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Invasive apple snails, Vietnam

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Black soldier fly as feed

Collecting shrimp seed

AQUACULTURE ASIA

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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Meat taxes: The wrong solution to a serious problem?

There is no doubt that agriculture is one of the largest contributors to greenhouse gas emissions and climate change. To date the sector has got off lightly, but it is increasingly coming under scrutiny. It is only a matter of time before agriculture comes under pressure to *specifically* reduce its greenhouse gas emissions. Of course "agriculture" covers an incredibly diverse range of practices, and some of them are more damaging than others.

While most agricultural practices have adverse impacts in one way or another, livestock industries appear to have relatively greater impacts. While an exact figure will never be agreed on, livestock industries are thought to collectively represent somewhere in the vicinity of 15% of global greenhouse gas emissions. When livestock and plant crops are compared, and the amount of food they produce considered, livestock does not stack up particularly well as an efficient use of resources. Far from it. How will we reconcile this situation with a growing world population and the increasing per capita demand for meat, as incomes improve?

One solution that has been raised and considered by several governments, mainly in Europe, is to tax meat consumption. The argument is that by raising the price consumption will be curbed, with feedback in turn limiting meat production and related environmental impacts.

While a "meat tax" might be a fine solution for Europe, it would not be appropriate for the Asian region or for any developing nation. Q: If you raise prices to curb consumption, who will be the first to go without meat? A: The poor and the malnourished, ie. the people that actually *need* it. Not a good public policy outcome.

But climate change isn't going away and something must be done, but what? Well not all livestock are equal. Some livestock have a demonstrably greater impact than others, for example cattle have considerably greater impact than (say) poultry. But it is fish that you'll find down at the bottom of the impact curve. Being endotherms, fish have relatively low metabolic requirements compared to warm blooded animals. They convert feed to flesh more efficiently.

Specifically, it is the herbivorous and omnivorous fishes such as carps and tilapia where the impact can be least. Those species that can feed close to the bottom of the food chain – grazing on plankton, biofilms and invertebrates – suffer less from the cumulative energy losses that occur with each step up the food chain.

Of course the production system matters too. Impact is lowest in extensive and semi-intensive farming systems where the fish depend, to varying degrees, on the natural foods present in the water body. Culture-based fisheries – where fish are stocked in a water body but not fed – are an example of a very low greenhouse gas production system. Once feeds are applied the impact goes up.

Perhaps policy makers could achieve more by looking at the types of livestock we are growing, the types of production system we are growing them in, and their relative impacts, rather than applying blunt instruments across the board.

Simon Wilkinson

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Invasive apple snails (*Pomacea* spp.) in Vietnam: Short review

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A single adult Pomacea spp. eating young rice seedling on a rice field in Phu Loc, Thua Thien Hue, Vietnam. (Credit: Dr. Do Van Tu).

Originating from South America the apple snail species of *Pomacea*, commonly referred to as golden apple snail, was imported into Vietnam from 1985 to 1988 with the intention of raising it for human consumption (Cuong, 2006; Huynh, 2006). Not long after that, the introduced snails quickly spread to most freshwater ecosystems of the country, becoming one of the major invasive agricultural pests, notably in wetland rice and vegetables, but also other aquatic crops in Vietnam (Do Van Tu, personal observation). A similar serious pest status was reported from southern and eastern Asia and islands of the Pacific (Cowie, 2002; Joshi & Sebastian, 2006; Joshi et.al, 2017), and it is listed as one of the world's 100 worst invasive alien species (GISD, 2017).

Pomacea species complex

Based on morphology, two *Pomacea* species have been identified in Vietnam, *Pomacea canaliculata* and *Pomacea maculata* (Do, 2015). Early on Cowie *et al*. (2006) and Hayes *et al. (2008) provided molecular and morphological data* identifying *P. canaliculata* and *P. maculata* (as *P. insularum*, which is now a junior synonym of *P. maculata*, according to Hayes *et al*. 2012).

Origin and Introduction of *Pomacea spp.*

According to the final report of the project "Integrated Pest Management of Golden Apple Snail on Rice in Vietnam" in 1998, *Pomacea* spp. was imported into Vietnam in 1988 through various ways without thorough quarantine. Before 1988, however, there were newspapers reports referring to some foreign businessmen bringing these snails into Vietnam because they had favourable characteristics such as being easy to raise, rapid growth, strong reproductive ability, high nitrogen level content and others. Some reported that many commercial companies could buy large quantities of these snails for export (MARD, 1998).

By 1990-1993, *Pomacea* spp. was being promoted by media as "a food industry that could bring prosperity to farmers" (PPD, 2000). So, in a short period, many people asked, inquired and rushed to find apple snails to raise and reproduce in ponds, lakes and in their houses with the intention to generate income.

By January 1991, based on many research documents, there were about 20 centres selling *Pomacea* spp. and thousands of families were raising them at the Mekong Delta River. In 1990, the Liksin Company, a printing and paper company in Ho Chi Minh City invested on their large-scale raising. From here, *Pomacea* spp. started to spread nationwide. At the same time, in 1990-1991, two foreign enterprises, one in Ho Chi Minh City and the other in Kien Giang Province, were involved in large-scale production of these apple snails for export (Huynh, 2006).

In 1992, from South Vietnam, *Pomacea* spp. started infesting Central and North Vietnam. However, after a long time, there was less interest to buy them for export and for the local markets. Consumers observed that *Pomacea* spp. flesh was not as good and delicious as local snails (*Pila* spp. and *Viviparidae*). As a result, no one wanted to continue raising them for food. The end of the miraculous story was the same as that of the Philippines. From private ponds and lakes, these non-native apple snails started to invade ditches, canals and then the rice fields (Huynh, 2006).

The damage by *Pomacea* spp. on rice was first recognized in Kien Giang Province in 1994. Many rice fields had to be re-sown two or three times because of their ravages. In the same year, the Thu Duc and Hoc Mon districts under HCMC, these apple snails seriously damaged the water morning glory (Ipomoea aquatica) plants (Huynh, 2006).

By November 1994, *Pomacea* spp. infested 38 provinces and damaged 1,678 ha of rice and140 ha of vegetables. Four years later, in 1998, infestation had increased to 57 of 61 provinces and cities and 304 of 534 districts in the whole country at different infestation levels. Many provinces in North and Central Vietnam recognised the presence of *Pomacea* spp. but less damage on rice was reported (Hung, 1999). However, in the Mekong Delta River, southern Vietnam, about 1.826 million hectares of rice fields, were infested because of favorable climatic conditions, rich food sources, year-round sowing, interlocking river systems and annual floods. As a result, apple snails could reproduce freely and the infested area increased greatly especially in times of flood. In the Ca Mau, Bac Lieu, Kien Giang, Soc Trang, Dong Thap and Vinh

Scattered Pomacea spp. infesting a rice field in field in Phu Loc, Thua Thien Hue (Do Van Tu, Vietnam. (Credit: Dr. Do Van Tu).

Pomacea spp. being sold as feeds for human and livestock in Krong Pa Market, Gia Lai, Vietnam. (Credit: Dr. Do Van Tu).

Long provinces, their density per square meter was very high. In some districts in Ho Chi Minh City, their density reached from 50-200 snails per square meter. Generally, *Pomacea* spp. invaded area increased yearly, mainly on rice and morning glory crops (Huynh, 2006).

Currently, *Pomacea* spp. is distributed throughout the country, from the mountains to the plains and estuaries, even in islands far from the mainland such as Bach Long Vy and Con Dao. It is listed as an invasive alien species in Vietnam (MONRE-MARD, 2013). However, apple snails are still sold in local markets especially in the south of Vietnam for human consumption and as livestock feed. The price for one kilogram of these apple snails is about 15,000 Vietnamese Dong (about 0.7 $US).

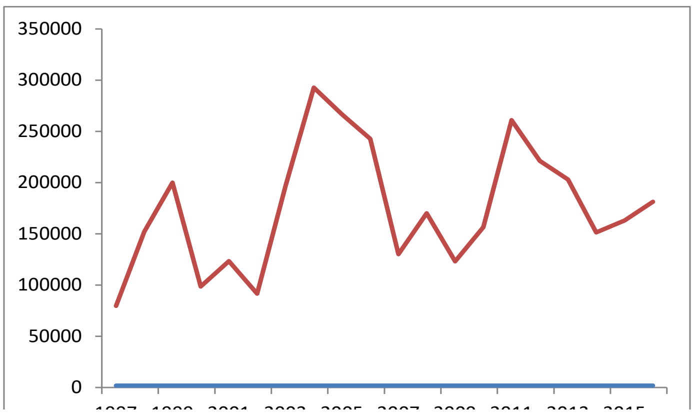
Impacts from *Pomacea spp.* invasions

In Vietnam, *Pomacea* spp. eats more than 20 kinds of crops, mainly vegetables, rice, water fern (*Azolla* spp.) and morning glory. They can consume 100% of newly sown rice plants and 20% of newly transplanted rice within 1 day (PPD, 2000).

Apple snail infestations of rice fields have fluctuated between 1997 to 2016. However, the infested area has increased.

Native apple snail (*Pila* spp.) is becoming rare, but the introduced apple snail (*Pomacea* spp.) becoming more abundant. There are many localities where *Pila* spp. has become extinct and *Pomacea* spp. are now found in abundance (Do Van Tu, personal observation). Other native fauna and flora are likely to be negatively impacted by the introduction of apple snails. However, there have not been any studies in Vietnam on their impacts to biodiversity and ecosystems.

Infestation of rice fields (ha) with *Pomacea* spp. in rice fields from 1997 to 2016 in Vietnam.



Water level is kept low for newly transplanted rice in order to prevent Pomacea spp. infestation in Phuoc Son, Quang Nam, Vietnam. (Credit: Dr. Do Van Tu).

Control management activities

In Vietnam a range of culture, biological and chemical control measures have been promoted as part of an integrated pest management strategy to control *Pomacea* spp. (Cuong, 2006; Huynh, 2006). These are:

Culture measures

Pick snails by hand. This is practical and economical only in small farm holdings. Before sowing rice, farmers collect apple snails and their egg masses in the field, around the lakes, rivers, streams, canals, and other places where the pest abounds.

