Aquatic Emergency Preparedness and Response Systems in Singapore

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Abstract

Singapore's population-dense, urban environment presents a unique context for her increasingly important aquaculture industry. This paper provides an overview of Singapore's existing aquatic emergency preparedness and response systems, which have been constructed and refined by the Agri-Food and Veterinary Authority (AVA) in view of past experience with detections of pathogens of warmwater fish. These systems have been developed to fulfil Singapore's obligations as an OIE member country and AVA's duty to safeguard food security, animal and public health. As a trade and export hub, it is critical for Singapore to have timely detection and reporting of diseases which can have an impact on trade. Singapore also needs to balance the needs and perceptions of the multiple stakeholders using the limited space and resources in our island state. Finally, this paper outlines the current issues and gaps of Singapore's existing aquatic emergency preparedness and response systems.

Status of Aquaculture in Singapore

Singapore has a small but thriving and increasingly important food fish farming industry which accounts for about 10% of local food fish consumption. The main bulk of food fish production comes from coastal fish farming in floating netcages along the Straits of Johor and the Southern Islands. Most of these floating netcages are traditional wooden platforms but some of the farms have cages made of materials like HDPE.

There are 114 coastal and deep sea fish farms (105 food finfish and 9 bivalve farms) and 9 land-based foodfish farms that produced about 4,808 MT of food finfish in 2017. Common marine food fish species cultured include Asian seabass (*Lates calcarifer*), groupers (*Epinephelus* spp.), snappers (*Lutjanus* spp.), milkfish (*Chanos chanos*), mullet (*Mugil* spp.) and pompano (*Trachinotus* spp.). Other than finfish, a few coastal farms also produce green mussel (*Perna viridis*) and oysters (*Crassostrea gigas*) which form the bulk of shellfish production in Singapore.

Land-based foodfish farms mainly culture freshwater species like the giant snakehead (*Channa micropeltes*) and tilapia (*Oreochromis* spp.). Other species include jade perch (*Scortum barcoo*) and catfish (*Clarias batrochus*). The culture system in traditional land-based farms are mostly earthen or concrete ponds. Recently, a number of land-based farms using recirculation aquaculture systems (RAS) technology have been set-up, mainly producing groupers and shrimp.

Growing the local food fish production

Our local food production target is 15% for fish. Local production has been rising over the years. Presently, local farms are producing 10% of our fish supply. The targets that we set are reviewed from time to time as our needs evolve and as technology becomes available. New technologies such as sensors, precision farming, automation, robotics, genetic improvements, and other engineering solutions are bringing many opportunities for increasing productivity and raising local production.

Singapore is the world's leading exporter for ornamental fish

Singapore has held this position over the past 20 years and exports appoximately US $40-50 million worth[1] of ornamental fish annually to over 100 countries. Our top markets are the US, UK, Japan and Germany. The market share has been stable over the years, making up about 15-20% of the global market value. To meet international trade requirements and facilitate trade for ornamental fish, the AVA has put in place quality assurance and surveillance programs to provide an all-rounded approach to assure quality and health status of animals for export to the global market. The success of this industry is due to Singapore's strengths in the provision of health certification, quality assurance, logistic channels and aviation connectivity. Inspection and health checks, continuous education and outreach are part and parcel of the efforts to ensure that only healthy and high quality ornamental fish are exported.

Disease Control

The control of diseases in food fish

Major bacterial diseases in food fish include streptococcosis, nocardiosis, vibriosis and tenacibaculosis. Viral infections with VNNV, SDDV and Iridoviruses have also been detected [Annex 2]. All farms have access to extension and laboratory diagnosis services to ensure timely and accurate detection of the causative agent of mortalities and morbidities in fish. Farms can also voluntarily submit imported marine food fish fry and fingerlings for disease screening. Such services are provided without charge to farms and costs are borne by the authority.

TABLE 1. Farm production of food fin fish for the last 10 years

Year	Farm Production									
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Locally produced Food Fin Fish (tons) *Excluding crustaceans and mollusc*	1970	2235	3186	3476	3157	4220	4205	5272	4851	4808

[1]Aquarium accessories and ornamental plants are consolidated with OF and shipped out together.

However, disease control remains a challenge. Apart from a few large progressive food farms, the majority of food fish farms are small-holder farmers with diverse education levels. In addition, vaccines for tropical food fish are limited in availability worldwide and rarely used by smaller farms. From a voluntary survey of wholesalers of veterinary drugs done in 2015 and 2016, the aquatic food fish sector is the largest user of antimicrobials in animals in Singapore, with 77.5% of the antimicrobials sold in 2016 being used here. Sales of antimicrobials in the aquaculture sector have increased by 33% from 892 kg in 2015 to 1185 kg in 2016. From the results in the chart below, it is evident that the food fish industry is the largest user of antimicrobials[2] in animals in Singapore.

