, using small mesh-size nets limited the offensive of small-sized rabbit fish while the bigger mesh was less effective. This caused seaweed biomass in the large mesh-size net treatment (T2) became similar with the biomass in the non-defended treatment (T4) after the rabbit fish breeding season. One evidence of the appearance of fingerling rabbit fish was some local fishermen reported that they could catch more than 1kg of under 20g/individual rabbit fish within only 15 minutes using 100m long fishing net at that time (Hai, N.V., 2013 - direct interview).

Generally, kappaphycus had highest growth rate in treatment T3 with a daily weight gain (DWG) of 17.7 ± 0.93 g.day-1 and specific growth rate (SGR) of 3.25 ± 0.072%.day-1, and statistically significantly different from all other treatments. The next following treatment was the treatment used small mesh-size net at a DWG of 12.9 ± 0.47 g.day-1. The growth rates of seaweed cultured in treatment T2 and T4 were lowest since their DWG were not reaching to 10 g.day-1 and not significant difference from each other (p < 0,05).

Figure 2. Fresh weight (g thallus) of kappaphycus cultured in different treatments. Different letters (a,b,c and d) indicate statistically significant difference (p0,05).



A bigger watch house for seaweed harvesting and seed multiplication.

Similarly, the dried/fresh weight ratio of kappaphycus resulted in significant difference between such treatments with highest dried matter contents in treatment T3, followed by T1 then T2 and T4. Some studies showed that kappaphycus harmed by rabbit fish at a moderate level could stimulate matter accumulation, reflected in a higher ratio of dried/fresh weigh ratio (Kha, T., 2004

Kappaphycus seeding in the watch house.

Some thalli were not suitable for seeding and were used for drying instead.

Discussion about the effects of rabbit fish on kappaphycus growth and quality.

Kappaphycus cultivation plays an important role in seaside livelihood improvement in the central part of Vietnam.

- direct interview). However, in this case, kappaphycus under continuous grazing by small-size rabbit fish caused poorer growth performance and dried matter accumulation compare to well-protected cultured seaweed.

In summary, in a similar environmental condition, the difference in growth of culture kappaphycus at different treatments was primarily due to the impact of grazing rabbit fish. During the early stage of the experiment, rabbit fish were less abundant and caused less seaweed damage, especially in treatments protected by nets. In later stages, the massive appearance of rabbit fish fingerlings caused poor growth performance of seaweed both outside and inside net-protected areas. Although the treatment T3 used biggest mesh-size net (5cm), the presence of seabass has limited the destruction of rabbit fish on kappaphycus and foster their growth performance better than remaining treatments.

Conclusion

Within the same culture area, the seaweed kappaphycus growth performance basically depended on herbivores, especially rabbit fish.

The most effective method for kappaphycus protecting against rabbit fish was cultivation in net pens with seabass stocked. Culture the seaweed without protection or in net pens with big mesh-size (3cm) resulted in poorer preventing effect than small mesh-size systems.

Recommendations

- Kappaphycus should be cultivated in seabass stocking net pens to acquire better growth performance.
- In case of monoculture, the seaweed could be cultivated in net pens with small mesh-size (2cm) for effective prevention of rabbit fish grazing.
- Some research and surveys on harming levels of rabbit fish at different size and season could be done to optimise kappaphycus crops in Vietnam.

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Sundrise on a kappaphycus farm in Cam Ranh Bay, Vietnam.

Exploring the fisheries of Wular Lake, Kashmir, India

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Wular lake is known as one of the Asia's largest freshwater lakes and is located in Baramullah district of Kashmir between the towns of Bandipore and Sopore approximately 60 kilometers from the city of Srinagar (latitude 34”16’- 34”26’N, Longitude74”33’-74”42’E). Wular Lake with its large expanse of water is an important resource for fisheries. The fisheries of Wular Lake are a combination of capture and culture fisheries. The annual table fish requirements for Kashmir is 37,000 metric tonnes as per the standard nutritional requirement of 11 kg / capita / annum consumption. The current production of the state from culture and capture fisheries is 19,500 metric tonnes / annum thereby indicating a deficit of more than 50% of the fish requirement. Heckel[1] (1844) published two volumes on taxonomic enumeration of fishes in

Sorting the catch.

Kashmir. He reported occurrence of 16 species, all of which were then considered new to the science. Later Das and Subla[2] (1963-64) produced a new list of 36 species based on fieldwork between 1961 and 1964. Further Nath[3] (1986) listed 42 species for which no proof is available to permit assessment of the status or originality of the work. Some of the reported species have never been subsequently recorded and their presence in the valley is rather doubtful. Recent surveys carried out by NIAE, J&KLWWDA (2000) indicate occurrence of 13 species from Jhelum and associated lakes including Wular. As the taxonomy of many species is still under scrutiny the total number may increase or decrease with further investigations in the field. However, whatever the number, it is clear that several species of schizothoracinae are endemic to the region are declining in both diversity and population. An analysis of fish fauna reveals that three species are endemic to Kashmir valley viz. *Schizothorax niger* (snow trout) *Triplophysa marmorata* and *T. kashmiriensis*. They feed on detritus, attached plant (including algae) coating of stones and rocks and the associated invertebrate fauna. They grow slowly and attain maturity at the age of two years. The commercially important fish species in Wular Lake are listed in Table 1.