Keep the water level below 2 cm when sowing and dig small trenches around field for deeper water. Adult and juvenile apple snails congregate on these trenches. Capturing them becomes easier and less costly.

Increase the seeding density (5-10%) to compensate for the plants that will be eaten by snails. Transplanting older rice seedlings (40-day-old) minimizes snail damage.

Keep shallow depth of water (0-3 cm) from sowing until 15 days later to restrict the snail movements and feeding.

Use trees and sticks as plugs in places with many apple snails to attract them to climb and lay eggs. Eggmasses are then collected and destroyed.

Use of filters such as nylon mesh with small holes at the water inlets to prevent re-infestation in rice field through the flow of snail-infested water.

Field sanitation such as cutting the grass around the field, removing dry rice straw and other plants which can be shelters of snails or egg laying sites.

After harvesting, dry the field for a while to prevent snail from breeding and also enhance snail mortality due to heat and desiccation.

Biological measures

Plants with snail-killing action: Several plants such as Chinaberry tree (*Melia azedarach*), Oleander (*Nerium oleander*), Poison vine (*Derris elliptica*) and Great basil (*Ocimum basilicum*) have been recommended to kill the adult and juvenile apple snails. However, high application rates (20-40 kg ha^{-1}) make their usage impractical.

Plants with attractant action: Leaves of papaya (*Carica papaya*) and cassava (*Manihot esculenta*) are potent snail attractants. Dead crabs and pig waste are sometime also used as attractant. A small bundle of the leaves is submerged in stagnant water at the edge of the field. Significant numbers of snails are attracted to the leaves after 24 hours and are collected and destroyed the following day. This method significantly reduces the time and labour required in the normal handpicking operation.

Ducks are allowed in the fields to consume snails and their egg masses.

An Food and Agriculture Organization (FAO) project in Vietnam entitled Integrated Golden Apple Snail Management in Rice used biological controls to combat apple snails, finding that rice-fish farming - where fish (black carp, common carp and catfish) are raised in the rice fields – is one of the best ways to control the snails. Common carp is the most efficient control agent for apple snails, having a better survival rate than black carp and eating more snails. Field experiments showed that the common carp reduced populations of the snail, particularly young snails of less than 1 cm shell height, by 90% in rice fields over a period of three months (FAO, 1998).

Apple snails are utilised as feed in giant freshwater prawn (*Macrobrachium rosenbergi*) farming (Hasan & Halwart, 2009), and for striped catfish (*Pangasianodon hypophthalmus*) fingerlings (Da *et. al.* 2012).

Chemical measures

Before 2006, farmers usually used the following pesticides to kill apple snails: Bayluscide 250EC, BOLIS 6B, Clodansuper 700WP, Oxdie 700WP, Pazol 700WP, VT-Dax 700WP, Tungsai 700WP, Padan 98%WP, Deadline Bullets (metaldehyde), Thiodane / Endosol (Endosulfan). In addition, lime is applied at 200kg/1000m^2 (before sowing or after harvesting), at 2-5 cm water depth and kept for 2-3 days, then dried.

Many pesticides are used against apple snails, a list of permitted pesticides is available. However, some pesticides not on the list are very toxic, but can be found in the markets.

Interventions by government

Since 1994, the Vietnamese Government has introduced some policies and decisions to control and prevent further spread of *Pomacea* spp. These include:

Decision No. 190 / NN-PPD / QD dated 31.03.1994 of the Ministry of Agriculture and Food Industry.

Golden apple snail (*Pomacea* spp.) is considered an alien invasive species in the Circular 27/2013/TTLT-BTNMT-BNNPTNT issued by the Ministry of Natural Resources and Environment and Ministry of Agriculture and Rural Development on September 26, 2013.

In recent years, especially in 2013, Vietnamese traders collected Pomacea spp. and exported them to China. This encouraged many households to culture them, and wait for the dry season to sell for higher price. Official Letter No. 3879/ BNN issued by the Ministry of Agriculture and Rural Development (MARD) strengthens the inspection and handling of the introduced apple snails to prevent its spread and culture. According to this Official Letter, apple snail trafficking and culturing in some provinces, cause risk of transmission and spread of the pests.

Many campaigns on a national scale have been launched to eradicate *Pomacea* spp. The media also participated actively to promote and raise awareness about their harmful effects, as well as preventative actions to take. However, with changes in natural conditions (frequent flooding), low awareness of the people, especially the less drastic measures of the administration, Pomacea spp. is still spreading strongly and causing serious damage to agriculture and the aquatic ecosystems of the country.

Conclusions

Introduction of *Pomacea* spp. around early 1985 to 1988 to Vietnam was followed by their rapid range expansion and development as invasive agricultural pests, especially in wetland direct-seeded rice ecosystems, vegetables and other aquatic crops. The invasion of these species have caused significant economic and ecological damage.

Pomacea spp. are also host to disease-causing trematodes and nematodes, including the endoparasite rat lungworm (*Angiostrongylus cantonensis*) which cause the disease Eosinophilic meningoencephalitis in humans; and intestinal fluke (*Echinostoma ilocanum*) (CABI, 2014). Many Vietnamese farm workers can be exposed to such infections if they consume under cooked snails, and also in wetlands because of a lack of protective clothing. We are not aware if the Ministry of Health has monitored the level of snail-borne disease infections in farm workers.

The two species of *Pomacea* remain the dangerous pests in Vietnam. Currently there are no measures to effectively prevent the growth, development and spread of *Pomacea* species. Therefore more applied research is needed to develop eco-friendly, and sustainable management options that can easily be adopted especially by smallholder farmers, as well as on community-area-wide especially with increased threats of flooding of the Mekong River and other water bodies caused by climate change.

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Egg mass of Pomacea spp. at the bank of a rice field in Phu Loc, Thua Thien Hue, Vietnam. (Credit: Dr. Do Van Tu).

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A review of fresh water integrated multi-trophic aquaculture (FIMTA): Catching up on the dream of a blue revolution in India

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Integrated multi-trophic aquaculture (IMTA) is a flexible concept, on which many variations can be developed and should not be viewed as confined to open-water, marine systems. Freshwater Integrated Multi-Trophic Aquaculture (FIMTA) is perhaps better known as "aquaponics." FIMTA applies the same principles as those used in marine IMTA but takes place in a freshwater setting. It is not only important for branding purposes, but can also increase the sustainability of the industry by reducing water usage and waste production, increase product diversification, and improve the societal acceptance of the industry. In particular, using plants to reduce phosphorus (and other nutrient) levels in effluents can help farmers meet water quality guidelines and prevent eutrophication in the environment.

Aquaponics is a form of FIMTA that combines aquatic animal and plant culture, through a microbial link and in a symbiotic relationship. It uses microbes to convert organic wastes produced by the fish into inorganic nutrients that are then consumed by plants, which also absorb inorganic nutrients that are available directly. This technology can be adapted to many fish- and plant species, in a range of growing conditions, and with a variety of techniques, including floating rafts and media filled beds.

Over the last two and a half years, a comprehensive field and laboratory feasibility study was conducted to investigate the potential for developing land-based freshwater IMTA (or FIMTA) systems for Atlantic salmon hatcheries operated in New Brunswick, Canada, by our industry partner, Cooke Aquaculture Inc. Both flow-through and recirculating facilities were assessed to design the most appropriate systems based on water quality, nutrient loading, flow- and discharge characteristics. Also important are nutrient concentrations and bioavailability, temperature, light, space availability, plant specific growth, absorption requirements, and economic viability and markets. The analyses indicate that recirculating hatcheries are more valuable candidates for FIMTA systems than conventional flow-through hatcheries.

Concept of integrated multi-trophic aquaculture

In many monoculture farming systems the fed-aquaculture species and the organic/ inorganic extractive aquaculture species (bivalves, herbivorous fishes and aquatic plants) are independently farmed in different geographical locations, resulting in pronounced shift in the environmental processes. Integrated multi-trophic aquaculture involves cultivating fed species with extractive species that utilise the inorganic and organic wastes from aquaculture for their growth. According to Barrington (2009), IMTA is the practice which combines, in the appropriate proportions, the cultivation of fed aquaculture species (e.g. finfish/shrimp) with organic extractive aquaculture species (e.g. shellfish/herbivorous fish) and inorganic extractive aquaculture species (e.g. seaweed) to create balanced systems for environmental sustainability (bio-mitigation) economic stability (product diversification and risk reduction) and social acceptability (better management practices).This farming method is different from finfish "polyculture", where the fishes share the same biological and chemical processes which could potentially lead to shifts in ecosystems. Multi-trophic refers to the combination of species from different trophic levels in the same system. The multi-trophic sub-systems are integrated in IMTA that refers to the more intensive cultivation of the different species in proximity of each other, linked by nutrient and energy transfer through water.

Selection of species

Environmental sustainability is the major consideration in FIMTA, therefore the criteria guiding species selection is the imitation of natural ecosystem. Fed organisms, such as carnivorous fish and shrimp are nourished by feed, comprising of pellets or trash fish. Extractive organisms, extract their nourishment from the environment. The two economically important cultured groups that fall into this category are bivalves and plants. Combinations of co-cultured species will have to be carefully selected according to a number of conditions and criteria:

- **Complementary roles with other species in the system:** Use species that will complement each other on different trophic levels. For example, species must be able to feed on the other species' waste in order for the newly integrated species to improve the quality of the water and grow efficiently. Not all species can be grown together efficiently.

- **Adaptability in relation to the habitat:** Native species that are well within their normal geographic range and for which technology is available can be used. This will help to prevent the risk of invasive species causing harm to the local environment, and potentially harming other economic activities. Native species have also evolved to be well adapted to the local conditions.

- **Culture technologies and site environmental conditions:** Particulate organic matter and dissolved inorganic nutrients should be both considered, as well as the size range of particles, when selecting a farm site.

