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Fish Disease Management

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FISH DISEASE MANAGEMENT BY THE AGRICULTURE, FISHERIES AND CONSERVATION DEPARTMENT (AFCD), HONG KONG

Production of seafood in Hong Kong is a primary industry, which has a long history of over 40 years (Fig. 1). The Hong Kong Government through the AFCD continues to support this local industry through its fish health services. This article highlights some practical aspects of that service.

Figure 1. Hatchery produced *Cromileptes altivelis* juveniles(魚苗).

Fish Health and Disease Surveillance

Sustainable aquaculture production can only occur when fish are healthy and free from disease. Fish disease management is a combination of preventing the onset of disease and measures to reduce losses from disease when it occurs.

This is particularly true for commercial fish farms (the usual in Hong Kong) where the number of interventions and treatments are limited.

By contrast, breeding fish farms (usually in other countries) can engage in much more labour intensive and sophisticated treatments due to the small size and relatively high value of their stock.

AFCD, in its extension services, provides advice on husbandry and water quality. This encourages optimum husbandry to reduce the risk of disease in farmed fish.

Figure 2. Water sampling for water quality testing at mariculture site.

Further, AFCD conducts a regular and extensive water sampling (Fig. 2) and testing program. An important purpose of this program is to give early warning to mariculture producers of toxic algae (有毒海藻)(red-tide)(紅潮) blooms, this enables farmers to take early precautions to protect fish stocks.

AFCD also conducts regular farm visits (Fig. 3) to teach farmers the proper use of basic water testing equipment, e.g. oxygen meters, so that farmers can be proactive about managing optimal water quality conditions for their fish stocks.

Figure 3. Water chemistry testing (水質化學測試) training seminar for fish farmers.

Fish parasite identification kits are also distributed to fish farmers by AFCD (Fig. 4 on page 2). Each kit contains a manual on fish parasite (魚類寄生蟲) identification, a set of dissection tools (解剖工具) for parasite isolation and a low-cost field microscope. Together with appropriate training provided by AFCD and invited experts from the Mainland, fish

Figure 4. Fish parasite identification kits.

Method of Submission	Diagnostic Tests
Live fish	Bacteriology (細菌學), Biochemistry (生物化學), Electron Microscopy(電子顯微鏡學), Haematology(血液學), Pathology (病理學), Histopathology(組織病理學), Parasitology (寄生生物學), Serology(血清學), Virology(病毒學).
Freshly killed fish on ice (examined within 24 hours)	Bacteriology, Virology.
Frozen fish	Toxicological Analysis (毒物學分析), Virology.
Fish preserved in fixative	Electron Microscopy, Histopathology.

Table 1. Laboratory Tests for Fish Disease

farmers are encouraged to monitor the health of their fish stocks closely, and notify AFCD when early sign of parasitic disease is observed.

Finally, AFCD also conducts investigations of fish diseases and mortalities which usually results in further husbandry and treatment advice being given. (Fig. 5).

Figure 5. Mortalities (死亡率) of fish on fish farm being investigated by AFCD.

This begins with the collection of an accurate history from the farmer as he or she has first hand knowledge of the behaviour (feeding and swimming) and husbandry (stocking and movement, grading, harvest and treatments) of the affected fish batches. In addition he or she would be able to relay information on recent weather, and water quality changes which are important to the development of disease in the fish. Typically a

form is used to record this information which is submitted with the samples of fish and water to the AFCD laboratories.

Proper sampling of fish, water, feed and other environmental samples are crucial to the definitive diagnosis of fish disease. Adequate sampling includes :

- Representative number of affected fish.
- Keeping fish alive in oxygenated water (帶氧海水) bags (Fig. 6) or proper preservation of fish in fixative.
- Preservation of environment or feed samples in specifically treated containers.

Figure 6. Oxygenation of fish sample bag at the farm.

Laboratory Diagnostic Services

One facet of surveillance is that AFCD reports to the World Organisation for Animal Health (OIE) on a quarterly basis. This Quarterly Aquatic Animal report sent out from Hong Kong covers over 25 important diseases. This is an important procedure to satisfy World Trade Organizations Sanitary and Phytosanitary Agreement (WTO SPS) requirements. This action also helps to promote the valuable trade of ornamental fish from Hong Kong. For example in 2010 over 500 consignments of ornamental fish were certified in line with OIE's requirements and exported from Hong Kong. Their destination was worldwide including European Union member countries, Australia and America.