Current status of the Aquatic emergency preparedness and response systems in Singapore

Legislative powers of the Agri-Food & Veterinary Authority of Singapore (AVA)

The Agri-Food & Veterinary Authority of Singapore (AVA) is the sole national authority responsible for all matters pertaining to aquaculture health, trade and food safety in Singapore. The management of aquatic animal health and aquatic emergency preparedness and response systems, cuts across several departments in the AVA. The AVA uses the powers provided by the Agri-Food and Veterinary Authority Act[1], the Animals and Birds Act[2], and the Wholesome Meat and Fish Act[3], and their subsidiary legislation, in order to safeguard aquatic animal health and protect the health of human consumers.

In particular, the Animals and Birds Act is for preventing the introduction and spread within Singapore of diseases of animals, birds or fish; the control of the movement of animals, birds or fish into, within and from Singapore; diseases notification; the prevention of cruelty to animals, birds or fish; measures pertaining to the general welfare and improvement of animals, birds or fish in Singapore and for purposes incidental thereto.

Section 62 (1) of the A&B Act empowers the AVA to at any time, suspend or revoke the license or restrict the operation authorized by the license, where the holder or the company,

(i) Is convicted or suspected of any offense under the Animals and Birds Act
(ii) Contravenes or fails to comply with any statutory requirement relating to the license
(iii) Contravenes or fails to comply with any condition or requirement specified by the license

The Wholesome Meat and Fish Act regulates the slaughtering of animals and the processing, packing, inspection, import, distribution, sale, transshipment and export of meat products and fish products and for matters connected therewith.

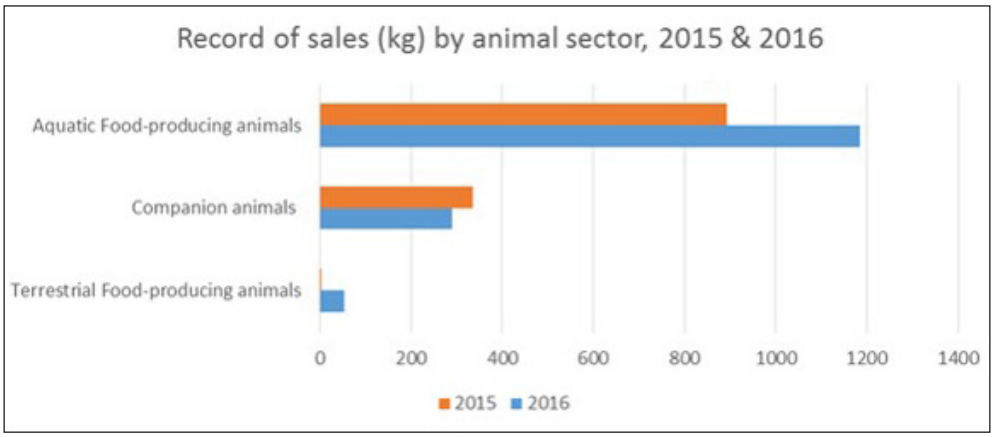

FIGURE 1. Results of survey of wholesalers of veterinary drugs

[2]Agri-Food and Veterinary Authority of Singapore is responsible for regulation and monitoring of AMU and AMR in aquaculture in Singapore. Outreach and education, accreditation schemes, good aquaculture practices, facilitation of vaccines, development of prudent use guidelines and strengthening of regulations are some areas AVA is working on in concert to reduce AMU in the aquaculture industry, especially those critically important to human health

Preparedness and response

AVA carries out national surveillance programs for significant viral and bacterial diseases of both ornamental and food fish. Based on the information derived from these surveillance programs, AVA's veterinarians, surveillance staff and extension personnel work closely with the aquaculture industry to control and manage aquatic diseases in Singapore. All farms have access to extension and laboratory diagnosis services to ensure timely and accurate detection of the causative agent of mortalities and morbidities in fish. Officers working with the farms on the ground will keep farmers informed of the results from tests. In addition to the surveillance implemented by AVA, it is a legal requirement to notify AVA if a notifiable or significant disease is suspected. It is also our obligation as an OIE member country to bear the cost of testing for notifiable diseases and report these when detected. Isolation or quarantine orders can be issued to control the spread of notifiable aquatic diseases on all premises, not limited to those licensed by AVA.