- **Ability to provide both efficient and continuous bio-mitigation:** Use species that are capable of growing to a significant biomass. This feature is important if the organisms are to act as a bio-filter that captures many of the excess nutrients and that can be harvested from the water. The other alternative is to have a species with a very high value, in which case lesser volumes can be grown. However, with the latter, the bio-mitigating role is reduced.

- **Market demand for the species and pricing as raw material or for their derived products:** Use species that have an established or perceived market value. Farmers must be able to sell the alternative species in order to increase their economic input. Therefore, they should establish buyers in markets before investing too heavily.

- **Commercialisation potential:** Use species, for which regulators and policy makers will facilitate the exploration of new markets, not impose new regulatory impediments to commercialisation.

- Contribution to improved environmental performance.

- Compatibility with a variety of social and political issues.

Benefits

In an experimental system in China extractive organisms - plants and shellfish - remove the excess nutrients from the water that is circulated between the fish rearing compartment of the pond and the water treatment unit. In Hungary the effluent of an intensive African catfish production system is efficiently treated on a constructed wetland where filter feeding fish species and plants are used for nutrient removal. Results of the experiments are being transferred to the practice.

- **Effluent bio-mitigation:** Mitigation of effluents through the use of bio-filters which are suited to the ecological niche of the aquaculture site. This can solve a number of the environmental challenges posed by monoculture aquaculture.

- **Increased profits through diversification:** Increased overall economic value of an operation from the commercial by-products that are cultivated and sold. The complexity of any bio-filtration comes at a significant financial cost. To make environmentally friendly aquaculture competitive, it is necessary to raise its revenues. By exploiting the extractive capacities of co-cultured lower trophic level taxa, the farm can obtain added products that can outweigh the added costs involved in constructing and operating an IMTA farm. The waste nutrients are considered in integrated aquaculture not a burden but a resource, for the auxiliary culture of bio-filters.

- **Improving local economy:** Economic growth through employment (both direct and indirect) and product processing and distribution.

- **Form of 'natural' crop insurance:** Product diversification may offer financial protection and decrease economic risks when price fluctuations occur, or if one of the crops is lost to disease or inclement weather.

- **Disease control:** Prevention or reduction of disease among farmed fish can be provided by certain seaweeds due to their antibacterial activity against fish pathogenic bacteria.

- **Increased profits through obtaining premium prices:** Potential for differentiation of the IMTA products through eco-labelling or organic certification programmes.

Challenges

Integrated aquaculture is not without challenges. These include:

- **Higher investment:** Integrated farming in open sea requires a higher level of technological and engineering sophistication and up-front investment.

- **Difficulty in coordination:** If practised by means of different operators (e.g. independent fish farmers and mussel farmers) working in concert, it would require close collaboration and coordination of management and production activities.

- I**ncrease requirement of farming area:** While aquaculture has the potential to reduce pressure on fish resources and IMTA has specific potential benefits for the enterprises and the environment, fish farming competes with other users for the scarce coastal and marine habitats. Stakeholder conflicts are common and range from concerns about pollution and impacts on wild fish populations to site allocation and local priorities. The challenges for expanding IMTA practice are therefore significant although it can offer a mitigation opportunity to those areas where mariculture has a poor public image and competes for space with other activities.

- **Difficulty in implementation without open water leasing policies:** Few countries have national aquaculture plans or well developed integrated management of coastal zones. This means that decisions on site selection, licensing and regulation are often ad hoc and highly subject to political pressures and local priorities. Moreover, as congestion in the coastal zone increases, many mariculture sites are threatened by urban and industrial pollution and accidental damage.

Prospects

There is tremendous opportunity to use marine macroalgae as bio-filters, process and produce products of commercial value. Globally, most open-water seaweed monoculture has taken place in Asia, South America, South Africa and East Africa. In 2013, 26.9 million tonnes (wet weight) of aquatic plants from aquaculture was harvested worldwide, while capture production was only 1.3 million tonnes, with China and Indonesia accounting for the major share in production. Instead of monoculture, a fraction of the seaweed aquaculture practice can be integrated with fed-aquaculture as bio-filters. This approach may generate a heightened commercial interest once high value seaweeds species can be cultured as biofilters that produce novel human food products. Aquatic plants and algae may offer similar opportunities in freshwater environments.

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Pre-pupae (larvae) of black soldier fly-a potential alternate protein source for aquaculture feeds

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Black soldier fly, Hermetia illucens, National Arboretum, Washington, D.C.

Feed represents a large proportion of expenditure in fish farming and current farming practices mean that the main limiting factor in terms of feed is the use of fish meal and fish oil (Tacon and Metian, 2008). Fish meal is a major source of protein used in the formulation of feed for different fish species to increase feed efficiency and growth, as it helps to enhance feed palatability; nutrient uptake, digestion and absorption. The balanced amino acid composition of fish meal complements other animal and vegetable proteins to provide synergistic effects that promote faster growth (Mile and Chapman, 2006). Fishmeal has low fibre content and is also a valuable source of vitamins B1, B2, B6 and B12, in addition to calcium, phosphorous, magnesium, potassium, trace elements, attractants and fatty acids (Sheen et al., 2014; Dawood et al., 2015).

Approximately 20 million tonnes of the total marine catches go into the production of fish meal (Natale et al., 2013), equivalent to 36% of the total wild capture fishery production. However, total output from capture fisheries have not increased since the1980s (FAO, 2006) leading to unstable supply, higher demand and increasing cost of fish meal, suggesting that the current practice of using fish meal and fish oil in aquaculture is environmentally and economically unsustainable.

Aquaculture production in developing countries is expected to be the worst impacted (El-Sayed, 1999, Tacon et al., 2009, Welch et al., 2010). The majority of finfish aquaculture production currently revolves around omnivorous and carnivorous species such as carp and other cyprinids (Welch et al., 2010). Hence, current fish farming practices involving the use of fish meal must be optimised if the sector is to continue its rate of growth.

Optimisation of fish meal and fish oil use may be achieved through the use of alternative sources of protein (Hardy, 2010; FAO, 2014) which are cost effective and rich in protein (Lim et al., 2011). As a whole, plant and animal derived sources of protein have shown good ability to replace portions of fish meal in the diets. However, the accessibility of these protein sources is limited in developing countries in which a large proportion of aquaculture production is occurring, since most fish meal alternatives are incorporated into human consumption (Sathe, 1968).

Studies have shown that there is potential for insect meals to be incorporated into aquaculture diets, reducing the reliance on fish meal (Kroeckel et al., 2012). Insect meals have also been shown to allow for enriching through dietary intake, possibly for enrichment of polyunsaturated fatty acid levels. Insects form a natural food source for some aquatic animals. This and the presence of chitinase in them makes insect meal a logical alternative to fish meal. Of particular interest has been the use of black soldier fly larvae in fish diets.

The black soldier fly

The black soldier fly (*Hermetia illucens* Linnaeus 1758) is a member of the Stratiomyidae family. The adult fly is wasp-like and 15-20 mm long (Hardouin et al., 2003). Primarily black, the female’s abdomen is reddish at the apex and has two translucent spots on the second abdominal segment. The male’s abdomen is somewhat bronze in color.

H. illucens is native to the tropical, sub-tropical and warm temperate zones of America, but during World War II they spread into Europe, Asia, including India, and even to Australia. The development of international transportation since the 1940s has resulted in its naturalisation in many regions of the world (Leclercq, 1997). It is now widespread in tropical and warmer temperate regions (Diener et al., 2011), breeding in compost, manure and outdoor toilets. The flies can be seen in bright sunlit areas, resting on nearby structures or vegetation.

They are generally considered a beneficial insect and non-pests. The adult fly does not have mouthparts and doesn’t even feed during its short lifespan. They do not bite or sting, feed only as larvae, and are not associated with disease transmission. Black solider flies make breeding areas of houseflies less desirable. The fly is often associated with the outdoors and livestock, usually being found around decaying organic matter such as animal waste or plant material. Adult flies are easily distinguished by their long antennae (Gennard, 2012). Black soldier flies are an extremely resistant species capable of dealing with demanding environmental conditions, such as drought, food shortage or oxygen deficiency (Diener et al., 2011).

Life cycle

The duration of the life cycle ranges between several weeks to several months, depending on ambient temperature, and the quality and quantity of the diet (Veldkamp et al., 2012). In natural areas, black solider flies lay their eggs on moist organic material while in urbanised areas the BSF lays eggs in dumpsters or compost, which provide similar odors and nutritional needs to naturally occurring organic matter (Diclaro and Kaufman, 2009). Mating usually occurs two days after adult emergence from the pupal case. The male fly intercepts a passing female in mid-air and they descend in copula. Soon afterwards females begin to deposit egg masses near the edges of decaying organic matter. Male flies utilize lekking sites (gathering of males for competitive mating display), where they await female flies (Tomberlin and Sheppard, 2003).

The lifecycle of the black solider fly begin with about 500 eggs laid in a cluster that hatch within four days to three weeks (Mullen and Durden, 2002). About 1 mm long, the elongate-oval egg is pale yellow or cream colored when newly laid, but darkens with time. When newly hatched, the larvae are creamy white and about 1.8 mm long, slightly flattened, with a tiny, yellowish to black head. The skin is tough and leathery. Under optimal conditions, larvae take two weeks to reach the pre-pupal stage, but this period can increase to five months if food is limited (Furman et al., 1959; Myers et al., 2008; Gennard, 2012). On reaching the pre-pupal stage, the larva empties its digestive tract and stops feeding and moving (Hardouin et al., 2003).

Mature larvae are flattened and have a reddish-brown, elongated and slightly flattened body (Mullen and Durden, 2002). They can reach 27 mm in length, 6 mm in width and weigh up to 220 mg in the last larval stage. The larvae can feed quickly, consuming from 25 to 500 mg of fresh matter per day, on a wide range of decaying organic materials, such as rotting fruits and vegetables, coffee bean pulp, distillers’ grains, fish offal, corpses (used for forensic purposes) and animal manure (van Huis et al., 2013; Diener et al., 2011; Hardouin et al., 2003). Gayatri and Madhuri (2013) observed the fly hovering on a compost bin containing vegetable kitchen waste including stalks and peels of vegetables, eggshells, raw and processed leftover vegetarian as well as non-vegetarian food. The flies were observed on the upper strata of the bin and their larvae were found buried in the middle layers of the compost. The pre-pupae then migrate in search of a dry and protected pupation site (Diener et al., 2011).

