Peter Edwards writes on

Rural Aquaculture

The development of 'modern' aquaculture in Java, Indonesia

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This is the second and final column following a visit I made to West Java in June and July last year to witness changes that have taken place in inland aquaculture over the past three decades. My column in the previous issue (Volume XIV, No.4, pp. 3-8) considered traditional aquaculture based on natural food produced by organic fertilisation and its augmentation by supplementary feed whilst here I discuss the development of 'modern' aquaculture, defined simply as the use of formulated pelleted feed from agro-industry. I also include some recent developments in Central Java, hence the broader title of this column. I spent another two days in the field in October last year following the annual meeting of the Aquaculture Society of Indonesia, 'Aquaculture Indonesia 2009', held in Yogjakarta for which I was I was sponsored by the Aquaculture Society of Indonesia to present a keynote on comparing small-scale aquaculture in West Java and other Asian countries.

Indigenous giant gourami are fed mainly commercial pelleted feed supplemented with elephant ear plant grown on pond dikes.

As mentioned in the previous column, there has been a dramatic 6-fold increase in inland aquaculture production over the past three decades in Indonesia. This has been made possible in part by introduction of new species and culture systems and especially by intensification of production of fish in monoculture through use of agro-industrial pelleted feed. I write 'in part' because these recent developments have built upon the long tradition of Javanese aquaculture and fish marketing.

Changes in species

Traditional polyculture has declined and several of today's major farmed species are exotic species. The indigenous common carp (*Cyprinus carpio*) still dominates inland aquaculture production at 36% of the total inland production of 740,000 tonnes in 2007 and production of native giant gourami (*Osphronemus gouramy*) has increased 9-fold over the past three decades although only comprising 5% of production as it is a high-value fish species. However, other major farmed species are exotics. There has been a major rise in production of Nile tilapia (*Oreochromis niloticus*), comprising 28% of national inland aquaculture production. African catfish (*Clarias gariepinus*) is a species being promoted by the government for national food security along with common carp and tilapia and its production in 2007 was 92,000 tonnes or 12% of the total.

Exotic African catfish being fed commercial pelleted feed in a small-scale farmer's pond.

African catfish is processed and packaged at village level.

Unlike several other Asian countries where pangasiid river catfish are major farmed fish, here they are relatively minor. Striped catfish (*Pangasianodon hypophthalmus*) was introduced from Thailand about 30 years ago but is not popular among consumers in Java. The indigenous *Pangasius djambal* is raised in traditional wooden cages in rivers in Sumatra but attempts to breed it in Java have not been very successful as fecundity is low, fingerling production is unstable, and mortality is high in static water ponds. As the flesh quality of the native species is higher than that of the introduced striped catfish, a hybrid has been developed by crossing male *P. djambal* with female *P. hypophthalmus* to combine the best attributes of the two species; the hybrid has a faster growth rate and higher tolerance to low dissolved oxygen than *P. djambal* and retains its white flesh. It was distributed to farmers in 2006. A species that is being increasingly cultured is pacu or freshwater pomano as it is sometimes called (*Piaractus* sp.) which the government would like to ban due to concerns about possible adverse impacts on native fish although it is now widely farmed.

While production of the native giant gourami, a herbivore traditionally fed soft leaves of plants, especially elephant ear plant (*Alocasia macrorrhiza*), has increased, today the main diet is pelleted feed although fish raised only on pelleted feed are reported not to have a good taste. Giant gourami can be bred naturally without artificial induced breeding provided that materials are provided in the pond for it to make a nest to lay eggs. Thus, it has potential to be bred by small-scale farmers and a small-scale farming family could keep 30-50 brood stock and sell the eggs. Unfortunately the growth rate of the species is only about half that of tilapia even when fed pelleted feed although the farm gate price is double that of tilapia as it is a prized restaurant fish.