Surveillance programmes for Ornamental and Food Fish

Disease surveillance for ornamental fish involves routine sampling for the following diseases: Koi Herpesvirus (KHV), Spring Viraemia of Carp Virus (SVCV), *Aeromonas salmonicida*, Megalocytiviruses (ISKNV & RSIV), and White Spot Syndrome Virus (WSSV) for ornamental crustaceans. Samples will be taken for disease diagnosis should there be any diseased fish observed during inspection of the ornamental aquaculture premises.

A marine food fish disease surveillance programme is also in place to provide diagnostic services for local foodfish farms. The surveillance is of a passive nature with farms submitting moribund or diseased fish on a voluntary basis. Only 10 to 20% of the coastal marine food fish farms currently submit diseased fish samples for surveillance. Results and findings of the diagnostic tests are then communicated to the farms via email. Should farms need a laboratory report for the diagnostic test (e.g. for health certification and export purposes), they also have the option of paying for the diagnostic services, rather than utilising the surveillance program.

Preventive health measures are the cornerstone in all livestock production systems, including aquaculture. Without farms committing to a health management plan, they are unlikely to see improvements to fish health or farm productivity. Apart from a few top tier food fish farms in Singapore, the majority of farms have yet to establish robust fish health management plans, which would consist of a biosecurity plan, and treatment plan for when fish fall sick. With this in mind, AVA has recently reviewed the marine food fish surveillance programme to include all land-based food fish farms. Under the revised "Food Fish Surveillance Progamme", disease surveillance and sampling would be part of a fish health management plan which is developed and owned by the farm. Plans will cover both regulatory diseases and production diseases which are of economic significance to the farm, and advice provided by AVA's fish health/ aquaculture specialists when required.

Besides the OIE-notifiable diseases, there are several common but significant production pathogens (viral, bacterial and parasitic) of foodfish in Singapore. These diseases include Benedenia, Big-Belly (BB) bacteria, *Streptococcus* sp., *Tenacibaculum maritimum*, Viral Nervous Necrosis Virus (VNNV), Megalocytivirus, Grouper Iridovirus and *Nocardia* sp. Emerging pathogens such as Tilapia Lake Virus (TiLV), Scale Drop Disease Virus (SDDV) and Lates Calcarifer Herpesvirus (LCHV), though not OIE-notifiable, also pose a potential threat. In the case of these non-OIE notifiable diseases, there will not be a regulatory requirement of compulsory culling. However, in most cases, operators will chose to voluntarily cull the batch to minimise disease spread. AVA will also advise and assist the affected farms in disease management. Annex 2 summarises the key control mechanisms for several major production diseases (both notifiable and non-notifiable), in Singapore.

Aquatic Animal Contingency Plans

The Aquatic Animal Contingency Plans are activated when there are detections of notifiable aquatic animal diseases on a farm or other aquatic animal holding facilities. Key aspects of the contingency plans include:

a. Quarantine and movement restrictions of affected animals.
b. Vaccination (for certain pathogens e.g. RSIV).

c. Compliance to proper biosecurity measures.
d. On-site investigation and sampling of susceptible fish species from the affected farm and adjacent farms, to determine extent of disease spread.
e. Culling of affected and in-contact fish.
f. Disinfection and cleaning of the premises and all in-contact equipment and tanks.
g. Re-inspection of the premises to ensure compliance with disinfection and biosecurity protocols.

Formation of the Disease

In 2017, the AVA appointed a team of veterinarians and field officers involved in different operational capacities (laboratory, surveillance and regulatory) to form the Disease Investigation team (DIT). The DIT is intended to be a rapid-reaction force activated by the Director-General of AVA, capable of mounting a swift and coordinated response to local disease outbreak situations including those of OIE-listed and nationally notifiable diseases, spanning across all animal species. The DIT is a crucial facet of Singapore's response system in detecting and containing aquaculture-related disease situations in Singapore.

Current issues and gaps

Need to Build Awareness and Education of the aquaculture industry

There is a need to raise awareness of the importance of biosecurity and prevention of disease spread in the local aquaculture industry. Industry needs to take responsibility for biosecurity, starting from simple low cost improvements to their practices so as to improve performance. Biosecurity plan templates and best practice guidance documentation will be developed for farms to follow, as part good aquaculture practices. In Singapore, an existing voluntary surveillance programme for disease screening of imported fingerlings is largely under-utilised by the majority of local farms. This suggests that farmers do not see the importance of knowing the pathogen status of imported fry. Local farmers need to be educated in the areas of import quality assurance (e.g. screening of imported stock, purchasing from accredited sources) and basic disease management.