The lifespan of an adult fly is about eight days (Mullen and Durden, 2002; Hardouin et al., 2003). These adults spend their short lifespan finding a mate and laying eggs (Mullen and Durden, 2002). The females mate two days after emerging and oviposit into dry cracks and crevices adjacent to a feed source (Diener et al., 2011). The adults do not feed and rely on the fats stored from the larval stage (Diclaro and Kaufman, 2009).The life-history traits of adults differ (Liu et al., 2008), depending on the quantity and quality of the food supplied to them as larvae (Tomberlin et al., 2002).The development of the ovaries and number of ovarioles in insects is genetically determined in most species. Nevertheless, the

Table 1. Mineral and amino acid composition of BSF larvae.

Mineral	Mean value	Amino acid	Mean protein
Calcium	75.6 g/kg	Alanine	7.7%
Phosphorus	9.0 g/kg	Arginine	5.6%
Potassium	6.9 g/kg	Aspartic acid	11.0%
Sodium	1.3 g/kg	Cysteine	0.1 %
Magnesium	3.9 g/kg	Glutamic acid	10.9 %
Iron	1.37 g/kg	Glycine	5.7 %
Manganese	246 mg/kg	Histidine	3.0 %
Zinc	108 mg/kg	Isoleucine	5.1 %
Copper	6 mg/kg	Leucine	7.9 %
		Lysine	6.6 %
		Methionine	2.1 %
		Phenylalanine	5.2 %
		Proline	6.6 %
		Serine	3.1 %
		Threonine	3.7 %
		Tryptophan	0.5 %
		Tyrosine	6.9 %
		Valine	8.2 %

Source: Arango Gutierrez et al., 2004; Newton et al., 1977; Sealey et al., 2011; St-Hilaire et al., 2007a.

number of ovarioles and their size can also vary depending on the quantity and quality of food consumed and stored during their life cycle (Magnarelli et al., 1982; Engelman, 1984).

Larva as bio-converter

Rearing *H. illucens* has been proposed as an efficient way to dispose of organic wastes, by converting them into a protein- and fat-rich biomass suitable for various purposes, including animal feeding for all livestock species, biodiesel and chitin production (van Huis et al., 2013; Diener et al., 2011; Li et al., 2011). They have been used to reduce animal manure in commercial swine and poultry facilities in western countries, but in India the practice is not common. Black soldier fly larvae can convert around 58% of the dry matter within an organic source into high quality animal feedstuff (Sheppard et al. 1994). There is a good opportunity to utilise these flies for bioconversion considering the fact that approximately 1.3 billion tonnes of food is wasted from the food produced each year (Gustavsson et al., 2011). The larvae work on organic waste material faster than worms used in vermicomposting. A colony of 2,000 larvae can consume about a kg of house hold food waste per day. They have large and powerful chewing mouthparts and hence are able to consume organic compounds before they have time to decompose, thereby immediately eliminating odor. Additionally, the larvae modify the microflora of manure, potentially reducing harmful bacteria such as *Escherichia coli* 0157:H7 and *Salmonella enterica* (van Huis et al., 2013). It has been reported that the larvae contain natural antibiotics (Newton et al., 2008). In addition to the larvae, the residue or castings which are obtained during larval rearing under controlled conditions can be used for soil amendment.

Rearing of the fly and larvae

Several methods have been designed for rearing black solider flies on substrates such as pig manure (Newton et al., 2005), poultry manure (Sheppard et al., 1994), and food wastes (Barry, 2004). The migrating behavior of the prepupae is used for self-collection (Diener et al., 2011). Optimal conditions for larval rearing include a narrow range of temperature (29-31°C) and humidity (between 50 and 70%), as well as a range of suitable levels of texture, viscosity, and moisture content of the diet. It is also necessary to maintain a year-round breeding adult colony in a greenhouse with access to full natural light. The greenhouse must be a minimum of 66 m3 to allow for the aerial mating process (Barry, 2004). Optimal temperatures for mating and ovipositing range between 24-40°C and 27.5-37.5°C, respectively (Sheppard et al., 2002). Wide ranges of relative humidity are tolerated: e.g. 30-90% (Sheppard et al., 2002) and 50-90% (Barry, 2004). The greenhouse would need a container with a very attractive, moist medium to attract egg-laying female adults (Barry, 2004).

Gayatri and Madhuri (2013) opined that rearing of black soldier flies is easier in India as larvae flourish more in a tropical environment than in a colder one. Larvae have been found in poultry houses in Punjab (Ashuma et al., 2007). For the first time in India, Freshrooms Lifesciences, Cuddalore, Tamilnadu, claims to have developed climate controlled artificial medium for rearing black soldier fly larae on large scale (http:// freshroomslifesciences.com/).

Nutritional composition of larvae

The larva is odorless and dry, and can still be easily dried for longer storage and friability. It can be fed to pets, fish and even earthworms and red worms (Leclercq, 1997; Veldkamp et al., 2012). Nutrient analysis revealed that freshly harvested pre-pupae contain 55-65% of moisture, a good amount of crude protein (40-44% dry matter), lipid rich in omega 3 and omega 6 fatty acids and crude fiber (7%) among other nutrients. The high dry matter content of larvae (35-45%) makes them easier and less costly to dehydrate than other fresh by-products (Newton et al., 2008).

The amount of fat is extremely variable and depends on the type of diet and on its fat content: Reported values are 15-25% of dry matter (larvae fed on poultry manure, Arango Gutierrez et al., 2004), 28% (swine manure, Newton et al., 2005), 35% (cattle manure, Newton et al., 1977), and 42-49% (oil-rich food waste, Barry, 2004).

Ash content varies from 11 to 28% of dry matter. The larvae are rich in calcium (5-8% dry matter) and phosphorus (0.6-1.5%) (Newton et al., 1977; St-Hilaire et al., 2007a; Arango Gutierrez et al., 2004; Yu et al., 2009). Many experts believe that the high calcium content of the larvae may halt or reverse the effects of metabolic bone disease. The amino acid profile is particularly rich in lysine (6-8% of the protein). Methionine, an essential amino acid is also found in the larvae (fresh-roomslifesciences.com).The fatty acid composition of the larvae depends on the fatty acid composition of the diet. The lipids of larvae fed cow manure contained 21% lauric acid, 16% palmitic acid, 32% oleic acid and 0.2% omega-3 fatty acids, while their proportions were 43%, 11%, 12% and 3%, respectively, in larvae fed 50% fish offal and 50% cow manure. Total lipid content also increased from 21% to

30% dry matter in the latter. Of the 30% lipid, 3% constituted polyunsaturated fatty acids (St-Hilaire et al., 2007a).This was in contrast to larvae reared on cow manure which had 21% total lipids with negligible amounts of long-chain unsaturated fatty acids (Sheppard et al., 1994).

Feeding trials with fish

Studies have shown that black soldier fly larval meal can replace a large proportion of the fish meal used in rainbow trout *(Oncorhynchus mykiss)* diets (St-Hilaire et al., 2007b; Sealey et al., 2011, Kroeckel et al., 2012). Dried ground pre-pupae reared on dairy cattle manure enriched with 25 to 50% trout offal replaced up to 50% of fish meal in trout diets for 8 weeks without significantly affecting fish growth or the sensory quality of trout fillets (Sealey et al., 2011). In a nine-week study, replacing 25% of the fish meal component of rainbow trout diets with pre-pupae meal, reared on pig manure, did not affect weight gain and feed conversion ratio (St-Hilaire et al., 2007a).

Chopped larvae grown on poultry manure fed to channel catfish *(Ictalurus punctatus)* alone or in combination with commercial diets resulted in a similar growth performance as the control diet. Aroma and textures of channel catfish fed larvae were acceptable to the consumer (Bondariand Sheppard, 1981). However, in a later study, replacement of 10% fish meal with 10% dried larvae resulted in slower growth of sub-adult channel catfish grown in cages over a 15-week period. However, the substitution did not reduce growth significantly when channel catfish were grown in culture tanks. Feeding 100% larvae did not provide enough dry matter or protein intake for channel catfish grown in tanks to allow sufficient growth. A comparison between menhaden fish meal and black soldier fly larval meal showed that the latter could be advantageous as a replacement for fish meal (Newton et al., 2005). A study wherein chopped larvae grown on poultry manure were fed to blue tilapia *(Oreochromis aureus)* either alone or in combination with commercial diets showed similar results as the control diets. Juvenile turbot *(Psetta maxima)* accepted diets containing 33% de-fatted larval meal without significant effects on feed intake and feed conversion. However, specific growth was reduced. Higher rates reduced intake and nutrient availability, with a further reduction in growth rate, possibly because of the presence of chitin (Kroeckel et al., 2012). Black soldier fly larval meal, reared on dried distillers' grains when fed to prawns *(Macrobrachium rosenbergii)*, resulted in a similar performance as regular prawn feed. The prawns fed larval meal were of a lighter colour (Tiu, 2012). Further studies are proposed to utilise this in the feeds for other cultivable fishes in larval, grow-out and brood-stock rearing.

Conclusion

The ability of black soldier fly larvae to convert low value organic waste products into a high value feedstuff accessible not only to carps, but also to carnivorous fish may limit the need for fish meal and fish oil in the aquaculture industry.

Larvae and pre-pupae of Hermetia illucens.

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Penaeid shrimp and giant prawn seed collection from Rupnarayan River in Purba Medinipur, West Bengal, India

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Operating a net.