Ecology and habitat of Wular Lake

Breeding and spawning

The breeding migration starts in March / April and the spawning takes place in April / May and even up to June[4]. All species of the group except *S. niger* exhibit spawning migration to the incoming streams and rivers and lay eggs in shallow pools amidst gravel and sand. Further *S. niger,* which prefers clean and cold pockets of water, is the only species, which has adapted itself completely to lacustrine habitat, not even showing the spawning migration towards the upper reaches of the streams. *S. niger* being a lacustrine fish does not show any spawning migration out of lake in comparison to other schizothoracine fish but shows a very low absolute

Table 1: Economically important fish species of Wular

Fish species	Local name
Schizothorax esocinus	Cherru
Schizothorax curvifrons	Sattar gad
Schizothorax micropogon	Chattir gad
Schizothorax niger	Aile gad
Schizothorax longipinnis	Dape gad
Schizothorax richardsonii	Khont
Nemacheilus sp.	Shud gurun
Cyprinus carpio communis	Punjabi Gad
Cyprinus carpio specularis	Scale Carp

Source: Department of Wildlife Protection, Govt of J&K.

fecundity, which seems to be related to its non-migratory behavior, as in migratory fish high fecundity compensates for the high mortality during the migration of both adults and juveniles. However, despite the lowest absolute fecundity, *S. niger* has the highest relative fecundity among the schizothoracine fish (Yousuf and Pandit 1989). This indicates the impact of the environmental stress on the fish. Exotic species such as *Cyprinus carpio* have adaptive advantages to utilise lake resources for its growth and dominate over other species due to its high fecundity.

This is quite evident that common carp, which was introduced in 1959, has invaded all the meandering rivers and water bodies including Wular and has driven out the endemic schizothoracids. Common carp usually spawns from May to June in beds of aquatic plants. The planktonic peaks from March to April and July to August concur with the spawning activity of summer and autumn spawners, suggesting that this adaptation in reproduction is closely related to the availability of food to young ones as well as reducing the chances of competition between the young ones of different fish species.

Feeding habits

The feeding habit and key biological features of major commercial fish species of Wular Lake indicates that *Cyprinus carpio* has high fecundity and grows at a much faster rate compared to the other species. A study on the food of some cyprinids has revealed that most of the cyprinids of the valley are omnivorous in habit. However, the share of different food items varies signifi-

Schizothorax micropogron.

Schizothorax richardsonii (centre), common carp Cyprinus carpio (left).

Table 2: Growth, feeding habits and fecundity of important fishes in Wular Lake

Species	Feeding Habit	Growth attainment	Fecundity/kg	Peak breeding
Schizothorax niger	Bottom detritus (Illiophagic herbivore)	1+yr - 80mm 4+yr - 200mm	8,000-23,000	March-April
S curvifrons	Illiophagic herbivore, occasional column feeder	1+yr - 130mm 4+yr - 305mm	25,000-40,000	May-June
S. longipinnis	Herbivore, detritophage	1+yr - 95mm 4+yr - 288mm	25,000-32,000	May-June
S. micropogon	Herbivore (bottom feeder)	1+yr - 110mm 4+yr - 280mm	20,000-25,000	May-June
S. esocinus	Herbivore / omnivore (bottom feeder)	1+yr - 135mm 4+yr - 400mm	35,000-40,000	June-July
S. richardsonii	Herbivore typical bottom feeder on rocks and stones	1+yr - 130mm 4+yr - 350mm	25,000-30,000	May-June
Cyprinus carpio	Detritus, bottom sediments	1+yr - 280mm 4+yr - 455mm	239,000-285,000	May-June

Source: Department of Wildlife Protection, Govt of J&K.

Schizothorax esocinus (foreground) and S. labiatus (rear).

S. curvifons.

S. niger.

cantly in different species. Crustaceans and insects are important and preferred food items. In case of *S. esocinus* the fish-remains forms the most dominant component of the food. Macrophytes being dominant component of Wular Lake, form the bulk of the plant matter present in the gut content of the fish. Numerically algae contribute a large proportion of the food items. Segmented worms contribute to the food of the common carp and to *S. niger* and *Orenius plagiostomus* that feed on the bottom organisms including sessile algae. *Crossocheilus diplochilus* has been found to be a mixed feeder while trout species are carnivorous in nature and feed on insects, molluscs and even on small fish.