Laboratory Diagnostic Services

The fish and water samples received by AFCD laboratories are used to conduct diagnostic tests and even research, to identify the causes of the disease problem reported by the fish farm. These tests are summarised in Table 1.

AFCD may, if appropriate, contract out the above mentioned tests and research to other public, private or university laboratories, either here in Hong Kong or even abroad.

The necropsy examination (解剖檢驗) of fish (Fig. 7 and 8) is a discipline necessary for the assessment of gross pathological changes, collection of tissue subsamples for microbiology, histopathology or toxicology and parasitology. Blood samples (Fig. 9) may also be taken for haematology and biochemistry.

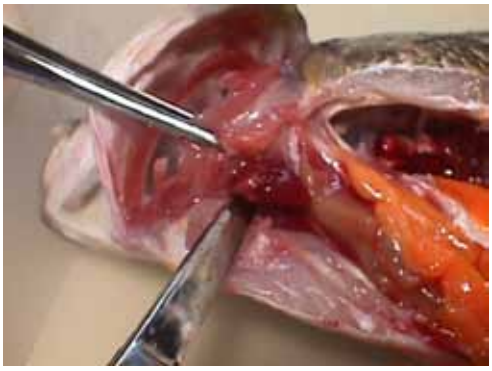

Figure 7. Fish necropsy involves dissection of organs and tissues for sampling.

Figure 8. Blood collection from the tail vein of fish.

Figure 9. Technical staff working in a laboratory.

Fish samples are tested to identify disease agents in the following ways –

- Pathology and histopathology is the examination of abnormal changes in the organs and tissues of diseased fish in order to determine the way a disease develops (Fig. 10 and 11). This enables the outcome of a disease to be predicted.

Figure 10. Gross pathological examination of organs in fish. Anatomy of a teleost fish– *Epinephelus coioides* (Green grouper). G= gill filaments, Gr= gill rakers, H= heart, L=liver, S = stomach, SB=swim bladder, UB=urinary bladder, PC= pyloric ceca, K= kidney, M= muscle, Sk = skin and scales.

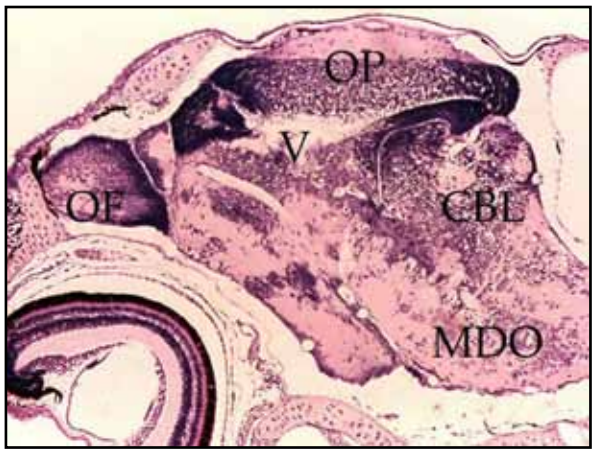

Figure 11. Histopathological examination of Sweetlip marine fry brain. OF = olfactory lobe, OP = optic lobe, CBL = cerebellum, MDO = medulla oblongata, V= ventricle.

- Bacteriology is the culture of bacterial pathogens on specialized growth media (Fig. 12). This allows identification of important fish bacteria that cause disease such as *Vibrio* (弧菌屬) spp. and *Streptococcus* (鏈球菌屬) spp.

Figure 12. Bacteriology employs specialized media plates for bacterial culture and identification.

- Virology is the testing of tissues for the presence of virus pathogens. It includes culture for viruses on living fish cells (Fig. 13) and DNA or immunologic tests to confirm the identity of important fish viruses such as Nodavirus and Iridovirus.