River Rupnarayan

The Rupnarayan River has its origin near Ghatal town in Paschim Medinipur District of West Bengal, where the Dwarakeswar River is joined by the Shilabati. The Rupnarayan joins the Hooghly River at Geonkhali in Purba Medinipur District after completing a 78-80 km course. The Rupnarayan is famous for the highly-priced hilsa *Tenualosa ilisha*; adults move upstream for spawning and are caught by fishermen in stationary gill nets at Kolaghat and other places. The Rupnarayan River forms the eastern boundary of Purba Medinipur with Howrah, flows along this region down to Bay of Bengal. Being a part of Hooghly estuary, the lower reaches of this river are affected by semi-diurnal tides from the Bay of Bengal. The tidal range is about 2.8 metres at Kolaghat. At this place, average water velocities of the river in mid-tide and full-tide are 1.75 and 1.63 ms^{-1} respectively. In most areas of Purba Medinipur District, the impact of the tides is felt in inland low lying areas[1]. Kolaghat station in the Rupnarayan River is located at a distance of 135 km from the sea. Almost every year, the river inundates its two banks during the peak of the rainy season in July-September.

Shrimp seed collection methods from inundated river bank

The practice of collecting penaeid shrimp seed (post-larvae and juvenile) and prawn seed (*Macrobrachium* sp.), the latter to a much lesser extent, from inundated agricultural fields comprising small individual plots located on western bank of the Rupnarayan river at Kharui, Gujarkharui, Gobra and Jamitta villages has become a supplementary source of income for local agricultural communities. From the month of June-July to August-September every year, the river floods during the spring tide supported by monsoon downpour and the extended open tract of unsown paddy plots. This occurs in a zone covering a 2.5-3 km stretch on the Kolaghat-Tamluk

Women catching shrimp postlarvae and juveniles.

roadway, which acts as a river bundh, and 400-700 m across towards the river on its western bank, which is inundated during full moon and new moon.

The water remains stagnant for 3-4 consecutive days twice a month at 45 – 105 cm depth. Innumerable numbers of penaeid shrimp *Metapenaeus monoceros* and *Metapenaeus brevicornis* post-larvae (PL) and juveniles of 1.9-6.3 cm in length and also of riverine prawn (*Macrobrachium* sp.) post-larvae of 5-6.3 cm length enter into these tracts, which offer an opportunity for local farmers and common inhabitants to exploit them.

During the period of June-July till mid of August, 3-4 persons (both elderly males and females of farming households) in each of the plots, which range from 325-1010 m^2 in area and are demarcated by wild grass-laden embankments 1 metre high, enthusiastically capture these young shrimp and prawns.

Indigenous triangular bamboo-built nets, locally termed “kolee jaal” are used, having a frame of 2-2.50 m on three sides (arm length) fitted with blue nylon mosquito netting cloth (6mm mesh size). Shrimp seed collectors in the aforementioned villages operate it first by pushing the net in front through a water column of water-logged fields a few times and then scooping it from the water to catch the seed, which are stored temporarily. Circular scoop nets (ring nets without handles) 90cm in diameter are also used in the shallow water column.

Shrimp juveniles caught in mughri

As water table recedes, *M. monoceros* and *M. brevicornis* PL and juvenile (locally called ‘honney chingree’, ‘nona chingree’ and ‘thora chingree’) become confined within embankments in each plot. As the water level drops from mid-August till the end of September, these are caught only in stationary triangular V-shaped box traps, which have white nylon mosquito net material called “mughri” placed at specific locations (at water channels) against the water current on submerged to semi-submerged embankments. During this time, paddy seedlings are sown in these plots and the shrimp attain 5-7.5 cm in length. The open end of mughri having the V-shaped inlet faces towards paddy plots. It is 60-75cm in length, cost Rs 80/- each, and have been built locally based on indigenous traditional knowledge. Nylon mosquito netting is tightly wrapped over split bamboo main frame to make the trap. In each of such mughri, 250-500 g of shrimp seeds are typically caught each night.

Shrimp and prawn seeds available in these areas, in the aforesaid time period, contribute considerably to satisfy the food requirements of local people and also generate additional income. Small finfishes like Glossogobius giuris, Pseudapocryptes lanceolatus, Xenentodon cancila, *Chanda* sp., *Chela* sp., Mystus vittatus are also caught in mughri, although very less in number. Amongst those caught, mostly shrimp seeds are abundant with much lesser numbers of prawn PL and sub-adult (non-penaeid; *Macrobrachium* sp., locally called ‘bhodrokee chingree’). Shrimp seeds are collected @ 1.5-2.2 kg / hour / person in triangular nets on the

Above: Juvenile Macrobrachium sp. caught in mughri. Below: Post larvae and juveniles.

first two days of spring tide when these abundantly occur. The dying and dead shrimp and prawn PL and sub-adults are sold in fresh condition at Kolaghat, Kaktia and Tamluk retail fish markets at Rs 150-200/- per kg.

Extensive culture of *M. monoceros* and *M. brevicornis* in extended tracts

Extensive culture of these marine shrimps in vast agricultural tracts (Bheri) is practiced at Dariara, Saira, Alinan, Mathuri, Siuri and Deemari villages in Sahid Matangini Block in Purba Medinipur; these villages are near to Tamluk town in Tamluk subdivision, which is the district headquarters of Purba Medinipur. Resource-rich persons and professional fishermen take each of such tracts on lease by paying around Rs 1,80,000/- per year for the 107,000-194,000 m^2 plots and around Rs 4,00,000/- for the 324,000-344,000 m^2 plots. Fields are ploughed/raked and thereafter paddy seedlings are sown. The earth remains soft, which encourages growth of wild shrimp seeds.

During April and till the end of July, at times of high tide, the Rupnarayan River water is let into these tracts via shallow water channels/canals (having provision of iron sluice gates), 4-6m in width, covering a distance of 1-3 km. Shrimp PL 12-15mm in length enter into these tracts along with tidal water and water remains stagnant at 90-105 cm depth. After 40-45 days, these attain 10-12 cm size. The 1.8-7.5 cm sized shrimp PL, caught from inundated small fields on the river bank, are also bought and stocked in these fields in addition to those who had entry via tidal water and these attain marketable size in next 25-28 days. They are caught during July-August until the end of September. From mid of October, fields begin to dry up.

Harvest of grown-up shrimps

The mughri used to catch these grown-up market-sized shrimps are more sturdy, devoid of nylon net material, and cost Rs 200-220/- for a standard size 100 x 50 cm^2. Three-fourths of its height remains submerged in water. Split bamboo strip screens previously woven are fitted over some transversely fixed bamboo pieces to construct the trap. It is set in water channels/canals flowing towards the vast tracts from Rupnarayan River. Near the sluice gate, a barricade made of knitted split bamboo screens (similar to a part of pen framework) is used to direct the grown-up shrimps towards open end of trap. During high tide, river water is pushed and impounded into paddy fields/tracts through the canals. Water flows back to the river during low tide. Market-sized shrimps moving along with receding water are caught in the mughri. These traps are placed in canals before high tide sets in and are taken up/harvested after the water has receded from the submerged field to reach its lowest level. Adult and market-able sized *M. monoceros* and *M. brevicornis* are sold in retail market at Rs 400-450 / kg.

Shrimp seed caught from river bank in non-stationary triangular nets and small circular nets and kept alive in hundi and in hapa cloth enclosures (constructed at one end of

Rupnaraya River.

Mughri trap with nylon net.

inundated fields) are transported and sold to prawn farmers and resource-rich farmers in nearby and distant villages at Rs 700-800/- per kg during May to June-July and Rs 250-300/- per kg (400-450 pieces / kg) during July-August and August-September (Rs 0.75 – Rs 1.00 per piece) for stocking in medium-sized to large ponds in this district and in the afore-mentioned inland low-lying vast agricultural tracts around 106,000-334,000 m^2 in area. Post-larvae of the shrimps *M. monoceros* and *M. brevicornis* obtained from Rupnarayan River grow well in large freshwater ponds along with *M. rosenbergii* and in tidal water-fed vast tracts, where exclusively shrimps are allowed to grow. During March-April, many freshwater prawn farmers in Purba Medinipur procures seeds of *Macrobrachium rosenbergii* (5-8 mm; paddy grain size) and *Penaeus monodon* (PL-15; 14-15mm size) from riverine prawn/shrimp seed collectors; these are available in Rupnarayan during March to July. Each seed of *M. rosenbergii* and *P. monodo*n costs Rs. 2.00-2.50 and 40-50 paisa respectively. Riverine *P. monodon* seeds are raised to marketable size in association with *M. rosenbergii* in freshwater ponds[2].

Occurrence of shrimp seeds in riverine freshwaters

Innumerable numbers of penaeid shrimp *M. monoceros* and *M. brevicornis* PL and juvenile 1.8-5cm size occur in river Rupnarayan during monsoon months. In support to this fact, these two species have been reported to utilise the Feni River estuary as nursery grounds. Feni River is a major river of Bangladesh that flows to the Bay of Bengal. These two are the monsoon season species; juveniles were fairly abundant or nearly so in the estuary when it became freshwater. In April, the juveniles suddenly occurred in abundance in the freshwater zone. During the peak of the monsoon season, they occupied the entire estuary. Juveniles of *M. monoceros* and *M. brevicornis* about 30 mm apparently require freshwater for nursing[3]. In West Bengal conditions, *M. monoceros* and *M. brevicornis* seeds attain marketable size of 100-130mm and 80-100mm respectively in five months in brackishwater ponds[4].

Giant prawn seed collection from the Rupnarayan River

Seeds of the giant prawn *Macrobrachium rosenbergii* (7-10mm; paddy grain size) are collected during beginning of April until the end of August every year from Rupnarayan River on its Purba Medinipur side, mainly by women in Gujarkharui village of Sahid Matangini Block, a distance of 5 km from Kolaghat proper on Kolaghat-Tamluk Road. Seed are collected from shallow riverine water along muddy bank at waist height to chest height depth during night hours 10.00pm-2.00am at ebb tide. Indigenous triangular bamboo-built nets (described earlier), locally termed “kolee jaal” and having fine mesh, are used to capture the tender stages of giant prawn. In one night, in April, a woman will be able to capture 12-20 pieces after pushing the net through water column in every 50 m distance single time. From June-July, she will capture at least 50 pieces from every 50 m distance and will be able to earn Rs 75/- by selling these to giant prawn grow-out farmers in Purba Medinipur (@ Rs 1.50/- per piece). In one hour, every woman captures 250-300 pieces of *M. rosenbergii* seed from every 50 m distance moving to and fro many times. About three women work in every 200 m zone in the night hours.

