Thai Fish Project: A path towards a sustainable aquaculture

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Thailand has always been among the top producing and exporting countries of fishery commodities. In terms of exports, it has served as the world's third largest exporter of fishery products, making up a considerable portion of the total global export value for many consecutive years (Jaya et al., 2019). A closer look reveals that a significant percentage of those fishery commodities are aquaculture products. In 2019, Thailand was ranked 10th in the world, in terms of aquaculture production (SEAFDEC, 2022). Aquaculture has been a sector of great importance to Thailand's socio-economic development. The fisheries GDP of Thailand was up to US$2.947 billion in 2015–with coastal and freshwater aquaculture together accounting for 56 percent of total fisheries production value (Yenpoeng, 2017). The sector is currently providing employment for over 650,000 people in the country (Yenpoeng, 2017). Despite such success, Thai aquaculture is not without challenges in sustaining its contribution to the economy nor its ability to satisfy increasing national and global demand for aquatic protein. This is especially the case when environmental sustainability is a major determinant for the sector's success because on multiple occasions in the past, the aquaculture industry has had negative impacts on the environment.

Generation one banana shrimp Penaeus merguiensis bred at the Trang Coastal Aquaculture Research and Development Center.

Asian seabass Lates calcarifer cultured in the Phuket Coastal Aquaculture Research and Development Regional Center.

One negative impact is the introduction of exotic species. Several major aquatic species cultured in Thailand are exotic, with some being considered invasive (Sampantamit, et al., 2020). This has the potential to disrupt local food webs and ecosystems, which can result in the decline and extinction of native species. To illustrate, the South-American whiteleg shrimp (*Penaeus vannamei*), which was introduced in Thailand in the 90s and subsequently became the country's main cultured species, has been reported to be found in Thai natural waters, including the mouth of the Bangpakong River, and in several coastal and offshore areas along Thailand's east coast (Partnerships in Environmental Management for the Seas of East Asia & Department of Marine and Coastal Resources, 2019). Some accompanying negative effects are the spread of an exotic pathogen, namely taura syndrome virus (TSV) and competition with local shrimp species.

The whiteleg shrimp is reported to have faster feeding rates than many Thai native shrimp species (PEMSEA & DMCR, 2019).

A disease outbreak also raises environmental concerns. It is suggested that the emergence and spread of diseases in fish and shrimp farms can pose a threat to wild populations and biodiversity by triggering among others, changes in predator and prey populations, changes in host abundance, and reduction in intra-specific genetic variation (Arthur & Subasinghe as cited in Walker & Mohan, 2009). Although it is also noted that environmental impacts of the disease outbreak in aquaculture farms are generally hard to assess and relatively under-researched, it certainly is a serious hindrance to the performance of aquaculture production. Thailand knows this well. From 2012 to 2013, disease outbreaks of early mortality syndrome/acute hepatopancreatic necrosis disease (EMS/AHPND) led to a substantial decline in the country's farmed shrimp production from 600,000 tons to 325,000 tons (Sampantamit et al., 2020).

Another environmental impact is water pollution. The discharge of nutrient-rich effluent from fish and shrimp farms into the environment, such as natural water bodies, can trigger eutrophication that will lead to poor water quality and consequently severe ecological damage. One study suggests the blue-green algae blooms in the Gulf of Thailand are caused by the release of nutrients (Sampantamit et al., 2020).

Thailand, sustainability, and aquaculture

Thailand places great importance on sustainable development. The country has been demonstrating its commitment to the concept through several policy initiatives. Sustainable Development Goals (SDGs) were integrated in the development agenda, including the 20-Year National Strategy Framework (2017-2036) and the 12th National Economic and Social Development Plan (2017-2021). This means that every government agency is required to align its policies and budget planning with the SDGs (PEMSEA & DMCR, 2019).

The Department of Fisheries is the principal government agency in charge of aquaculture development planning and implementation in Thailand. Its main regulatory framework is the Fisheries Act 2015, which was established to support sustainable fisheries and aquaculture. Chapter 7 of the Act specifically highlights aquaculture promotion to achieve long-term economic, social, and environmental sustainability and ecosystem balance; DOF is responsible for promoting, developing, and providing guidance with respect to aquaculture to achieve such goals "without compromising the state of the ecological environment" (Royal Ordinance on Fisheries, 2015). In short, at the heart of the Department of Fisheries' direction for aquaculture development is environmental sustainability. Other equally important considerations include food security, food safety, economic growth, and adherence to international agreement.