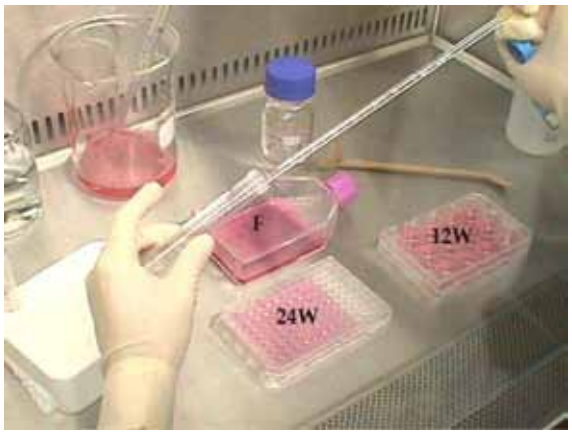

Figure 13. Fish virus culture using plates used for virus inoculation.

- Parasitology is the examination of parasites in tissues and organs such as the gills, skin and intestinal tract. It is useful for identifying important fish parasites such as monogenean flukes and protozoa.
- Water chemistry is the testing of water samples from disease locations to examine the role of water quality problems that may promote stress in fish and hence fish disease. Important tests include dissolved oxygen, pH, salinity, and pollutants such as ammonia, nitrite and toxins.
- Haematology and biochemistry of fish blood

is the testing of blood for changes in blood cells and enzymes or metabolites that indicate abnormal physiological changes in the fish. It provides information of how the fish are coping with a disease.

- Molecular (分子學) and immunological (免疫學) tests are specialized tests using DNA and antibody-antigen technology for the identification of bacterial, parasitic, viral and fungal disease agents. These are rapid and highly accurate tests. They include polymerase chain reaction tests (PCR) (Fig. 14) and serology tests.

Figure 14. PCR thermocycler machine.

- If the situation ever demands it, radiation monitoring (輻射監測) of fish can be performed.

Fish Diseases Managed by AFCD

Vibriosis (弧菌屬)

Vibriosis is a bacterial disease causing significant losses of fish in marine fish farms. Grouper, seabream, snapper and pompano species are affected. Vibriosis accounts for an estimated two-thirds of disease reported in grouper species. Vibriosis results in severe skin, muscle, fin, eye and internal organ damage of fish (Fig. 15 and 16). Diagnosis of the disease requires bacteriological culture of kidney, spleen, skin or eye lesions.

Figure 15. Brown spotted grouper (*Epinephelus areolatus*) near market sized fish with skin ulcerations (潰瘍), tail necrosis and exophthalmos (眼球突出症), panopthalmitis (全眼球炎) due to *Vibrio parahaemolyticus*.

Figure 16. Giant grouper (*Epinephelus lanceolatus*) with extensive ulcerative myonecrosis. *Vibrio alginolyticus* isolated from kidney and skin lesion.

Stressors (應激因數) that trigger vibriosis outbreaks include high water temperatures, high stocking densities, poor handling of fish, and an organically polluted culture environment.

Antibacterial medication, reducing stocking densities, careful handling of fish, improving the culture environment through the use of clean pelleted feeds, stocking of fish in cooler season of the year and vaccination are important control measures.

Streptococcosis (鏈球菌病)

Purple amberjack (*Seriolae quinqueradiata*), giant grouper (*Epinephelus lanceolatus*) and snapper (*Lutjanus* spp.) are susceptible to the bacterial disease of streptococcosis. Clinical signs include cloudy eyes (Fig. 17), exopthalmos

(Fig. 18) and focal, ulcerative skin lesions along the caudal peduncle area. Diagnosis of the disease requires bacteriological culture of kidney, spleen, eye lesions.

Figure 17. Corneal opacity (角膜混濁) with isolation of *Streptococcus morbillorum* in *Seriola quinqueradiata*.

Figure 18. Red snapper (*Lutjanus* sp.) with exopthalmos and streptococcosis due to Streptococcus Lancefield group B.

Control of streptococcosis relies on the administration of an antibiotic to which the isolate is sensitive together with control of any associated ectoparasites (體外寄生物) and appropriate risk reducing husbandry measures.