The culture of African catfish (local name lele) has expanded rapidly as it can be raised at high density in small ponds and can be marketed at a relatively small size of 125-200g, the traditional Javanese size for eating fish. In my previous column I wrote about a large-scale farm using dried marine trash fish and chicken offal (in what may be considered traditional ways of feeding fish) as well as pelleted feed. However, most of the African catfish being farmed in Java is pellet-fed as I witnessed in Mangkubumen Village, Boyolali Regency near Yogyakarta in Central Java. Here almost all the rice fields in the village have been converted into 1,600 small ponds, mostly very small, about 40-50m^2. About 100 families

in the village raise African catfish with most families having 10-16 ponds with a range from 6-160 ponds per family. The usual rate of production is 800-1,200 kg/pond equivalent to about 160-300 tonnes/ha per 3.0-3.5 month grow-out cycle. Such high small-pond production makes it very attractive for poor farmers. Harvested fish are sorted into three categories: large fish which fetch a lower price and are processed; optimal sized fish for marketing fresh; and small fish which are restocked. There is also village-level processing of fish by women to make fried fish skin and fried flesh which are marketed in attractively designed packages. Fingerlings are mainly produced in another village, Tulungagung, in East Java, a six hour drive.

A newly constructed running water pond farm in Subang.

Changes in systems

Two major new grow-out systems were introduced into Java by government aquaculture officers in the 1970's: running water ponds and floating net cages, both developed in Japan, the former directly from Japan and the latter indirectly via Taiwan.

Running water ponds

Mountainous areas in West Java have lots of water to supply running water ponds (RWPs) constructed alongside streams and irrigation canals by gravity. The RWP system was rapidly taken up by farmers from about 1975 and at its peak a decade later there were said to be 10,000 such farms raising common carp in West Java as it was a good business. Most farmers were not poor because of the high capital construction and operating costs. I saw several fully operational RWP farms during my visit in 1981, mostly quite large operations, but last year I saw mainly abandoned systems. Most RWPs ceased to function in the late 80s as they were outcompeted by floating net cage culture in reservoirs which was developed a few years later. Floating net cage culture has a lower cost of production of carp than RWPs and now dominates grow-out production. The RWP farms were small because of highly intensive production, ranging from 100-5,000m^2 although most were less than 1,000m^2. Gravity-fed water exchange was estimated at up to 100 times/day with annual fish production up to 90kg/m^2, equivalent to an extrapolated fish harvest of 900tonnes/ha/year.

Red tilapia being fed with commercial pelleted feed in a floating net cage farm in Cirata Reservoir by Dr Agus of JAPFA an AIT alumnus who arranged and guided my visit.

Farmers were observed mincing and sun drying farm-made feed during my visit in 1981 but the RWP system stimulated the development of factories to produce pelleted feed, the availability of which encouraged more farmers to build RWPs, a good example of positive feedback. Use of commercially produced feed is universal in intensive culture in Java today.

A tilapia floating net cage farm owned by AquaFarm in Gadjah Mungkur Reservoir.

On my recent visits I saw a few RWPs still in operation but to hold table fish harvested from reservoir cages until they are sold on the local market and to hold common carp brood stock which are rented to seed producing farmers. RWPs are also used for high density nursing of giant gourami, pacu and striped catfish. However, I visited a RWP system in Cisalak subdistrict in Subang which had been closed until recently for several years but had been renovated; and also a newly constructed RWP farm. These are used to produce

Bambang Gunadi an AIT alumnus feeding commercial feed in a high density pond trial of common carp at the Research Institute for Freshwater Aquaculture Sukamandi.

Pond nursing of common carp fingerlings with commercial pelleted feed in Subang.

Close up of pellet-fed common carp fingerlings Subang.

higher-value large common carp, greater than 1 kg, for sports fishing and restaurants. This is a niche market with relatively low demand but as the farm gate price is about one third higher than that of reservoir cages which produce smaller and lower-value fish of a preferred size for the domestic market of 0.20- 0.33 kg, they are profitable. Furthermore, cage-raised common carp often have an off-flavour, unlike those from RWPs.