Fish yield

Wular Lake contributes 60% of total fish production to the state of Jammu and Kashmir. Overall, seven native and two exotic species of Wular Lake are commercially important. In commercial catches, the exotic carps contribute 52-67% and the local fishes (*Schizothorax* spp.) and other miscellaneous fishes of less economic importance like *Barbus conchonius* (button), *Gambusia affinis* (maih gad), and *Carassius carassius* (ganga) contribute 25 – 30% of total fish catch. The state government Fisheries Department has established nine landing centers at different locations of the lake. These landing centers lack adequate infrastructure, facilities, and even proper road connectivity. They serve merely as connecting points. Intermediaries and moneylenders collect fish harvested from the fishing boats directly. The overall trend indicates increase in production with some fluctuations.

Craft and gear

Several types of fishing gears are traditionally used in Wular lake for fish harvesting, the main being cast nets, bag nets (khurijal), dip nets, multiple head spears (panzri), long lines (wal raz) single/double pronged spear (narchoo), and gill nets. However, due to decline in fish productivity, the fishermen have resorted to use of nylon nets with mesh size of 10mm and mesh bar of 0.5mm to catch fish of all sizes. The gill nets locally called thani are 15 to 40m long and 1.5 to 3m wide. The use of these nets has seriously affected the regenerative capacity of the fish fauna. It was highlighted that the communities themselves had imposed restrictions on the use of lower mesh size nets due to decline in fish catch. Promotion of gill nets was also undertaken by the State Government Department at select locations. Wooden primitive boats of varied dimensions of 5 - 10m length, 0.5-0.75 m width are exclusively used for fishing, transportation of fodder, water chestnuts etc as well as navigation. Wooden boxes have been constructed in the middle of the lake to store catch. At Zurimanz village, the fishers have constructed ponds on the lake periphery to store surplus catch, and regulate fish supply for better price recovery. However, the structure of these ponds is very irregular and needs interventions for optimum us of space.

Information on Wular fisheries is highly fragmented and inadequate to support systematic management planning. There is absence of systematic inventorisation and assessment of overall species richness and diversity. There is no proper monitoring mechanism to assess fish yield using appropriate methodology and long-term assessment.

View of Wular Lake.

Dip nets.

Key issues

Key issues in Wular lake's fisheries include:

- A decline in fish diversity and yield due to changes in hydrological regimes and loss of critical habitats. The construction of hydraulic structures particularly hydroelectric projects has seriously affected migration of fishes.

- Changes in species richness, due in part due to large quantities of sewage discharge from the Srinagar city and major towns which flows into the lake thereby leading to increased eutrophication which has adverse impacts on the growth and development of the fisheries in general and sensitive species including *Schizothorax* in particular. Increased pollution levels are favorable for the prolific growth of aquatic vegetation, which seems to be more favorable for hardy species thereby altering the balance of species richness.

Panzri spear.

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Golden mahseer, *Tor putitora* - a possible candidate species for hill aquaculture

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Adult Tor putitora.

Mahseers are excellent game as well as food fishes, found in the lakes, streams and rivers of India, Pakistan, Bangladesh, Afghanistan, Sri Lanka and Myanmar. Because of their fierce fighting nature, mahseers have drawn the attention of anglers and eco-tourists worldwide for the past several decades. Anglers from all over the world visit the Himalayas to fish for mahseer, although the fish is also known to provide recreation to naturalists more than the salmon. The mahseers inhabit lakes and fast flowing streams of hilly regions, with a preferred water temperature range of 10-20°C[1]. They can also survive in non-hilly, tropical areas with water temperature of 30°C. However, mahseer are not found in regions where water temperature falls to near freezing. In such areas, trout are the most widely found fish. Apart from its recreation value the golden mahseer is also highly sought after as a food fish due to its richness in omega-3 fatty acid content and very good taste.

Altogether, there are seven species of mahseer known from India at present. They are *Tor putitora* (golden mahseer or Himalayan mahseer), *T. tor* (tor mahseer), *T. mosal* (copper mahseer), *T. progeneius* (jungha mahseer), *T. khudree* (deccan mahseer), *Neolisschilus hexagonolepis* (chocolate mahseer) and *T. mussullah* (humpback mahseer). Among all of these the golden mahseer was once abundantly found in mid hill regions of Himalaya in the northern part of India, from Kashmir to Arunachal Pradesh. Golden mahseer is found in Sikkim, Afghanistan, China, Nepal, Pakistan and Myanmar. It is a largest growing cyprinid fish of Himalayan region with reported length of > 2.5 meters[2]. However, due to indiscriminate fishing of brooders and juveniles, habitat destruction, and construction of dams, barrages, and weirs, its natural stocks have depleted over the period of time, and so golden mahseer is now an endangered fish, listed under red data book. To conserve this native fish, several hatcheries and culture systems has been established by Government of India. Attempts were made to breed this species in captivity, so that seeds for ranching in natural water bodies and for aquaculture purpose can be produced in good quantity. The matured brooders for seed production are collected from lakes and rivers, during the breeding season (May to August). The collected brooders are hand stripped and eggs are fertilised manually by dry fertilisation method.