Preventative measures are dependent on an effective vaccine against the pathogenic strains of Streptococcus present in the fish environment or to which the susceptible fish stocks are likely to encounter. Strains of *Streptococcus iniae* being important in mariculture.

Streptococcosis is also a very important disease of freshwater pond fish cultures, particularly *Streptococcus agalactiae* of tilapia (*Oreochromis* spp.).

AFCD is also working with a local tertiary institution on developing an immunostimulant and a vaccine against *Lactococcus garvieae* and *Streptococcus iniae* infection for freshwater fish.

Viral Encephalopathy and Retinopathy (VER) Disease

VER is a viral disease of hatchery fingerlings affecting marine species. VER is caused by related viruses of the *Nodaviridae* family (羅達病毒科). The infected fingerlings are not able to swim properly and remain at the bottom of the tanks initially. After 24 hours, they lie on their sides (Figs. 19). Fish may twist their bodies in an attempt to swim, but gradually the affected fish become thin and will die after a week of onset of symptoms.

Figure 19. VER affected *Cromileptes altivelis* lying on their sides.

Diagnosis of VER is based on the demonstration of vacuolative and degenerative changes in the brain and retinal structures (Fig. 20), a PCR test,

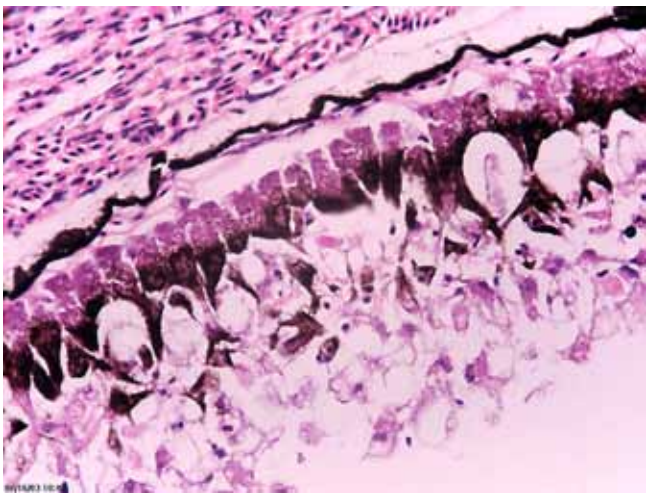

Figure 20. Advanced (eye) retinal vacuolation (視網膜組織空泡化), degeneration (退化) and dehiscence (裂開) of the retinal nuclear layers (核層) extending to the pigment cell layer (色素細胞層). *Cromileptes altivelis* with VER.

an immunoperoxidase test and virus culture.

There is no treatment for VER; affected fish stocks are humanely destroyed and the hatchery properly disinfected with quarantine strictly maintained to avoid spreading the infection. Import health testing against VER is critical in avoiding future introduction of the disease.

Grouper Iridoviral Disease (GID)

Grouper iridoviral disease (GID) is a significant cause of production loss primarily in the grow-out of giant grouper (*Epinephelus lanceolatus*), but also in green grouper (*Epinephelus coioides*). Losses of sea-caged giant grouper occur in the first few days of stocking but onset can be delayed up to 2 months post stocking. Infected fish become weak, floating near the surface, darkened and die with wide opened mouths with little external lesions. Splenic (脾臟的) enlargement, necrosis and congestion are observed. Pale gills indicating

Figure 21. Pale, anemic gills. *Epinephelus lanceolatus* with GID.

anaemia may be present (Fig. 21).

Diagnosis of GID is based on Giemsa stained smears of kidney, spleen or gills demonstrating presence of hypertrophic basophilic cells (HBCs), (Fig. 22) and confirmed with PCR and immunohistochemistry (免疫組織化學) tests, with virus culture in fish cell lines.