Thai Fish Project

The continuously growing demand for fishery products and the ongoing concerns with respect to the culture of aquatic animals highlight an urgent need for the promotion of research and development in aquaculture, which has recently become the main source of global supply for aquatic protein. In the Department of Fisheries' 5-Year Strategic Plan 2017-2021, a reference is made to several national planning frameworks and strategies, which the Department has to conform with in terms of its developmental direction. And in many of these strategies, a heavy emphasis is placed on promoting research as the way to facilitate knowledge and capacity development in order for Thailand to maintain sustainable aquaculture, effectively respond to domestic demand for fishery commodities, and improve competitiveness in the global market (Department of Fisheries, 2017).

As a result, Thai Fish Project started in 2019. Thai Fish Project is the simple name for the project more formally titled Utilization of Thailand Local Genetic Resources to Develop Novel Farmed Fish for Global Market. It is led by the Tokyo University of Marine Science and Technology (TUMSAT) and the Department of Fisheries, Ministry of Agriculture and

The 4th Joint Coordinating Committee (JCC) meeting of Thai Fish Project in 2022 - the JCC is where the research progress will be updated and monitored to make sure the project meets its goal.

Juvenile Asian seabass in the Songkhla Coastal Aquaculture Technology and Innovation Research and Development Center.

Cooperatives, Thailand, with other notable research institutes in both Japan and Thailand, involving around 200 research members.

This joint research project is funded by Japan International Cooperation Agency (JICA) and Japan Science and Technology Agency (JST). The project was initially expected to last 5 years from 2019-2024 but due to COVID-19 that had created a big disruption for project activities, the end year was extended to 2025.

Thai Fish Project aims to promote domestication and wise use of two Thai native aquatic species, namely the Asian sea bass (*Lates calcarifer*) and banana shrimp (*Fenneropenaeus merguiensis*) through increasing productivity, reducing the impact of infectious diseases, and preserving genetic resources. Considering the issues related to the sustainability of aquaculture practices, including the introduction of exotic species, disease outbreaks and water pollution, the Thai Fish Project selected Asian sea bass and banana shrimp, which are both native to Thai natural waters. The project also encompasses several specific research topics to ensure that it comprehensively addresses the concerns on safeguarding the food security and enhancing the environmental sustainability as much as possible.

In total, there are nine research sub-groups, which can be classified into four main research outputs, as follows:

1. Create through molecular breeding

The project is making use of molecular breeding technology to identify at least one useful molecular marker(s) that correlate with economically important traits of the target species. The molecular maker(s) identified will be a precise and useful piece of information, which will enhance the effectiveness of the breeding and the efficiency of the aquaculture. To begin this study, we have evaluated the genetic diversity of the target species. We are also now working to identify at least one family of each target species that possesses economically important traits. Finally, the project expects to establish a breeding program for resilient and fast-growing families.

2. Control by developing disease prevention method

The project is developing prevention methods against infectious diseases common among Asian sea bass (e.g. scale drop disease virus (SDDV), viral nervous necrosis (VNN), and infectious spleen and kidney necrosis virus (ISKNV)) and banana shrimps (e.g. WSSV, *Enterocytozoon hepatopenaei* (EHP), *Vibrio parahaemolyticus* (VpAHPND), yellow head virus (YHV) and hepatopancreatic parvovirus (HPV)). Under this output, we conduct disease surveillance of common diseases among the two target species. We aim to develop at least one on-site disease detection method and protective vaccine for Asian sea bass. Likewise, the project expects to develop a prevention method for banana shrimps against common diseases by using probiotics, taking into consideration the nature of the aquaculture environment including the season, temperature, water quality, and microbial flora.

3. Add value and wise use

The project is attempting to develop new culture technologies to produce high value-added fish and shrimp. One group of researchers is developing a nutrient-enriched diet that will enhance maturation and fertility for the target species. For

Aquaculture cage donated by JICA to the Phuket Coastal Aquaculture Research and Development Regional Center.

Asian sea bass, we aim to increase eicosapentaenoic acid (EPA) and docosahaxaenoic acid (DHA) by 20 percent. We are developing a non-fish meal and non-fish oil diet (e.g. soybean, palm oil, marine by products), and the results so far show that fish meal and fish oil replacement does not have a negative impact on the species' growth. Plus, a certain percentage of dried *Schizochytrium* sp. supplementation can lead to better growth, higher DHA, and better sensory properties of the Asian sea bass.

Another group focuses primarily on the development of a sex reversal method to enable all-female production of shrimp. Our expected outputs are that at least one sex-specific DNA marker of banana shrimp is identified to enable the sex reversal manipulation, and that novel maturation induction for the female shrimp is developed.