Identification of *Tor putitora*

The scales on the back above the lateral line are sap green and bright orange in the centre. The region of the body below the lateral line is silvery white on the belly. The head below the eyes is light yellow in color. Fins are yellow and the tip of the caudal fin is reddish orange.

Age and growth

The golden mahseer is somewhat slow grower. It grows to the maximum length of 135 mm during the first year in rivers 3. Although males grow faster than females, the female attains a larger size than the male.

Bhimtal lake, a mahseer habitat.

Culture of mahseer

Procurement of stocks

The golden mahseer seed can be collected from shallow hill streams and rivers just after the breeding season. Fry have one black spot at the centre of caudal peduncle, just at the base of caudal fin Alternatively, mahseer matured spawners can be collected from Bhimtal and Sattal lakes during May to August. During this period matured brooders are available in these water bodies, and are generally captured by gill net. Mature females are larger, and have a soft belly, whereas males are smaller, and have a slender body. In mature males, milt oozes out freely when slight pressure is applied to belly. Mature males are generally above 300 g whereas females attain the maturity above 380 g. The highest and lowest gonado-somatic index (GSI) observed in the male and female brooders collected from Bhimtal lake is shown in figure below.

Spawning

In nature, golden mahseer migrates upstream into shallow running water for spawning. This migration mainly takes place during the floods. The upstream water serves as fresh feeding grounds, and fish release their eggs in sheltered, shallow regions having pebbles and sand. After laying eggs, spent fish migrate downstream to its original habitat. Spawning of golden mahseer has been reported from Anji stream, a tributary of River Chenab in Jammu and Kashmir4. The spawning mainly takes place during the low phase of floods, where the flow of water is fast. Eggs are laid in gravel and sand and hatchlings prefer to remain in shallow, marginal areas in between the stones, which are highly oxygenated by flow of water. The eggs of golden mahseer are 1.5 to 2.0 mm in diameter, yellow and demersal in nature.

Golden mahseer breeds several times during the breeding season. In Bhimtal and Sattal Lake, it breeds from May to August. In mature gonads, sperm and eggs of three or more developmental stages can be found simultaneously, which indicated that it is a protracted spawner and same fish releases 2-3 batches of gametes. The Directorate of Coldwater Fisheries Research, Bhimtal has established a flow through hatchery unit for golden mahseer seed production. This hatchery unit has the capacity to hold 0.30 million fertilised eggs and, 0.25 million fry. The brooders are collected from Bhimtal Lake by gill net and stripped for egg and sperm in-situ. The fecundity is 3,500-8,900 eggs/kg body weight. The fertilised eggs are incubated in wooden or fiberglass hatching trays, with a bottom made up of net. The flow of water is maintained throughout the incubation period. Four to five hatching tray are arranged in one trough. A shower is also provided at one end of the hatching trough and nursery tank for proper oxygenation of inflow water. After hatching and absorption of yolk sac, the hatchlings are given ground goat liver as starter feed.

Anji Stream - a golden mahseer habitat.

Mature mahseer ovary.

Mature male mahseer gonads.

Hatchling rearing tank at Bhimtal mahseer hatchery with shower facility.

Above, below: T. putitora hatchery unit at Anji mahseer farm.

Hatching tray at mahseer hatchery of bhimtal.

Golden mahseer hatchlings.

There are programmes for enhancement of natural fishery of golden mahseer in Kumaon lakes of Bhimtal, Sattal and Naukuchiatal, and the hatchery produced mahseer fingerlings are also ranched in rivers and streams of Uttarakhand region.

Tata Electric Companies (TEC) is a mahseer seed production hatchery unit at Lonavala, Maharastra. This hatchery, since has carried out propagation, rehabilitation and conservation of golden mahseer since the 1970s. For hatching of fertilised eggs, cement cisterns, floating wooden trays and perforated pipes are used. The pipes are perforated at regular intervals to provide oxygen rich water to fertilised eggs. Golden mahseer was successfully bred in this farm in 1996 using ovaprim in induced spawning. However, natural spawning of golden mahseer has not yet been reported so far from India in captivity.

Pond and cage culture of mahseer

In Jammu and Kashmir owned state government Anji mahseer farm, at Reasi *T. putitora* is successfully raised from fry to marketable size of around 800 g. This farm also has hatchery facility to breed the fish in captivity. Artificial breeding and propagation of golden mahseer has been carried out from August 2011, onwards. The hatchery unit was established in 1995, and the source of water is nearby Anji stream, which is a tributary of river Chenab. The environmental conditions and water quality parameter in this region is found to be conducive for mahseer culture. Thus, there are immense potential of seed production and intensive culture of golden mahseer in Jammu state of India. This farm has five concrete rearing ponds, one hatchery unit, and a well-equipped laboratory. Captive breeding is an important step taken by Jammu state fisheries department for the conservation and rehabilitation of this fish.