There is no treatment for GID; affected fish stocks are humanely destroyed and the farm properly disinfected with quarantine strictly maintained to avoid spreading the infection. Import health testing against GID is critical to avoid future introduction

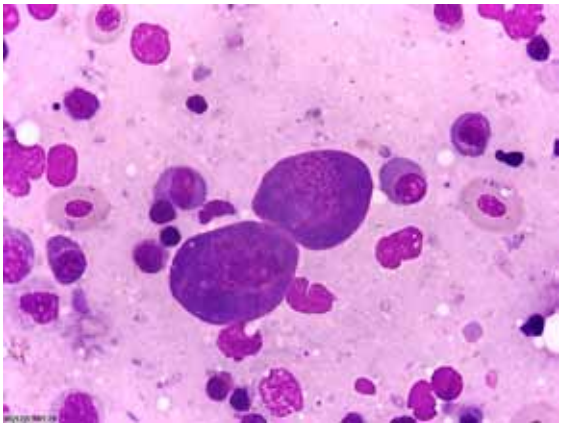

Figure 22. Giemsa stained kidney smear with two hypertrophic basophilic cells. *Epinephelus lanceolatus* with GID.

of the disease.

Benediniasis

Benediniasis, caused by the capsalid fluke affecting grouper (Fig. 23 and 24), snapper and amberjack species, particularly during autumn

Figure 23. *Epinephelus* spp. (brown spotted group) with heavy benediniasis causing corneal erosion and opacity.

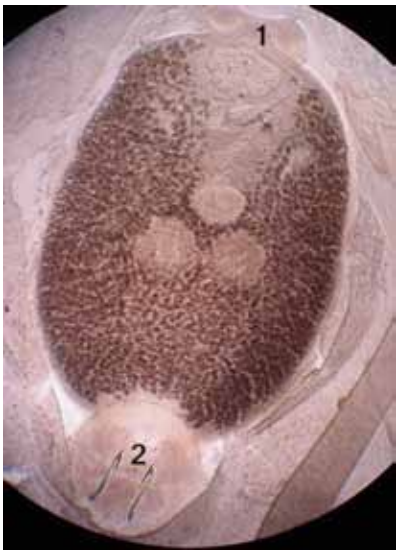

Figure 24. Adult *Benedinia* capsalid fluke. 1 = oral suckers, 2 = haptor organ for host attachment.

and winter months. Capsalids are transparent and move over the skin of the fish amongst the excessive mucus produced by the fish. This mucus makes the fish lose its normal shiny, wet appearance to become dull and whitish. Fish may rub on surfaces and create skin and fin ulcerations, pigment loss and erythema (紅斑). In eye infestations, the cornea becomes eroded and cloudy. Affected fish become inappetent (食慾不振), lose condition and mortalities occur in heavy infestations particularly with secondary vibriosis. Control is by freshwater bathing which may need to be repeated as the fluke produces eggs. Antibiotic treatment of vibriosis may also be required.

Ich Disease

The protozoan has a wide species range with *Cryptocaryon irritans* (Fig. 25 and 26) found in marine species and *Ichthyophthirius multifiliis* in freshwater species. Ich typically expresses disease as white spots of about 1 mm diameter on the skin and gills. However the absence of these spots does not preclude infestation with the parasite. Affected fish often have increased mucus production, which gives them a pale to whitish appearance and pallor on the gills.

Figure 25. *Cryptocaryon irritans* trophonts (營養體) in *Epinephelus lanceolatus* gill mount.

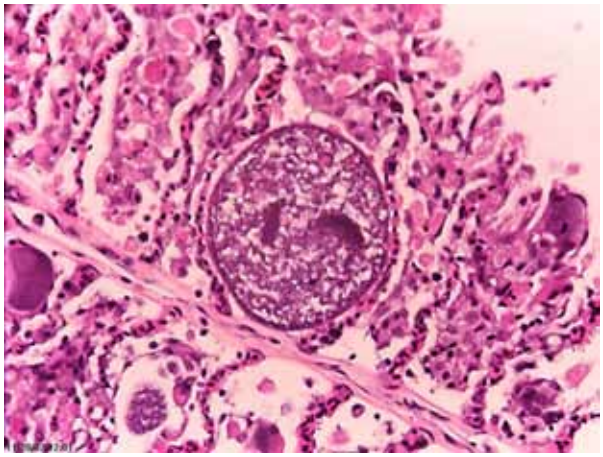

Figure 26. *Cryptocaryon irritans* trophont. Note the multilobed nucleus, and gill lamellar hyperplasia around the trophont.