During the peak period of seed availability (until mid-August), a woman can capture 1,300 pieces by operating the net for two hours continually every night along the river bank; a few women may individually capture even 2,500 pieces in a three hour period. But when availability is greater the price of seeds falls to Re 0.40-0.50/- per piece. Elderly males, though lesser in number, also participate in giant prawn seed collection. During April-June (i.e., at the beginning of the season), these are sold @ Rs 2.00/- per piece. In June-July, *M. rosenbergii* seeds are stocked in freshwater ponds and in monoculture system (with provision of commercial formulated pelleted feed), these attain 200-250 g body weight in next 6-7 months and are harvested in January-February of the following year.

Women collect giant prawn seeds from nets and safely keep them in aluminium hundi. After returning back home (with the Hundi on head for 20-30 mins), during midnight hours, these are transferred to a white porcelain dish, counted with help of a table spoon and sold to prawn seed traders during dawn hours. Before carrying, traders sprinkle salt in the container of *M. rosenbergii* seeds. In a 2-3 month period every year, woman working as giant prawn seed collectors in this village earn Rs 7000-10,000/-. A woman in one night can earn a maximum of Rs 600/- by selling *M. rosenbergii* seeds. After high tide had set in, river water becomes calm, M. rosenbergii seeds aggregate in shallow region along banks. This income-generating activity helps local women to supplement and contribute to their family income to a considerable extent.

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Operating a triangular net.

NACA Newsletter

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First training course on culture-based fisheries held in Nha Trang, Vietnam

Participants and trainers, Nha Trang University, Vietnam.

There are many initiatives underway which are designed to increase food supply, employment and income opportunities in developing countries, most of which require considerable capital inputs. Often overlooked, are the opportunities to produce more food from the natural productivity of local ecosystems. Culture-based fisheries (CBF) are one example of a relatively simple and low cost technology that can deliver nutritional and economic benefits to rural communities, which often have few livelihood options.

The first ever Regional Training Course on Culture-based Fisheries in Inland Waters was held at Nha Trang University from 30 October to 8 November. The objective of the course was to provide participants with the skills to assist local communities to plan and manage culture-based fisheries. The course included training on:

- Current practices and relevance.
- Evaluation of water bodies for CBF.
- Establishing a management system, legal and policy framework.
- Community consultation.
- Gender mainstreaming.
- Entrepreneurship development.
- Risks and risk management.
- Stocking practices & stock assessment.
- Harvesting and marketing strategies.

The course included practical sessions and simulations on many of these aspects, and participants also provided briefings on culture-based fisheries practices in their own countries.

Video recordings of the lectures will be available for viewing and download from the NACA website in due course.

We had an unusually broad range of participants, even for a NACA event, with 41 trainees from throughout Africa (Liberia, Namibia, Nigeria, Uganda, Zambia), Asia (Bangladesh, Cambodia, China, India, Indonesia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam) and Australia, including many local and international students from Nha Trang University. Questions, feedback and input from the participants was exceptional, and our expert speakers certainly learned a thing or two from their students!

An unexpected feature of the course was a tropical storm that, having done substantial damage over the Philippines, intensified to a category 1 typhoon before making landfall in Nha Trang. The city was shut down to prepare for the storm, which arrived in the early hours of 5 November and we spent most of the day waiting for the winds to abate. Sadly, there were quite a few casualities for which NACA wishes to offer condolences. However, despite widespread damage and power outages the course resumed the following day and we were able to complete all planned sessions thanks to Dr Hung and his team.

The course was made possible thanks to the generous financial support of the **United Nations University Fisheries Training Programme** (UNU-FTP), which co-organised the course in partnership with NACA and Nha Trang University (NTU).

NACA wishes to express our sincere thanks to the United Nations University Fisheries Training Programme for its vision and exceptional support in making the course possible and for supporting the participation of trainees from throughout Asia and Africa.

NACA would also like to thank the Fisheries Research and Development Corporation of Australia for supporting the participation of two indigenous trainees: Mr Jerry Stephen, Member for Ugur and the Fisheries Portfolio of the Torres Strait Regional Authority (TSRA); and Mr Charles David, Senior Project Officer of TSRA.

We would also like to express our sincere gratitude to Prof. Pham Quoc Hung, his students, the staff of Nha Trang University and the Vietnamese Government. Organising an international training course is not easy at the best of times, but to do so while recovering from a public emergency is a truly exceptional effort that we will not forget. Thank you!

GAF7: Gender in Aquaculture and Fisheries – Expanding the Horizons

The 7th Global Conference on Gender in Aquaculture and Fisheries (GAF7) will be held from 18-20 October 2018, at the Asian Institute of Technology, Pathum Thani, Thailand.

GAF 2018 invites participants to learn about and share the latest trends and knowledge on gender in aquaculture and fisheries to become more aware of opportunities and approaches to achieving greater gender equality.

The journey of the GAF network over 20 years has been slow but steady and has partnered with the Asian Fisheries Society's Triennial Forum throughout its evolution. Today the GAF is a formal Section of the Society and is expanding its horizons, starting with its first independent event.

Through the long journey bringing gender to the fore and including it in the general discourse in fisheries, new insights have been gained. However, challenges continue – some as old as the debate itself and some relatively new and emerging in the face of sector dynamics. Real change can come only with new commitment to equality principles, strong policies translated into sensible and implementable programmes and long term commitment. While a lot of lip service is given to the issues, very little translates into funding for work on the ground. Gender is generally a tail-end component in projects. However, several examples of gender inclusion right from inception are beginning to emerge, and this is a welcome change.

GAF conferences endeavour to explore the expanding horizons of gender dimensions in aquaculture and fisheries, while highlighting the need for expanding gender inclusiveness and equity.

The GAF7 website and a conference brochure are now available. Please submit your abstracts, session and training workshop proposals by 31 March:

http://www.gafconference.org/

3rd International Symposium on Aquaculture and Fisheries Education, 16-18 May 2018, India

The 3rd International Symposium on Aquaculture and Fisheries Education (ISAFE3), a triennial event of the Asian Fisheries Society (AFS), is being organised by the ICAR-Central Institute of Fisheries Education (CIFE), Mumbai, India in collaboration with the Indian Fisheries Association (IFA) and Asian Fisheries Society Indian Branch (AFSIB) at CIFE, Mumbai, India during 16-18 May, 2018. The theme of ISAFE3 is "Fisheries Education for Sustainable Blue Economy".

The AFS, a non-profit Scientific Society, has been promoting networking and co-operation in fisheries and aquaculture sector for higher production, research and development in Asia since 1984. ICAR-CIFE is the only National Fisheries University of India catering to the higher education needs of this sector and producing quality human resources, including researchers, academicians, managers, entrepreneurs and policy makers, since 1961. The symposium is supported by several national and international educational and research institutions.

World aquaculture has witnessed tremendous growth since last 50 years and is also expected to be a potential sector in future for providing quality protein to the ever-increasing human population. Aquaculture in freshwater and marine environments provides about 45% of the total fish production, of which about 60% comes from freshwater aquaculture. It is expected that the dependence on aquaculture sector would grow further in years to come. Besides increasing production and productivity, there have been several other goals posed before the sector, which include ensuring quality and safe produce, environmental sustainability, increasing export, and above all increasing farmers' income. In this endeavour, it is necessary that all the stakeholders associated with the sector are well-informed and sensitised with the latest available knowledge and wisdom. Quality human resource development through formal and informal education, therefore, is of paramount importance for taking the fisheries and aquaculture sector to meet the challenges posed from time to time.

The present symposium will discuss issues highlighted during ISAFE2 at Shanghai Ocean University, Shanghai, China and on-going issues pertaining to the fisheries education in Asia-Pacific region. It is expected that harmonisation of fisheries education across the Asia-Pacific region will enable easy mobility of researchers and students leading to wider job opportunities. This will make the sector attractive for young talent, promote technology and entrepreneurship development. The deliberations during the symposium will provide a direction to fisheries education for "Sustainable Blue Economy".

To register for the conference, view the programme or investigate sponsorship opportunities, please visit the conference website at:

http://isafe3-cife.edu.in/index.asp

International Fishing Industry Safety and Health Conference, 10-13 June, Canada

The National Institute for Occupational Safety and Health in collaboration with the SafetyNet Centre for Occupational Health and Safety Research (Memorial University) and the Food and Agriculture Organization of the United Nations (FAO), will be hosting the 5th International Fishing Industry Safety and Health Conference (IFISH 5) in St. John's, Newfoundland and Labrador, Canada from June 10-13, 2018.

The IFISH 5 Scientific Committee is now inviting participants in developing countries representing Africa, Asia, Pacific and Latin America to submit abstracts on their research and/or experiences with occupational safety in small-scale fisheries, aquaculture, and seafood processing. Travel and other conference-related expenses of eligible applicants with accepted abstracts will be funded from a dedicated fund established by FAO and administered by Memorial University.

The IFISH 5 conference will offer researchers, safety and health professionals, instructors, workers and industry experts, ergonomists, governmental and regulatory representatives, and other professionals the opportunity to attend workshops, presentations, and poster sessions that feature new occupational health and safety research findings and innovations. Keynote speakers will provide an overview of advances in the field and priorities for the future, and they will highlight success stories in research, training, and industry collaboration. In the evenings and between scheduled presentations and workshops, attendees will have a chance to network with organisations and individuals attending the conference.

Key themes for IFISH5 will include topics on safety in commercial fishing as well as occupational health and safety issues related to aquaculture and seafood processing. We anticipate that the agenda will include occupational safety and health studies highlighting collaboration with industry, evaluations of interventions, improvements to protective gear such as personal flotation devices, fisheries management and safety relationships, and the economic impacts of occupational safety and health.