Cage culture of *T. putitora* in Bhimtal Lake.

Anji mahseer farm - harvesting of mahseer.

The trials with cage culture of golden mahseer have been carried out at Bhimtal Lake for more than a decade. The stocking density of fry (weight 0.1 to 0.2 g), in net cages of 3×3×3m, were approximately150 fish/m^3. The fish, were fed twice a day with pellet feed (35% protein) and maintained in cage until fingerling stage.

Food and feeding

In cage culture trials of *T. putitora* at Bhimtal, advanced fry were given pellet feed prepared from rice bran, groundnut cake, mineral mix and fish meal. The feed acceptability was found to be optimum. The optimal protein requirement is 35%. Since *T. putitora* accepts supplementary feed and can utilise it efficiently, this fish can be also be cultured in cages installed in lakes and reservoirs.

Disease control

Very limited information is available about the microbial and nutritional diseases of golden mahseer. There is a report of *Argulus* infection in mahseer fingerlings from cage of Bhimtal[5]. Eye lesions were reported from captive *T. putitora*[6]. Occasionally fungal infections were also observed in mahseer maintained in pond environments, where water exchange is limited. Occasionally, darkening of body was observed due to nutritional deficiency.

Socio-economic and technical aspects

Golden mahseer fisheries represent a small and seasonal, but important livelihood for many fisher groups around the world. Fish are easily collected from natural water bodies by long line and pole and line. In ponds, drag net is commonly used for harvesting. Since the collection of this fish can be accompanied with little initial capital, gear, skill and equipment, the fishery can be carried out by people of diverse age, skills and economic status. Golden mahseer is sold at a higher price by fishers. Its cost is around Rs 150-300/kg, depending upon the demand and availability. Thus, economic return is also good. The capture from natural water body in lakes of Uttarakhand, India is done throughout the year, except during winter from December to March, when the fish migrate to deeper water bodies to avoid winter. It is a delicious fish and highly preferred by consumers. Processing of mahseer is not generally done and this fish is preferred for consumption fresh. In Bhimtal Lake, fisherman get licenses to capture the mahseer during fishing season. All this indicates that farming of golden mahseer could be a viable option for income generation and employment for local hill communities.

As this fish is listed under red data book and considered endangered, its catch is in decline and the focus worldwide has been on reviving the depleted stock through stock enhancement programmes and increasing the production through aquaculture. Mahseer aquaculture is practiced very sporadically in Asian countries. In India this fish is stocked in polyculture system with carps. Some of the state governments have developed mahseer farms and hatcheries.

Factors to be considered for golden mahseer farming in hill regions

- Adequate supply of mahseer seed at farmer's level
- Cost effective formulated feed with good FCR
- Channelised marketing facility and accessibility to transport facility
- Availability of water
- Control of disease and predation
- Improvement of growth rate of golden mahseer by taking up genetic improvement programmes i.e selective breeding and biotechnological interventions. Growth can also be improved by manipulation of environment and formulation of supplementary feed.

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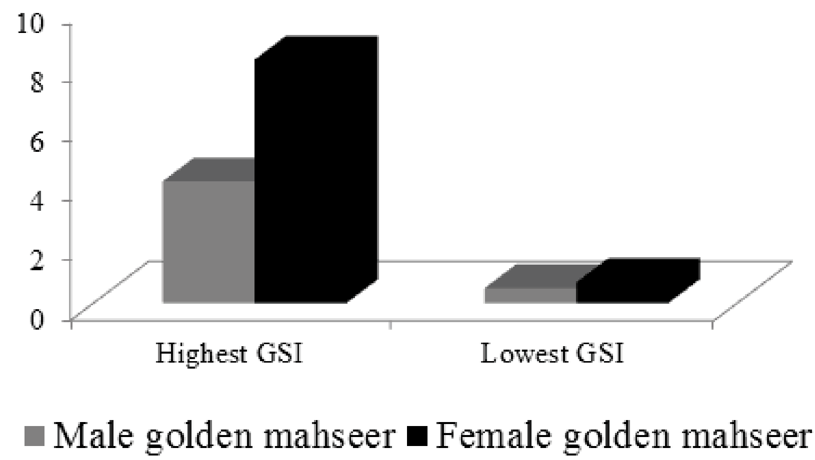
Figure: Highest and lowest gonadosomatic index of male and female mahseers collected from Bhimtal lake.



Tor putitora harvested at farm.