Cryptocaryon irritans is treated with freshwater bathing. *Ichthyophthirius multifiliis* requires salt bathing to kill the released and free-swimming tomites as the embedded trophonts are immune to chemical treatment. Formalin baths are also effective but fish heavily infected will suffer mortalities despite treatment.

Fish Disease Control and Prevention

Fish disease management is a combination of preventing the onset of disease and measures to reduce losses from disease when it occurs.

In this section, the discussion will be focused on four broad strategies of achieving sustainable fish health: Two of these are under the direct control of the farmer. They are:-

- Husbandry
- Biosecurity

The other two are best performed under the advisement of a veterinarian. They are:-

- Medications
- Vaccination

Husbandry

Without optimum husbandry, the risk of disease increases on a farm. Fish stocks living under stressful conditions become less able to defend against a pathogen and hence will become sick more readily. Fish that are well cared for generally do not become sick even in the presence of a pathogen.

The principles of optimal fish husbandry are:

- Proper stocking densities
- Proper feeding
- Water quality management and hygiene

The most common error in fish husbandry is overstocking. This leads to problems such as :

- Fish to fish aggression
- Increased fish and feed wastes
- Ease of disease spread

- Increased concentration of pathogens
- Resultant poor water quality

Stocking density should be determined according to:

- the species of fish – some fish species do not tolerate crowding, as they are more aggressive or territorial.
- capacity of water exchange – low water exchange rates must mean lower stocking densities so that wastes do not accumulate.

Feed costs can constitute up to 55% of fish farming expenditure in the mariculture sector. Therefore strategies to maximise feed efficiencies and productivity are important. Feed management is also a part of environmental management. For the most part, fish farmers in mariculture rely on the supply of bait-fish or trash fish. This can present the following problems:

- Variability in the freshness of the bait-fish or spoilage.
- Transmission of parasitic and infectious diseases.
- Wastage and pollution.

The advantages of using pellet feed are:

- Improved feed conversion
- Improved hygiene
- Reliable supply and quality

Feeding rates are determined by the following factors:

- Stocking density and biomass (生物量) – larger quantities of feed are required for higher stocking densities but care is needed to avoid over-feeding by reducing feed rates as fish grow.
- Water temperature – lower water temperatures lower the metabolic rate (代謝率) and hence the energy and feed requirement of fish. At higher water temperatures, fish usually have very good appetites. But it is important not to overfeed when dissolved oxygen is marginally adequate i.e. < 5 ppm.
- Dissolved oxygen – oxygen demand increases when fish need to digest feed. If weather conditions are hot, and tidal current is slow, it is best to postpone feeding or restrict feeding. This avoids the loss of fish from post-prandial oxygen insufficiency.
- Handling – prior to and after handling such as in grading, transportation, harvest or disease bath treatments, feed should be withheld for at least 24 hours prior to handling. Again it is to minimise the risk of post-prandial oxygen insufficiency.
- Appetite response – observing the response of fish to food stimuli and feed consumption is an important husbandry activity. Where appetite is reduced, it may be an early symptom of disease or stress. Feed rates should be reduced until the reason is defined or appetite of fish returns.

A hygienic fish culture environment is essential to the health and productivity of farming operations. The reasons for this include:

- Disease risks are increased in poor and polluted environments.
- Quality of the product depends on clean and healthy environments.

The culture environment incorporates the following components:

- Physical farm infrastructure e.g. fish cages, floats, nets, and utensils.
- Water quality e.g. dissolved oxygen and microbial contamination.
- Seabed sediments e.g. solid wastes measured as carbon, nitrogen and phosphorus.
- Introduced chemicals e.g. antibiotics, metals and pesticides.

Farm hygiene is vital to maintaining fish health. It involves routine activities carried out by the farmer to ensure the following:

- Removal of biofouling from netpens.
- Cleaning of utensils and equipment used to handle or feed fish.