Surveys of a small proportion of local farmers also reveal non-specific use of antimicrobials and other pharmaceuticals to treat moribund stock, and correlates with data on antibiotic sales data described earlier in paragraph 7. This raises grave concerns on the development of antimicrobial resistance in the aquaculture industry. In view of the diverse educational backgrounds of farmers within the industry, AVA has organised regular Fish Farmers' Workshops and basic laboratory technique practical sessions (necropsy and wet mount parasitology examination). An annual Fish Farmer's Newsletter is also circulated to the industry to update farmers of industry and regulatory developments and provide informative content on relevant topics such as disease management, biosecurity and laboratory testing. AVA will continue to create relevant training opportunities for local farmers to address the gap in industry education.

Lack of commercial vaccines for tropical food finfish

As mentioned previously, vaccines for tropical food fish are limited in availability worldwide and rarely used by smaller farms. Combined with a lack of education in disease diagnosis and management, the lack of vaccine availability may potentiate the aforementioned non-specific use of pharmaceuticals in aquaculture. AVA is working with local farmers to increase uptake of existing vaccines, and encourage improvements in husbandry as both a preventative and reactive management tool for disease situations. As commercial vaccines have developmental periods of up to 6 to 7 years, this will be too long a wait for the management of emerging diseases in minor aquaculture species. Autogenous vaccines are customised and herd specific products. While their efficacy is unassessed experimentally, the shorter development timeframe for such products is crucial for the management of emerging diseases in minor use species such as food finfish. There is a need to develop regulations for autogenous vaccines manufacture and use in tropical food finfish. This would outline the roles and responsibilities of the farm, veterinarian and the vaccine manufacturer. AVA intends to conduct further consultation with stakeholders before these guidelines are finalised.

Inadequate public awareness

There is a need to address public education in disease outbreak situations. For example, public

education efforts in harmful algal blooms (HAB)[3] episodes could involve increasing awareness of the public health impacts of HABs, such as the adverse consequences of humans or pets swimming in waters with dead decomposing fish, and elevated microbial content. With the advent of social media and increased adoption and penetration of telecommunications technology, consumers have easy access to a whole slew of information online, both true and false alike. Widespread erroneous information could adversely affect consumer perception and cause public alarm. Authorities need to step up efforts in educating and informing the public so they would know what actions can be taken to protect themselves in such an incident, and know who to report these incidents to. There is also a need to strengthen communications between countries sharing the same water resources to facilitate the timely reporting and response to HABs. The same mechanism can be applied in a disease outbreak, where the rationale for measures such as movement restriction have to be communicated and explained to ensure compliance from both local and overseas stakeholders.

Transparent Reporting of Disease Status

The OIE WAHIS system and the Quarterly Aquatic Animal Disease (QAAD) Reports to NACA serve as excellent platforms for transparent reporting of country disease status. It is believed that continued utilisation of these reporting platforms by OIE and NACA member countries, will facilitate timely notification of significant pathogen detections and implementation of mitigation measures within a region that depends heavily on commercial trade and culture of live aquatic animals for livelihood and economic growth.

Emergence of New Pathogens

The recent, rapid emergence of new pathogens, such as Scale Drop Disease Virus, Tilapia Lake Virus and *Lates calcarifer* Herpesvirus, could potentially present new disease situations and necessitate formulation of new trade requirements within the region. Hence, AVA needs to stay abreast of emerging disease situations in the region, relying on pre-emptive horizon scanning for disease threats, existing mechanisms (WAHIS and QAAD), and transparent and prompt trans-national notification of new disease situations. Moreover, pathogen emergence necessitates rapid development and advancement of the AVA's laboratory diagnostic capabilities and potentially a ramping up of disease surveillance, as well as closer partnerships with research-intensive entities (academia and pharmaceutical companies) to better understand the disease epidemiology, public health impacts and management.

[3]**Preparedness and response systems for Harmful algal blooms (HABs):** While HABs are not brought on by a pathogen but rather by plankton, their spread across nautical boundaries and zones means the effects of a bloom will be experienced by farms located in the same body of water. Early detection may allow for emergency harvest of fish stocks, which is especially vital for the farms. Following a plankton bloom episode in 2014 which resulting in massive loss of stocks for both Singaporean and Malaysian coastal netcage farms, four alert levels with trigger points were set, to provide pre-determined alert levels in a HAB event. Determination of the Alert level at any point in time depends heavily upon routine surveillance of plankton counts in local waters, as well as routine surveillance of marine biotoxin (via sampling of farmed shellfish and wild mussels), in all ten of Singapore's offshore farming sites. Any detection of elevated seawater plankton counts also acts as a stimulus for stepping up of surveillance efforts. The response protocol involved the activation of crisis investigation teams to provide technical assistance to affected farms and to collect samples for laboratory diagnostics.