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25th NACA Governing Council held in Vientiane, Lao PDR

The 25th Governing Council Meeting was convened from 25-27 March 2014 in the Mercure Hotel, Vientiane, Lao PDR. The meeting was attended by 17 member governments, the Australian Centre for International Agricultural Research (ACIAR), the Food and Agriculture Organization of the United Nations (FAO), INFOFISH, the Mekong River Commission (MRC), the Southeast Asian Fisheries Development Center (SEAFDEC) and the USAID MARKET Project. A welcome address was given by The Hon. Dr H.E. Phuang Parisack Pravongviengkham, Vice Minister for Agriculture and Forestry. Opening remarks were given by the outgoing Chair of the Governing Council, Dr Nguyen Huy Dien, the incoming Chair Dr Bounthong Saphakdy and Dr Ambekar Eknath, Director General of NACA.

Highlights of the meeting included:

- NACA welcomed the Republic of the Maldives as the 19th member government of NACA. As a small island developing nation the Maldives is heavily dependent on fisheries resources for economic development. Given the limitations of its wild fisheries and a comparative advantage in the high quality of its marine environment the Maldives wishes to develop a mariculture industry and to focus on value-adding to provide an alternative source of income and employment to fishers. The Maldives therefore looks forward to collaboration with NACA members in these areas.
- The Governing Council elected Dr Cherdsak Virapat as the next Director General of NACA, who will serve a five year term from 2014-2019. Dr Virapat (see bio overleaf) will commence duties in June after a handover period from the outgoing Director General, Dr Ambekar Eknath.
- The Governing Council has commissioned a comprehensive review of NACA to evaluate its role, operations, staffing and funding levels in light of the contemporary operating environment and changing needs of member governments. The development landscape has changed considerably over the past 25 years of NACA's existence as an independent inter-governmental organisation and it was considered timely to evaluate the status and direction of the organisation.
- Aquatic animal health (particularly the current state of acute hepatopancreatic necrosis disease of shrimp) and aquaculture certification and benchmarking issues featured prominently in the discussions.

The 26th NACA Governing Council meeting will be held in Indonesia in 2015, the date and venue will be announced at a later time.

The 25th Governing Council.

Dr Cherdsak Virapat elected as next Director General of NACA

The NACA Governing Council elected Dr Cherdsak Virapat as the next Director General of NACA. Dr Virapat will commence duties in June 2014 and will serve a five-year term.

Dr Virapat is presently Executive Director of the International Ocean Institute (IOI), where he has worked since May 2008. He previously served as an officer of the Royal Thai Government for 27 years. He worked as a fishery biologist for the Department of Fisheries, Ministry of Agriculture & Cooperatives during 1981–2002. He was appointed director of IOI–Thailand Operational Centre by the Office of the Thai Marine Policy and Restoration Committee, Office of the Prime Minister, and worked voluntarily in this position during 2000–2008. He was also chief of the Public Sector Development Group, Ministry of Natural Resources & Environment, during 2003–2005 and chief of International Coordination and assistant executive director of Thailand's National Disaster Warning Center, Office of the Prime Minister and the Ministry of Information & Communication Technology, during 2005–2008.

He holds a BSc in fishery management from Kasetsart University, Thailand; an MSc in fishery science from the University of Helsinki, Finland; and a PhD in fisheries management from Dalhousie University, Canada. While serving in the Royal Thai Government, he obtained the Royal Decorations of the Exalted Order of the White Elephant and the Noble Order of the Crown of Thailand.

9th Symposium on Diseases in Asian Aquaculture 24-28 November 2014, Vietnam

The Fish Health Section (FHS) of the Asian Fisheries Society (AFS) is very pleased to announce the 9thSymposium on Diseases in Asian Aquaculture (DAA9) in Ho Chi Minh City, Vietnam from 24-28 November 2014.

The Fish Health Section of the Asian Fisheries Society was founded in May 1989. The FHS is credited with holding triennial symposia on "Diseases in Asian Aquaculture" (DAA) where members and aquatic animal health professionals meet to discuss broad issues and specific topics related to aquatic animal health in Asian Aquaculture.

The symposium ususally brings together more than 300 aquatic animal health scientists, students, government researchers and industry personnel from over 30-40 countries. In keeping with the unique tradition of previous DAA symposia, DAA9 in Vietnam is going to be a unique experience that you don't want to miss.

The symposium is being organised by the Viet Nam Department of Animal Health (DAH) coming under the Ministry of Agriculture and Rural Development (MARD) will be our local host and will organize the event in close cooperation with FHS. The DAH has already formed a Local Organising Committee and has launched the official DAA9 website for handling registrations, hotel bookings, abstract submissions and other logistics. Please visit www.daa9.org for more details including a downloadable flyer.