Water quality testing and correction of poor water quality includes the following:

- Measure dissolved oxygen and water chemistry values e.g. salinity, temperature, pH, ammonia, nitrite and nitrates.
- Measure bacterial counts e.g. *Vibrio* spp. counts of the water
- Aeration to maintain dissolved oxygen
- Cleaning of the farm seabed and fallowing (休耕) or rotation of sites (輪耕)
- Minimising organic pollution from fish wastes and feed wastes

Biosecurity (生物安全)

Biosecurity is an essential component of aquaculture operations given the serious risks of infectious disease transmission through the frequent movement of live fish and shellfish between countries, regions and farms. Biosecurity is about protecting a farm, region or country from the threats of infectious diseases, in particular exotic pathogens. Some practical examples are quarantining fish before inspection, removal of sick fish as soon as detected, frequent changes of water and never using fish trash for feed.

As part of sustainable and cost effective disease surveillance, prevention and early response to disease outbreaks to support both export trade and border protection of imported aquatic animals and commodities, a robust health testing, inspection and certification program is required. To that end AFCD initiated a health program for the ornamental fish export trade in Hong Kong. The program is composed of four activities:

- Farm inspection and biosecurity
- Health testing
- Health certification
- Disease notification, eradication and control

Medications (治療)

The role of medications in the management of fish disease outbreaks is well recognised as an important aspect of aquaculture operations and animal welfare. It is however a complex matter with many variables: it is thus best taken under advisement of a veterinarian. A veterinarian is required to ensure that the medicines used present no risk to human health. For example the banned drugs malachite green (孔雀石綠) and furazolidone (呋喃它酮) are effective at curing fish but they do make the fish unsuitable for human consumption. Also, veterinarians can guide farmers in the use of other more appropriate drugs which when properly used have no effect on human health. Otherwise medicines and money can be wasted due to poor efficacy. It has to be recognised that not all situations can be successfully treated with medicines.

The recognition of the pitfalls (隱藏的危險) and limitations of medications in sustainable health management is necessary. In addition if the fish are to be sold for human consumption the matter of drug residues and using the correct withdrawal procedure has to be addressed

The prescribing veterinarian should make the farmer aware of the main principles of medication. These are:

- Correct selection of medicine
- Correct dosage calculations
- Correct method of application
- Test batch treatment
- Observation and emergency resuscitation (搶救) measures
- Post treatment management
- Correct drug withdrawal time

It is critical that withholding periods for prescribed medicines including antibiotics are followed and records maintained, so that fish treated with medicines only enter the market for human consumption that do not exceed legal maximal residue limits (MRLs) for drug residues.

Vaccination

The vaccination of fish is still in its infancy compared to terrestrial animal disease vaccination programs. However there have been recent advances in fish vaccines. In certain circumstances the availability of a commercial vaccine is a highly valued tool in disease prevention and management. In the ideal world, if one is purchasing fish to grow out, one would want them vaccinated against relevant diseases. This is not a reality for all major fish diseases yet. However it is still a matter worth addressing and discussing vaccination in detail with a veterinarian. The veterinarian should be able to highlight some of the benefits, requirements and pitfalls of vaccination. As one can see from the Box 1 on the next page, this is a complex multifactorial (多種因素的) issue which requires the advice of an experienced veterinarian.

BENEFITS, REQUIREMENTS AND PITFALLS OF VACCINATION

BENEFITS

- Stimulate the production of specific protective immunity in vaccinated fish. Protect against specific diseases.
- Provide an extended level of immune protection against the vaccinated disease during the grow-out period.
- Limit the severity of infections should they occur and improve the survival and recovery from an infection of the pathogen vaccinated for.
- Reduce the use of antibiotics for bacterial diseases.
- No withholding period for vaccinated fish. No residue issues.
- Addresses environmental issues associated with chemical treatments.

REQUIREMENTS

- Good husbandry and nutrition.
- Proper size and water temperature at the time of vaccination.
- Route of vaccination: Injection better than immersion which is more efficacious than by feed.
- Correct technique (sedation & handling) and hygiene during vaccination.
- Adequate booster vaccinations.

PITFALLS

- Vaccinated against the wrong pathogen(s).
- Poor husbandry and nutrition, fish too small and temperatures below physiological optimum for fish species.
- Poor technique and handling during vaccination.
- Use of expired or compromised product eg. improper storage conditions for vaccine.
- Concurrent disease (併發症) at the time of vaccination.
- Use of immunosuppressive (抑制免疫反應的) drugs, e.g. corticosteroids and oxytetracyclines.