One other group is working on developing a feasible and effective culture method for banana shrimp, such as recirculating aquaculture system (RAS) and biofloc system. In fact, biofloc technology has been becoming more popular as an efficient alternative water management system, which effectively gets rid of excessive nutrients in the water by turning them into microbial biomass that can later become a feed supplement for the cultured species (Sampantamit et al., 2020). This can minimise the chance of water pollution caused by aquaculture operations. The result from our research so far is also pointing towards biofloc as a better system for the banana shrimp delivering improved average daily growth (ADG), feed conversion ratio (FCR), survival rate and weight gain.

4. Preserve genetic diversity through gene bank

Without attention, aquaculture practices can lead to a decline in genetic diversity, as a result of founder effects, inbreeding, and genetic drift. This can later affect disease resistance and adaptability to changes in the environment of the cultured species.

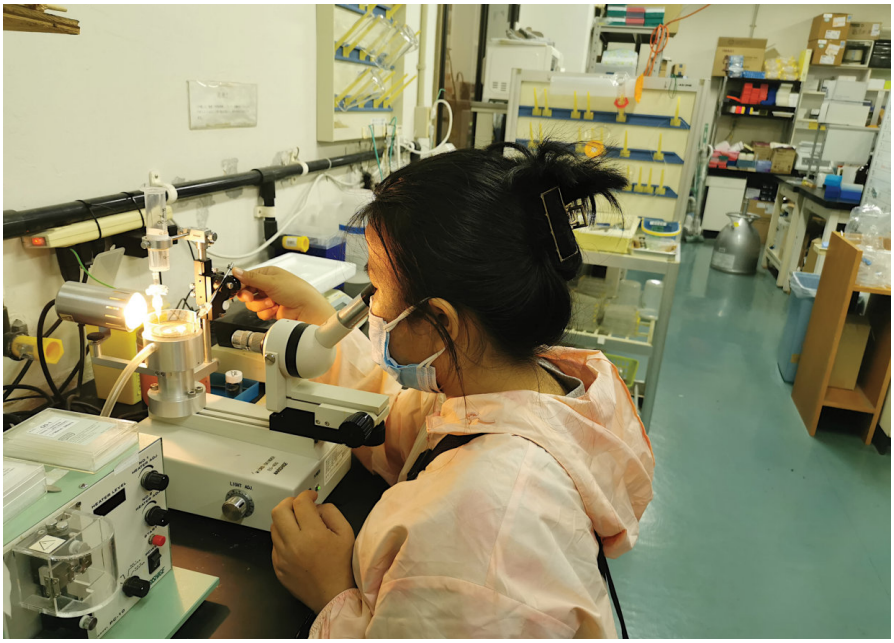
The Thai Fish Project wants to ensure that genetic diversity of native species is preserved to avoid aforementioned concerns. Under this expected output, two groups of researchers are working on the development of germ cell preservation methods—one for Asian sea bass, and the other one for banana shrimp. Our expected output is that at least one germ cell transplantation method and germ cell preservation method for Thai native aquatic animals is developed.

Future expectations

"The benefit from the Project is that our staff and students have been trained by the expertise (Group 4-2 Leader, Dr Monwadee WONGLAPSUWAN, Prince of Songkla University)".

With an emphasis on building the capacity of young researchers, Thai Fish Project aims to develop innovative aquaculture technologies that will allow for effective disease control, nutrition administration, and management of genetic diversity. Through that, we expect the establishment of a comprehensive package for Asian sea bass and banana shrimp aquaculture systems that are ready to be implemented by interested farmers and companies.

Ideally, we hope that farmers and companies that adopt our package will have a linkage to be acknowledged as a case of good practice by a globally or regionally well-known aquaculture



A researcher from Suranaree University of Technology (SUT), Thailand joining a training on germ cell transplantation in TUMSAT, Japan.

A researcher from TUMSAT demonstrating the germ cell transplantation and cryopreservation techniques to the researchers of DOF and SUT.

certification system. This is because it will play a great role in enhancing the package's credibility and notability, which can in turn, lead to the wider implementation of such a sustainable aquaculture system by other ASEAN countries.

All in all, we believe that the project strengthens Thailand's commitment to sustainability. The Project's expected outputs can allow Thailand to further express its adherence as well as simultaneously contribute to global SDGs, particularly, SDG 2 Zero Hunger, SDG 9 Industry, Innovation and Infrastructure, and SDG 14 Life Below Water. We expect this to greatly add to Thailand's effort to become an environmentally friendly and sustainable "Kitchen of the World".

If you want to know more about our project, please check out our Facebook page.

https://www.facebook.com/thaifishproject

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