Submission of Abstracts

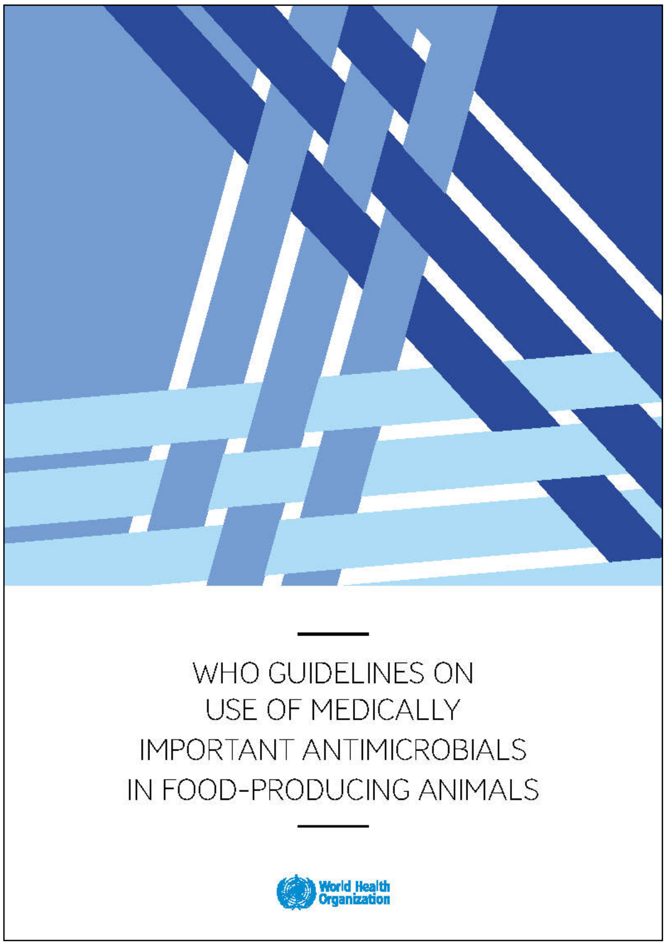
Individuals are invited to submit abstracts for oral presentations and poster formats.

Abstracts can be submitted electronically until 31 January, 2018. Questions about submissions may be addressed by sending an e-mail to ifish@mun.ca.

To register, view the programme or sponsorship opportunities please visit the conference website at:

https://ifishconference.ca/

WHO: Stop using antibiotics in healthy animals to prevent the spread of antibiotic resistance



The World Health Organization (WHO) is recommending that farmers and the food industry stop using antibiotics routinely to promote growth and prevent disease in healthy animals.

The new WHO recommendations aim to help preserve the effectiveness of antibiotics that are important for human medicine by reducing their unnecessary use in animals. In some countries, approximately 80% of total consumption of medically important antibiotics is in the animal sector, largely for growth promotion in healthy animals.

Over-use and misuse of antibiotics in animals and humans is contributing to the rising threat of antibiotic resistance. Some types of bacteria that cause serious infections in humans have already developed resistance to most or all of the available treatments, and there are very few promising options in the research pipeline.

“A lack of effective antibiotics is as serious a security threat as a sudden and deadly disease outbreak,” says Dr Tedros Adhanom Ghebreyesus, Director-General of WHO. “Strong, sustained action across all sectors is vital if we are to turn back the tide of antimicrobial resistance and keep the world safe.”

A systematic review published in The Lancet Planetary Health found that interventions that restrict antibiotic use in food-producing animals reduced antibiotic-resistant bacteria in these animals by up to 39%. This research directly informed the development of WHO’s new guidelines.

WHO strongly recommends an overall reduction in the use of all classes of medically important antibiotics in food-producing animals, including complete restriction of these antibiotics for growth promotion and disease prevention without diagnosis. Healthy animals should only receive antibiotics to prevent disease if it has been diagnosed in other animals in the same flock, herd, or fish population.

Where possible, sick animals should be tested to determine the most effective and prudent antibiotic to treat their specific infection. Antibiotics used in animals should be selected from those WHO has listed as being “least important” to human health, and not from those classified as “highest priority critically important”. These antibiotics are often the last line, or one of limited treatments, available to treat serious bacterial infections in humans.

“Scientific evidence demonstrates that overuse of antibiotics in animals can contribute to the emergence of antibiotic resistance,” says Dr Kazuaki Miyagishima, Director of the Department of Food Safety and Zoonoses at WHO. “The volume of antibiotics used in animals is continuing to increase worldwide, driven by a growing demand for foods of animal origin, often produced through intensive animal husbandry.”

Many countries have already taken action to reduce the use of antibiotics in food-producing animals. For example, since 2006, the European Union has banned the use of antibiotics for growth promotion. Consumers are also driving the demand for meat raised without routine use of antibiotics, with some major food chains adopting “antibiotic-free” policies for their meat supplies.

Alternative options to using antibiotics for disease prevention in animals include improving hygiene, better use of vaccination, and changes in animal housing and husbandry practices.

WHO’s Guidelines on use of medically important antimicrobials in food-producing animals build on decades of expert reports and evaluations of the role of agricultural antibiotic use in the increasing threat of antibiotic resistance. They contribute directly to the aims of the Global action plan on antimicrobial resistance adopted by the World Health Assembly in 2015 and the Declaration of the High-Level Meeting of the United Nations General Assembly on Antimicrobial Resistance, adopted in 2016.

To download the guidelines please visit:

https://enaca.org/?id=932

Register for the 8th International Symposium on Aquatic Animal Health

Organisers of the 8th International Symposium on Aquatic Animal Health (ISAAH) have opened the conference registration and put out a call seeking abstract submissions for oral and poster presentations. The 2018 symposium marks the thirtieth anniversary of the ISAAH, which will be held September 2 – 6, 2018 in Prince Edward Island, Canada. The ISAAH meets every four years and typically attracts 300–400 fish health professionals from around the world.

Delegates attending ISAAH 2018 will be have the opportunity to join other aquatic health professionals from around the world for scientific workshops, business meetings, keynote and research presentations. The theme of this year’s symposium is “Integrating Biotechnology in the Advancement of Aquatic Animal Health”.

Early Bird registration rates are available now, and, as there are limited spaces for registered delegates to attend the pre-conference scientific workshops, organisers encourage participants to sign up as soon as possible.

https://isaah2018.com/

Quarterly Aquatic Animal Disease Report, July-September 2017

The 75th edition of the Quarterly Aquatic Animal Disease Report contains information from 14 governments. The foreword discusses the 10th Symposium on Disease in Asian Aquaculture, and the 11th Technical Group Meeting and election of a new Executive Committee for the Fish Health Society (2018-2020). To download the report please visit:

https://enaca.org/?id=938


2017/2

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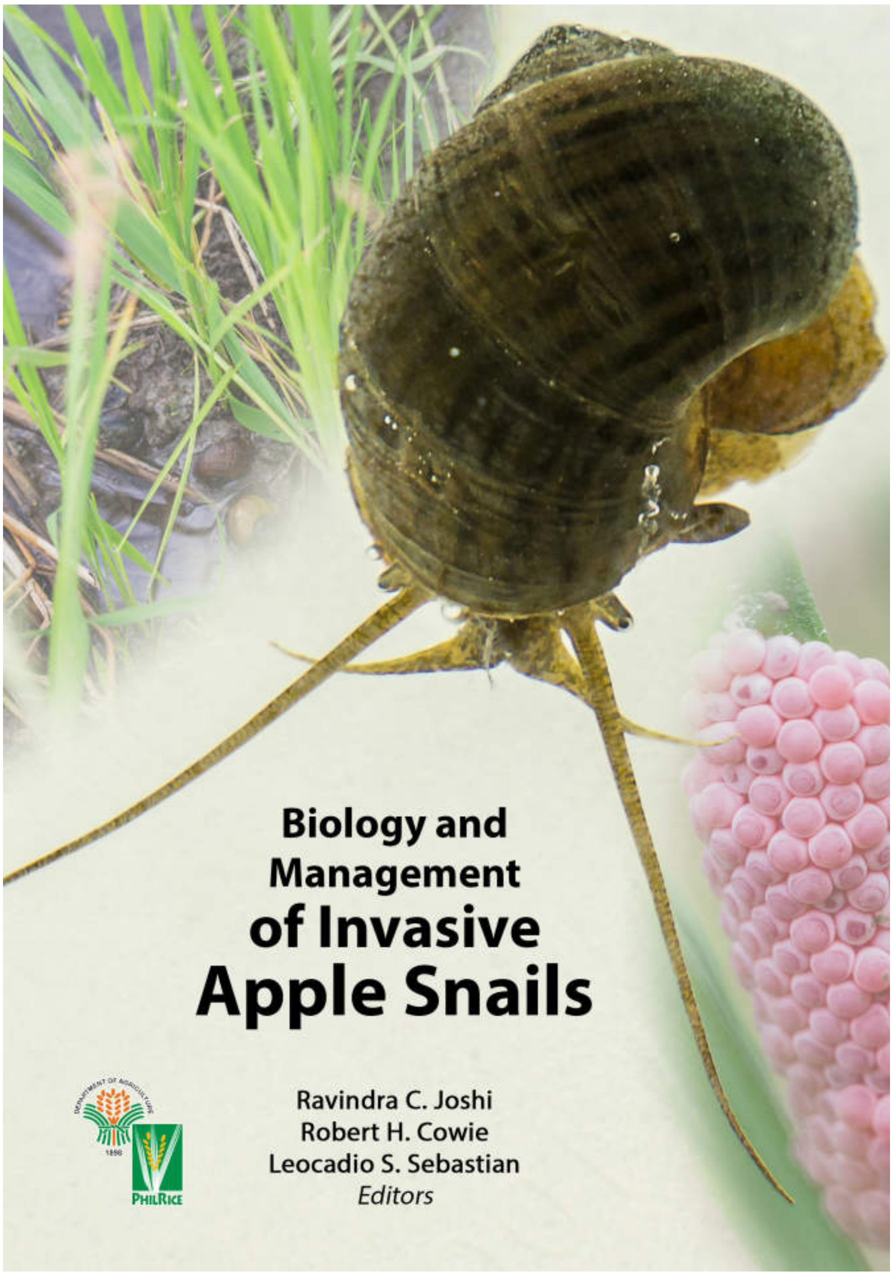
October 2017

Free download: Biology and Management of Invasive Apple Snails

Apple snails, family Ampullariidae, are so called because many species, notably in the genera *Pomacea* and *Pila*, bear large, round shells. *Pomacea* species are native to South and Central America, parts of the Caribbean, and the southeastern USA, while *Pila* species are native to Africa and Asia. In the year 2000, one species of apple snail, *Pomacea canaliculata*, was listed among the world’s 100 most invasive species, largely because it had become a major pest of wetland rice in much of Southeast Asia. However this listing was published at a time when there was still confusion regarding the true identity of the invasive species in Asia; in fact two species are involved, not only *Pomacea*



canaliculata but also *Pomacea maculata*. *Pomacea canaliculata* is native to Argentina and Uruguay, while *P. maculata* is more widely distributed from the La Plata region of Argentina to the Amazon basin of Brasil, including Uruguay and Paraguay, and possibly Bolivia, Ecuador and Peru.