Box 1

Conclusion

"Prevention is better than cure" is an old English adage. Never is this truer than when considering the matter of fish diseases and maintaining the health of farmed fish.

Prevention of disease is not simply a matter of trying to use modern vaccines to halt disease. Prevention of disease starts with the sound management of the living creature. With regard to mammals this is called 'good stockmanship'. The same principle of good stockmanship applies to managing fish. It is vital that the fish are managed with consideration of their optimum requirements. This would mean many things, for example, ensuring that water quality is good and planning ahead on how to achieve this. Consideration should be given as to how to create an environment with few fish pathogens present in the water: this would mean being careful with stocking density, obtaining fish from 'clean' sources, emptying ponds and cleaning them, using 'clean' food, etc. In mariculture, a clean environment can be achieved by rotation of culture sites and proper disposal of dead fish.

AFCD officers continuously remind the farmers of these and other matters since these matters are the foundation, the base and the building blocks for a successful fish farm.

One of the ways to avoid disease for example parasitic diseases causing a significant outbreak is to spot the problem early. If a problem is spotted early at the very least one has given oneself some time to consider various possible steps to be taken before the outbreak becomes significant. It is for this reason that among other actions AFCD officers aim to equip and train farmers to spot a parasitic disease at an early stage.

The onset of fish disease usually has precipitating causes (e.g. introduction of subclinical disease carriers) therefore proper and early diagnosis is vital to minimise the impact of a fish disease. A fish health surveillance program is a vital asset to keep the farm disease free and maximise efficacy of disease control strategies in the event of an outbreak. This is the reason why AFCD officers emphasize the importance of farm management as a tool to prevent disease.

On a farm with terrestrial mammals one can separate out individual animals, for example, an individual calf. One can examine the calf and treat it by injection. This is also possible with farmed fish. Again on a terrestrial farm it is possible to very accurately mix medicine in the feed such that one has a very good idea how much medicine each creature has taken. Accuracy in the dosage and administration of farmed fish is necessary to ensure fish are effectively and safely treated because fish diseases spread rapidly and precise treatment is essential, as well as to maintain food safety standards by ensuring that chemical residues are minimised in treated fish.

It is routine, using races and fences, to manage cattle and sheep such that within 20 minutes, you can have 20 or more animals all stationery at one place. Then one can easily treat 20 animals in less than five minutes. On the terrestrial farm there may be less than 200 animals so that the administration of the medicine to a whole farm can take a few hours.

Fish farming is an intensive production system and requires proper management of fish stocks through proper siting of sea cages and cleaning of cage nets. In pond systems, regular draining and drying with cleaning of pond sediment is essential. Disease treatments require automation such as use of medicated feed and mechanical distribution of medicated feed. Water bath treatments utilise mechanised boats and tarpaulins to minimise the amount of drugs used. Tank based fish are treated with accurate calculation of tank flow rates, control of water exchange to maximise efficacy of medicines while minimising environmental impact.

As disease rates in fish occur quickly, emergency harvested of remaining healthy stocks may be more economical than trying to apply medication. Both treatment and prevention must be based on proper laboratory diagnosis, rather than attempting one treatment after another in the hope that one works.

Once that diseased batch has been farmed and harvested, it will be the work again of the AFCD officers to discuss with the farmer the best steps that can be taken to avoid a recurrence of the past outbreak. Advice both verbal and written will be delivered but it is of course the responsibility of the farmer to decide how to act on this advice.

The world population continues to increase and at the same time with continued economic development so does the demand for food with high quality sources of protein. While some of these new protein requirements may be satisfied by a worldwide increase in farmed animals there is certainly a large role to be played by the aquaculture industry. There are also sound health reasons for having a variety of sources of protein.

Aquaculture systems can be innovated to make use of limited land or sea sites, for example – intensive recirculation systems for hatchery fish production can be achieved with a small land area footprint. This will be relevant as the population increases and pressure builds up on the demand for utilization of certain land areas. AFCD officers in conjunction with the fish farmers in Hong Kong will continue to play their relatively small but highly relevant part in this developing story.

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