Cages

Dams constructed in the 1970s and 1980s in the densely populated lowlands of Central and West Java displaced tens of thousands of poor rice farmers as their rice farms and communities were flooded. Cage culture was subsequently developed in the reservoirs and the intended beneficiaries were poor farmers. However, today cage farming is dominated by urban entrepreneurs and in some reservoirs by multinational companies, with some of the local former farmers employed as labourers on the cages, as related by interviewed cage farmers and also well documented in the literature.

Caged fish production in reservoirs has become the main source of fish for the domestic market and supplies about 80% of the total consumption in Java and so is extremely important for national food security. The main species is common carp raised in two cycles annually on pelleted feed with one crop of tilapia usually raised in a separate cage below the main cage on the wastes from carp culture.

I visited the first trial of floating net cages during 1981 in the small 20 ha, 15m deep, Lido Lake, which had started in 1978 and revisited it last year. Last year I also visited Cianjur Reservoir in West Java and Gadjah Mungkur and Kedung Ombo Reservoirs in Central Java.

Lido Lake

In 1981 there was a government farm and two private farms. The 10m^2 net cages had a metal frame and oil drum floats and a 1.5m deep net and were stocked with either common carp or Nile tilapia at 6kg/m^2, fed with a 25-30% protein pellet, and harvested at 28.5 kg/m^2 after 4.5 months. Earlier trials in polyculture had been unsuccessful as common carp exhibited poor growth. During my recent visit to Lido Lake, Nile tilapia, pacu and striped catfish were being raised by 26 farmers but in smaller 12 m^2 cages with 12 cages/farmer. Poor water quality was now reported to be a problem, especially during January and February when heavy rain caused a water ‘turnover’.

Cirata Reservoir

A successful cage trial with common carp had also been conducted in Jatiluhur Reservoir which had been constructed earlier in the1970s by the time of my visit in 1981 but Cirata and Seguling dams only came into existence in 1985 and 1988, respectively.

Cirata with an area of 62 km^2 has about 73,000 cages but during my visit about 50% may not have contained fish as many farmers lacked capital. Fish are raised in cages 7m x 7m x 3m deep. A stock of 100 kg of fingerlings of common carp per cage grew to 1.8-2.0 tonnes in 4 months when cage culture was first established but there has been a gradual decline in production to due to increasingly poor water quality. Now farmers stock only 50 kg of fingerlings per cage, with a correspondingly reduced use of feed, and the fish grow to only 0.8 tonnes in 4 months. Food conversion ratio is 1.6 with

good quality feed. One hundred kg of normal coloured black tilapia are stocked in the lower cage and grow to 0.3 tonne in 6 months. Some farms are now raising pellet-fed red tilapia in the main cage which fetches a higher price in the restaurant trade. Some cage farms are trialling milkfish and silver striped catfish.

Small-scale farmers nurse common carp and tilapia fingerlings in Subang.

Mr Imsa inside an aquarium filled nursing shed belonging to one of his small-scale farmer network memebers in Darmaga.

Nursing giant gourami in aquaria.

Central Java reservoirs

Gadjah Mungkur, an 84 km^2 reservoir in Wongojiri to the south of Solo has 15 farms each with 10-50 cages which are mostly owned by investors from the local area but Aquafarm, a Swiss-owned multinational company which exports tilapia has more than 500 cages. Interviewed cage operators reported that there used to be about 20 farmers but the number declined as some farms went out of business due to low profit as the local market, unlike in West Java, is not good. Farmers reported concern over mortality of Nile tilapia but not common carp or striped catfish due to declining water quality. Dead fish are either used by a local factory to make fish powder or are fed directly to common carp, neither practice being advisable from a fish health management perspective.

Kedung Ombo reservoir to the north of Solo has an area of 47 km^2 but also with only a small number of about 30 farms each with 10 to 200 cages, mostly owned by off-farm investors who hire operators, including one belonging to AquaFarm with 240 cages. A notable exception was the farmer interviewed who used to be a construction worker but had saved and invested his own money in aquaculture. He now operates 25 cages and hires five workers. He copied cage farming from other farmers as well as learning through experience. During his first year in 2000 he had only a single cage but he re-invested the profit to operate 6 cages in 2001. Four other farmers started small like him but with four cages initially rather than a single cage. The interviewed farmer was also building a restaurant at the side of the reservoir. He intended to use his own cage raised tilapia, barbecue them and sell them at double the farm-gate price to local mainly weekend tourists. The water quality was also declining as in other reservoirs, with increasing fish mortality although the number of cages was now stable as the local government had recently introduced a regulation to curb a rise in the number of cages.