These two species have commonly been referred to as golden apple snails, or GAS, often without clarifying specifcally which species, perhaps both, was involved, or indeed simply assuming it to be *Pomacea canaliculata*. For clarity, this book avoids this ambiguous common name designation, and hopes that others will move forward with the correct species designation for the apple snails with which they work. Only in this way can research results be truly comparative and useful.

One or both of these species of *Pomacea* have become widely established not only in many parts of Southeast Asia but also in Japan, Taiwan Province of China, Guam, Hawaii, Papua New Guinea, the Dominican Republic, Spain and parts of the mainland USA. *Pomacea diffusa* has been introduced to Sri Lanka, and *Pomacea scalaris*, as well as *Pomacea canaliculata*, has been introduced to Taiwan Province of China. An additional unidentifed species has been introduced to the southeastern USA. Most of these introductions are the result of escape or release from aquaculture operations, or happen through the pet trade. In the Philippines alone, estimates of economic losses associated with apple snails ranged from US$425 million to US$1.2 billion in 1990.

Pomacea species are also important transmitters of *Angiostrongylus cantonensis*, the rat lungworm, which has had major human health consequences, most notably in southern China, where the snails are eaten raw as a delicacy.

There is therefore a clear need to control the proliferation and spread of these pests in ecologically and economically sustainable ways. This requires research on control and management measures, but also a clear understanding of the identities and basic biology of the species involved.

In 2006, a previous book, Global Advances in the Ecology and Management of Golden Apple Snails (edited by R. C. Joshi and L. S. Sebastian), documented progress in this arena. However, in the decade since publication of that landmark book, research on apple snails has burgeoned and the identities of the species involved has been clarifed.

The present book reinterprets old problems and presents much of this new knowledge, with the lessons learned and knowledge available in one country or region informing management approaches more widely.

We hope that this new book will not only bring together this new knowledge in a single accessible place but also highlight the need to prevent the further spread of these invasive species, especially in the context of a changing climate.

The book is available for free download from:

https://enaca.org/?id=931

Emergency Regional Consultation for Prevention and Management of Tilapia Lake Virus in the Asia-Pacific

Since 2009, tilapia aquaculture has been threatened by mass die-offs in Israel and Ecuador, which have been caused by a novel Orthomyxo-like (RNA) virus named Tilapia lake virus (TiLV). This has been reported as a newly emerging virus that causes syncytial hepatitis of tilapia (SHT). As of 2016, countries affected by this emerging disease included Israel, Ecuador, Colombia and Egypt. In 2017, Thailand and Taiwan Province of China confirmed the presence of the virus among farmed tilapia, which has caused mass mortalities since 2015. This is the first report of the disease in Asia-Pacific region. NACA released a Disease Advisory as part of the awareness programme in the region. The advisory was widely disseminated to all NACA member governments, partner institutes and other interested parties in the region and beyond.

As tilapia is a highly important aquaculture species in the region, it is highly important to contain the disease and prevent its spread to other major tilapia-producing countries such as China, the Philippines, Indonesia, Lao PDR and Bangladesh. Tilapia-producing countries in the region should be able to harmonise efforts in preventing the entry of the pathogen through improved quarantine and biosecurity measures. As such, the Emergency Regional Consultation was held to discuss and plan actions on the overall prevention and management of this disease. The consultation focused on the following:

- Implementation of proper quarantine and biosecurity measures, as well as responsible movement of live tilapias within the country and across the region.
- Strengthening of diagnostic capacities as well as active surveillance for the disease (to detect presence or absence of the virus).
- Formulation of recommendations on the sanitary measures for disease prevention
- Emergency preparedness for countries not yet affected by the disease highly considering the capacity of each country. As tilapia is a common food for many people in the region, especially among rural communities, emergency preparedness will make a big impact in the management of this emerging threat for tilapia aquaculture.

The Consultation was organised by NACA in collaboration with the National Fisheries Technology Extension Center (NFTEC), Ministry of Agriculture (MOA) and Sun Yat-Sen University, People's Republic of China. It was held at Sun Yat-Sen Kaifeng Hotel, Guangzhou, China on 27-28 September 2017, and was attended by 45 foreign and local participants. The following topics were presented and discussed:

- Tilapia aquaculture in the Asia-Pacific Region: Status and Trends (Dr Derun Yuan, NACA).
- Important diseases of cultured tilapia (Prof. Jianguo He, Sun Yat-Sen University).
- The Role of Trade in Spread of Transboundary Aquatic Animal Diseases (Dr Eduardo Leaño, NACA).
- Overview of TiLV (Dr Mona Jansen; Norwegian Veterinary Institute).
- Update on TiLV research in Thailand and potential strategies for control (Dr Ha Dong; KMUTT, Thailand).
- Virus characterisation, clinical presentation and pathology of TiLV (Dr Win Surachetpong, KU, Thailand).
- Import Risk Assessment: Role in prevention of transboundary aquatic animal diseases (Dr Hong Liu; AQSIQ, China) .
- Biosecurity: Role in aquatic animal disease prevention and control (Dr Jie Huang; YSFRI, China).

Country representatives then presented "Tilapia Health Management with Focus on Status of and National Action Plan on TiLV". Countries represented were China (Dr Li Qing), Egypt (Dr Shimaa Elsayed Mohamed Ali), India (Dr Pravata Pradhan), Indonesia (Ms. Ratna Amalia Kurniasih), Malaysia (Dr Azila Binti Abdullah), Myanmar (Dr Kay Lwin Tun), Philippines (Dr Sonia Somga), Thailand (Ms. Jaree Polchana) and Vietnam (Dr Pham Hong Quan). A panel discussion was held and discussed the following issues:

- Formulation of regional plan for prevention and control of TiLV.
- Research gaps and priorities.
- Surveillance and reporting.
- Listing in OIE.
- Way forward.

Panelists include representatives from regional and international organisations as well as key institutes in China including: Dr Hong Liu (AQSIQ), Prof. Jianguo He (SYSU), Dr Yan Liang (NFTEC), Prof. Hong Yang (FFRC), Dr Stian Johnsen (OIE), Dr Shimaa Ali (WorldFish), Dr Rolando Pakingking, Jr. (SEAFDEC AQD), and Dr Eduardo Leaño (NACA). The proceedings of the consultation are still under preparation and will be available on the NACA website once published.

Antimicrobial use in the aquaculture sector

NACA has recently completed two FAO funded projects on antimicrobial usage in the aquaculture sector. Antimicrobial resistance (AMR) poses a fundamental threat to human and animal health, development and security. It occurs when pathogens undergo adaptive evolutionary changes that enable them to withstand antimicrobial substances.

Every use of antimicrobial agents in food production creates opportunities for the development of AMR, and this is more apparent when antimicrobials are overused or misused. The consequences of the development of resistance to antimicrobial agents are potentially severe, with a real risk of losing treatment options which could jeopardise not only human and animal health, but also global food safety and food security. In aquaculture the use of antimicrobials has historically been practiced in response to many devastating disease outbreaks, either as a prophylaxis for disease prevention or as a treatment when disease occurs.

The projects were *Documentation and characterisation of antimicrobial use in the aquaculture sector, including current and proposed practices in aquaculture and aquatic disease status in Asia*; and *Review and comparative study of the antimicrobial usage and practices in the aquaculture sector on selected aquaculture species in Indonesia, Myanmar, Thailand and Vietnam, and the application plan of the methodology for use by other countries in Asia*. The projects largely ran throughout 2017 with some activities scheduled for early 2018.

In most intensive aquaculture production systems AMR can develop in the culture water or the fish gut bacteria as a result of antimicrobial therapy or contamination of the aquatic environment. However, the extent and persistence of antimicrobial residues in aquatic systems is unknown and current evidence is conflicting. Water is an important vehicle for the spread of both AMR and resistance determinants. Minimising the emergence and spread of AMR requires coordinated, focused and multi-national effort.

These projects were undertaken to assess the current status of AMU in selected aquaculture species in Indonesia (groupers) Myanmar (freshwater finfish), Thailand (shrimp) and Vietnam (catfish). The projects accomplished the following activities:

- A review of current aquaculture practices for major aquaculture species in selected countries.
- A comprehensive review of diseases affecting identified major aquaculture species.
- Piloted methodology for AMU documentation on selected farms in Indonesia, Myanmar, Thailand and Vietnam.
- Developed a framework methodology document for assessing antimicrobial use in the aquaculture industry. The methodology framework includes the value chain, datasets to obtain and specific industry profiles to describe assessment procedures at farm and national levels.
- Provided recommendations on prudent and responsible use of antimicrobials that will contribute to existing good aquaculture practices and biosecurity practices.
- Conducted and documented aquaculture stakeholder consultations (government, industry and academe) to raise awareness on anti-microbial usage and resistance surveillance in aquaculture.
- Used the results of these activities to identify specific capacity requirements to implement effective anti-microbial usage and resistance surveillance / diagnosis in the aquaculture sector.
- Conducted a final workshop on AMU to share experiences and lessons learned in Singapore, from 11-14 December 2017.

Network of Aquaculture Centres in Asia-Pacific

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