NACA to convene the 11th AFS Asian Fisheries and Aquaculture Forum

NACA has agreed to convene the 11th Asian Fisheries and Aquaculture Forum in conjunction with the Asian Fisheries Society, which will be held in Bangkok, Thailand in 2016. The meeting is tentatively scheduled for late April/early May. The Asian Fisheries and Aquaculture Forum is the premiere event of the Asian Fisheries Society and is held tri-annually. The forum usually attracts in the vicinity of 1,000 professionals from the region and beyond. Further details concerning co-convenors, venue, sponsorship opportunities, abstracts and registrations will be announced in due course through a dedicated website.

Free primers for specific detection of bacterial isolates that cause acute hepatopancreatic necrosis disease

Efforts to control AHPND have been hampered by the lack of a specific and rapid detection method that could be used to determine the reservoirs of the causative bacterial isolates, to insure their absence in shrimp broodstock and post larvae, to monitor shrimp during cultivation and to aid research on possible control measures.

In Thailand and Taiwan Province of China since 2012, our two groups have been conducting cooperative research on possible PCR methods to detect isolates of AHPND bacteria. On 5 December 2013 we obtained the sequence comparison information that allowed us to prepare several test PCR detection methods, and we have spent the last 20 days validating them. Today we are announcing the best method we have found so far. For the full details, please download: http://www.enaca.org/publications/health/disease-cards/ahpnd-detection-method-announcement.pdf

In Thailand, this research has been carried out through cooperation among researchers at Centex Shrimp (Mahidol-BIOTEC cooperative center) and the Department of Public Health both at Mahidol University and theAquaculture Business Research Center, Faculty of Fisheries, Kasetsart University. The work has been supported since 2011 by contributory funds from many sources including the Agriculture Research and Development Agency, the National Research Council of Thailand, the Thai Commission for Higher Education, Mahidol University, the National Science and Technology Development Agency, the Patani Shrimp Farmers Club, the Surathani Shrimp Farmers Club, the Thai Frozen Foods Association, Charoen Pokphand Company, SyAqua Co. Ltd. and Thai Union Co. Ltd. In Taiwan Province of China, the research has also been supported from several sources including the Taiwan National Science Council, National Cheng Kung University (NCKU), National Taiwan University (NTU) and Unipresident Enterprises Corporation.

Contributed by Tim Flegel and C.-F. Lo.

World Aquaculture Adelaide 2014: Special session on regional cooperation for improved biosecurity

A special session on regional cooperation for improved biosecurity will be held at World Aquaculture Adelaide 2014, which runs from 7-11 June. The special session will be held on 11 June from 9am to 12:30pm.

Aquatic animal health issues cause massive losses in the aquaculture industry each year. It is estimated that in tropical shrimp production alone around 40% is lost to disease. Much of the impact falls upon small-scale farmers, who constitute the majority of producers in the Asian region, with devastating effects on their incomes and livelihoods as well as on international trade.

Due to close trade connections aquatic animal pathogens tend to spread rapidly throughout the region and internationally, multiplying the losses and impact on farmers. Effective health management is a shared responsibility that requires a coordinated approach from all countries. This is particularly true of emergent (previously unknown) pathogens such as the acute hepatopancreatic necrosis syndrome of shrimp, where containment requires a rapid response from the international community.

There are good reasons to believe that wide and increasing inbreeding is also a significant factor in frequent epidemics observed in the aquaculture industry, especially in stocks raised by small-scale farmers. Inbreeding generally causes increased susceptibility to disease and loss of genetic diversity is a contributing factor to epidemics. Very few hatcheries or farms have broodstock management plans in place to maintain the genetic integrity of their stock. Inbreeding is widely acknowledged as a serious and growing problem across the aquaculture industry as a whole. If inbreeding continues to increase the severity and frequency of epidemics is likely to increase.

The special session will be organised into three sub-sessions:

- **Regional cooperation in aquatic animal health management**: The rationale, trans-boundary nature of aquatic animal diseases, current aquaculture practices and global trade, what has been done and accomplished, where are the gaps, what needs to be done and the way forward. Presenters will include Dr Brett Herbert (Department of Agriculture, Forestry and Fisheries) and Dr Eduardo Leano (NACA).
- **Dealing with emerging diseases - focus on shrimp acute hepatopancreatic necrosis disease ("EMS")**: Why do new disease emerge? Can we predict disease emergence in aquatic systems? What have we learnt from emerging diseases in the region? Updates on AHPNS including primary pathogens, geographical spread, and the latest on diagnostics and management interventions. Presenters will include Peter Walker (CSIRO) and Siripong Thitamadee (Mahidol University).
- **Domestication programmes and disease emergence / management**: Concept of domestication and breeding programmes, implications of genetic diversity, disease susceptibility and resistance, dependence of the Asian shrimp industry on SPF P. vannamei. Are we heading on the right path and should there be regional efforts for domestication of native species? What are the implications for disease occurrence and production? Presenters will include Dr Greg Coman (CSIRO) and Prof. Roger Doyle (Genetic Computation Ltd.).