Experimental systems

Two systems are being trialed at the Research Institute for Freshwater Fish Breeding and Aquaculture in Sukamandi: intensive culture of common carp in lowland stagnant water but aerated ponds; and static water pond culture of striped catfish. Trials are being conducted with intensive culture of common carp and striped catfish in ponds as a possible alternative grow-out system in anticipation of a decline in reservoir production due to pollution.

Common carp fingerlings stocked at high densities of 50-75 individual 6-10g fingerlings in a 200m^2 pond with a 1-HP paddle wheel and fed commercial pelleted feed, which produced an extrapolated yield of almost 100 tonnes/ha of 0.25-0.3 kg fish in 4-5 months. The idea for raising striped catfish in ponds was borrowed from Vietnam. An extrapolated yield of 100 tonnes/ha has been obtained with pelleted feed in a 6,000m^2 pond.

Seed production and marketing

Traditional small-scale wastewater-fed ponds are probably still the major source of seed for common carp and Nile tilapia. However, because of the tremendous increased demand for fingerlings to stock grow-out systems, especially

cages in reservoirs, these two species are also produced in pellet-fed nursing systems in areas close to the reservoirs such as in Subang.

It is not economic for small-scale farmers to still be involved in grow-out of traditional low-value species if they want aquaculture to make a significant contribution to their income. Grow-out also needs much more water than nursing and more time is needed for table fish to reach marketable size compared to fingerlings. Thus there has been a major shift in production of small-scale aquaculture from grow-out to nursing because of its inherent advantages for small-scale farmers. Nursing requires less investment as the fish are small, especially in terms of feed required, and the cash flow is better and the risk less because of the shorter cycle. Many small-scale farmers nurse high-value species as I saw when visiting hatcheries and nurseries in Darmaga near Bogor for giant gourami, pacu and striped catfish.

I visited two areas where small-scale farmers have been organized into nursing networks, in Subang for common carp and tilapia and Darmaga for high-value species.

Common carp and tilapia

In Gembor Village, Pegaden subdistrict, Subang more than 1,000 former rice farmers each has a minimum of one 0.5-1.5 ha pond for nursing common carp and Nile tilapia to provide fingerlings for RWP systems in Cisalat subdistrict, Subang and cages in Cirata Reservoir. Fish culture started in the area about 20 years ago after the current village head moved there from Saguling Reservoir where he had learned how to raise fish and the other farmers copied from him. There are six large farmers in the village, each with a network of 70-100 small-scale farmers, to facilitate input supply, credit and marketing fingerlings. Nightsoil was used to be used to fertilise ponds but now commercial feed is used.

High-value species

Mr Imsa, a large-scale seed producer with 6 farms informed me that the Darmaga area has changed from mainly RWP farms for grow-out of common carp to mainly hatcheries and nurseries of high-value species such as pacu and striped catfish. There are about 50 hatcheries for pacu and about 20 hatcheries for striped catfish, both large and small. Mr Imsa has organized 10 farmers into a nursing group to strengthen his business. He supplies his group with eggs and one day-old larvae of pacu (10% of the total) and striped catfish (90% of the total). *Artemia* are fed for 4-5 days followed by *Tubifex* and finally crumbled shrimp pelleted feed. Mr Imsa buys back 21-40 day-old nursed fingerlings from the group and sells them to many regions in Java, Kalimantan and Sumatra. He supplies the farmers with feed and an aquarium production facility for nursing and also provides working capital if needed. Each farmer has 70-100 units of 100-120 l aquaria with each aquarium stocked with 200,000 to 400,000 larvae / batch; there are an average of 7 batches/year.

The aquaria are a fairly low-cost nursing system as they are installed in bamboo-framed sheds covered in plastic to maintain a high temperature of 30 degrees celsius. This system was developed by Bogor Agricultural University and has replaced nursing in concrete tanks in the area.

A small-scale farmer feeding commercial pellets to striped catfish fingerlings.

Checking for ripe eggs in a pacu broodfish.

The main business at Cibaraja Fish Seed Market in Sukabumi is now ornamental fish rather then food fish fingerlings.

Most of the farmers in Mr Insa's nursing group are small-scale operators who used to be rice or vegetable farmers but now have a most profitable extra livelihood; some were laid off from other jobs or were government officers. Nursing now provides them with 70-100% of their total income. Mr Imsa who has 10 years experience is a university graduate who used to work for a feed company. He pointed out that operating a hatchery requires considerably more skill than nursing or grow-out.

Cibaraja Fish Seed Market

I also visited the famous Cibaraja fish seed market in Sukabumi which has been operating for over 50 years. The sale of fingerlings is much reduced today as purchases of the large number of fingerlings required to stock cages in reservoirs is done directly from nursing farms. Table fish harvested from cages are also held live in the running water system at the market prior to being sold but the largest business is now ornamental fish, especially gold fish and koi carp. I also visited a local government project near Sukabumi in which about 100 poor farmers were raising ornamental fish in suspended net cages in a small reservoir. The project was ideal for poor farmers as it did not require land, each cage was small and little capital investment was required. Harvested fish were quarantined in aquaria in a building by the side of the reservoir prior to marketing.

Towards the future

The biggest concern expressed repeatedly during my visits is the future of cage culture in reservoirs, especially in Cirata Reservoir, which currently supply about 80% of the domestic fish supply of the densely populated island of Java. A major concern is the declining water quality due to massive inputs of nutrients from pelleted feed. In Cirata the early morning dissolved oxygen is often as low as 0.8 ppm at 1m depth. During the last turnover of the reservoir's water two years ago, there was an 80% mortality of all species.

A local government project in which poor farmers are raising ornamental fish in suspended cages in a small reservoir.

Of the three large reservoirs in West Java, I was informed that common carp can no longer be grown in Saguling Reservoir as the water quality is now so poor, only more tolerant species such as giant gourami, Nile tilapia and striped catfish. Production and intensity of cage culture have been reduced in Cirata and if water quality continues to decline only species more tolerant of poor water quality will be able to be farmed. A new reservoir in under construction to the east of Bandung, Rajamandala. It is to be hoped that the introduction of cage culture in the new reservoir will be regulated so that poor rice farmers will be able to farm fish in cages and fish production will be within the reservoir's carrying capacity. The trials of high density pond culture of common carp and striped catfish have been stimulated by the need to develop an alternative grow-out system to cage culture.

There is concern about sustainability of the water supply in West Java as it is declining year by year due to population growth and the development of settlements in rural areas, especially in the watersheds in the mountains. I was informed that Sumatra is about 10 years behind Java in the development of aquaculture and has great potential for seed and grow-out production. Many areas in Sumatra are similar to the main aquaculture areas of West Java so it is likely to become a major frontier for aquaculture development and may eventually supply fish to Java.

Better Management Practices (BMPs) - gateway to ensuring sustainability of small scale aquaculture and meeting modern day market challenges and opportunities

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Development and adoption of Better Management Practices (BMPs) for key aquaculture commodities is gradually increasing in the region. However, there appears to be lot of confusion in the minds of farmers, policy makers and other stakeholders about the concept and approaches. Often, it is confused with standards and certification. The purpose of this article is to highlight the concept of better management practices, how they can be developed and adopted for specific commodities and or farming systems, and their benefits to small scale farmers and rural communities. NACA has been involved the development and adoption of better management practices since 2000 in a number of countries in the Asia-Pacific region, working in conjunction with country partners and donors, and international organisations. The lessons learned and experience gained strongly suggest that better management practices are the gateway to ensuring sustainability of small scale aquaculture and meeting modern day market challenges and opportunities. The purpose of