Discussion panels will be held after the sub-theme presentations to allow participants to interact with the presenters. The session will bring together industry and scientists performing agricultural research and development to discuss closer cooperation in health management and biosecurity. In particular, it will raise awareness of the link between genetic erosion and disease, an issue which has not been previously investigated or addressed by the aquaculture community. This is a foundation issue that must be addressed in domestication and genetic improvement programmes for prominent aquaculture species.

The session has been made possible through sponsored by the Australian Centre for International Agricultural Research, to whom NACA extends our thanks. For more information about World Aquaculture Adelaide please visit: https://www.was.org/WAA14/

AHPND detection discussion group established

A Google Group on AHPND detection has been established to promote communication about the two AHPND detection methods (AP1 and AP2) that Dr Chu-Fang Lo and Dr Tim Flegel announced on 24 December 2013 (see article on preceding page).

The purpose of the group is to allow people using the methods to send in their comments and experiences about use of these two methods and other methods that might be developed. For example, the IQ2000 method from GeneReach in Taiwan Province of China was recently released and results using that system may be compared with those obtained using AP1 and AP2.

Anyone may join the group or view the discussion by visiting the link below. Please note that this group is specifically to discuss detection and is not for general advice on AHPND.

https://groups.google.com/forum/#!forum/ahpnd

OIE Regional Workshop on Emerging Aquatic Animal Disease Response, in collaboration with NACA, Bali, Indonesia

The OIE has been working to improve aquatic animal health globally through various activities including the development of Aquatic Animal Health Code and Manual of Diagnostic Tests for Aquatic Animals. Considering that aquaculture is expanding and becoming a major food producing sector in the region of Asia and the Pacific, recent spread and outbreaks of some aquatic animal diseases in the region is our concern.

The OIE organised, in collaboration with the Network of Aquaculture Centres in Asia-Pacific (NACA), the Regional Workshop on Emergency Aquatic Animal Disease Response in Bali, Indonesia from 6 to 8 November 2013.

The objectives of the meeting included:

- To identify the factors that constrain regional members' abilities to apply appropriate sanitary measures to protect aquatic animal health;
- To raise awareness of OIE standards including standard setting procedures, OIE Aquatic PVS as well as FAO/NACA Asian Regional Technical Guidelines (TG) to support capacity building of members' effective application of those standards and guidelines;
- To inform participants about the OIE/NACA regional core for better reporting and information sharing;
- To help improving national coordination between OIE Focal Point and NACA National Coordinator which are not necessarily the same.

A total of 35 participants including country representatives from Bangladesh, China PR, India, Indonesia, Japan, Korea RO, Myanmar, Philippines, Sri Lanka, Thailand and Vietnam attended the workshop. The programme for the first two days of the workshop was dedicated to country reports on current aquatic animal disease situations in the selected countries and presentations on the national aquatic animal health programmes of China, Japan and Korea. In addition, case studies on the molluscan diseases (Akoya Oyster Disease and Soft Tunic Syndrome), shrimp diseases (Acute Haematopancreatic Necrosis Syndrome, AHPNS) and finfish diseases (Koi Herpes Virus) were presented to facilitate the subsequent discussion on emergency response of those diseases in the national and regional level.

The workshop was successfully completed with the visit to the Institute for Mariculture Research and Development (IMRAD) and PT Suri Tani Pemuka Hatchery for Marine Fish (JAPFA), Gondol.

The OIE RRAP would like to thank to the Directorate General of Livestock and Animal Health Services and Directorate General of Aquaculture, Indonesia for hosting this important workshop with a nice field trip in Bali, Indonesia.

Please visit the link below to download the summary report, programme, presentations and photographs from the workshop: http://www.enaca.org/modules/news/article.php?article_id=2017

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

United Kingdom – Southeast Asia Workshop on Sustainable Aquaculture

The British High Commission and NACA collaborated in organising a United Kingdom – Southeast Asia Workshop on Sustainable Aquaculture in Bangkok from 20-21 January 2014. The workshop brought together 32 participants from seven countries, namely Thailand, Indonesia, the Philippines, Vietnam and the United Kingdom.

The objectives of the workshop were to:

- Gain a better understanding of the current status of research in each country, including funding mechanisms and topic prioritisation mechanisms as well as funding opportunities.
- Identify specific areas of mutual interest, potential partners and their possible roles.
- Encourage the development of collaborative proposals that address key knowledge gaps.

The workshop covered a broad range of topics of mutual interest, although aquatic animal health issues featured very heavily. The workshop included a session on funding opportunities for collaborative projects between UK and Southeast Asia.

The workshop was very successful from a networking perspective and will be followed up with the preparation of joint project and funding proposals. The report of the workshop will be made available for download from the NACA website in due course.

NACA would like to thank the British High Commission for funding this event.