Health Management in Tropical Aquaculture Systems

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Abstract

Health management strategies are very important in aquaculture. In Asia, health management practices are broadly similar for the various aquatic species that are cultured. These focus mainly on maintaining the good health of the organisms throughout the life cycle. Good health management is based on an understanding of the interactions between the environment (water), the host, and the pathogens. In an ideal system, the three factors are balanced to offset a disease process. This balance is difficult to maintain in an intensive culture system and significant mortalities usually result. The outbreak of disease is thus related to poor health management. This paper deals with the health management practices applicable to the hatchery and grow-out stages of shrimp and fishes cultured in the tropics.

Introduction

The main aim of a fish farmer is to optimize production and minimize inputs. To succeed, the farmer must practise good health management from the hatchery to the grow-out farms, and until the fish, shrimp, or mollusk is sold in the market or processed into value-added products.

Fish farming is more complex than terrestrial animal husbandry. This is because in the aquatic environment, the physical and chemical changes can be very unpredictable and rapid. The health of aquatic organisms depends on the water quality. Poor water quality can stress the organisms and make them more susceptible to disease-causing pathogens present in the water. Fish health management must thus be oriented towards reducing the stress factors and the risk of infection by potential pathogens.

A careful study of all routine work in the hatchery or pond complex will reveal that health management practices can be and must be incorporated at every stage of the operation. Trained personnel and good engineering design are required to ensure this. Many operations have failed in the past due to unqualified personnel or poorly designed systems. It is imperative that the management of the operation be on a sensible and rational basis. Expensive foreign consultants hired to do the job often do not succeed because they do not understand local environmental conditions.

This paper discusses the health management practices that must be adopted in tropical aquaculture systems. Many of these practices have been refined over the years either by trial and error or more recently through scientific studies (Shariff et al. 1992).

Health Management in the Hatchery

Water quality

Good water quality is crucial in the hatchery and can be the deciding factor in its success. Most hatcheries treat the water before use, either with chemicals or with ultraviolet radiation to remove potential pathogens. In shrimp hatcheries, it is normal practice to pump the water from as far as possible at sea to ensure optimal water quality. Alternatively, water may be pumped through a sand filter bed. Hatchery operators unable to pursue these two options often pump water into large settling tanks and hold it there for 12-24 hours to allow the organic matter to settle or oxidize. Particulate matter may also be removed by filter bags, which come in various mesh sizes from 1 to 5 μm. Water may then be treated with calcium hypochlorite at a minimum dose of 5 mg/l. Chlorine reacts rapidly with sea water by freeing bromine to form oxidative by-products such as bromoform and bromate (Mangum and McIlhenny 1975), so it is essential to aerate the water to remove the toxic residues. Baticados and Pitogo (1990) have shown that water treated with chlorine should be used within 6 hours or else the bacteria will multiply back to pre-treatment levels.

Many hatcheries use ultraviolet irradiation of water for rearing. Ultraviolet kills 98% of the water-borne pathogens (Clary 1978). It also reduces by 99% the levels of infectious hematopoietic necrosis virus (IHNV), *Oncorhynchus maso* virus (OMV), channel catfish virus (CCV), and *Herpesvirus salmonis* (Yoshimizu et al. 1986). The ultraviolet disinfection is nontoxic, does not affect water chemistry, and can be designed to suit any flow rate. Water to be treated must first be cleaned of particulate matter that otherwise hinders the transmission of ultraviolet and makes it ineffective.

The use of ozone is yet another way to remove pathogens. Yoshimizu et al. (in press) have shown that ozone at a dose of 0.5 mg/1 for 15-30 seconds can remove 99.9% of *Vibrio anguillarum, Streptococcus* sp., *Aeromonas salmonicida, A. hydrophila* and *Escherichia coli* and inactivate 99% or more of hirame rhabdovirus, IHNV, and OMV. Ozone (O3) is formed with atomic oxygen when O_2 molecules are sufficiently excited to collide. Ozone is toxic to aquatic animals and ozonated water must be passed through activated carbon before it is used in culture tanks with animals. Besides removing pathogens, ozone also oxidizes some of the organic matter in the water.

Sanitary measures and quarantine

A well designed hatchery must be fully enclosed. To prevent the introduction of potential pathogens via movement of personnel, a dip containing a disinfectant must be provided at the entrance to the hatchery. All who enter must first step into the disinfectant. Inside the hatchery, disinfectant dips must also be provided to treat nets and other equipment used in the culture tanks.

Any animal brought into the hatchery must be checked to ensure that it is healthy and has been purchased from a reliable source. Some hatcheries have a quarantine area to ensure that animals are disease-free, or if necessary, are treated for a given period. New animals are usually given a dip or bath in formalin (25-250 mg/l) to remove external parasites.

Feeds can also be a source of pathogens. For example, *Artemia salina* has been shown to carry *Vibrio harveyi* which can cause severe mortalities among shrimp larvae (Pitogo et al. 1992).

There are no treatments for viral infections. Oftentimes hatcheries cannot get virus-free broodstock, particularly tiger shrimp free from monodon baculovirus (MBV). However, the transfer of infectious agents to the eggs can be minimized by removing the parents after the eggs have been fertilized. The eggs and larvae of shrimps can also be washed with clean filtered sea water to reduce the incidence of MBV infection (Chen et al. 1992). However, in various fishes, the larvae survive better when they are looked after by their parents. Thus, it is always better to use parents that are free of pathogens.

When shrimp or fish larvae or juveniles are purchased, they are usually examined for health status, external parasites, and signs of diseases. MBV is a common viral infection and can be easily detected under fresh smears as viral inclusion bodies. However, there are still many hatcheries that do not screen the shrimps for MBV inclusion bodies. Other visual criteria may also be used to determine the health of larvae. Healthy fish exhibit bright body color, well spread fins, and active swimming. The guts are full of food, and the larvae have straight bodies and swim actively against the current when the water is spun around. One significant point to note is that a sick fish or shrimp does not feed.

Routine procedures

Proper health management in the hatchery includes proper feeding regimes, sufficient water exchange and aeration, appropriate stocking densities, and maintenance of optimum temperatures. Excess feeds and feces increase the organic load and the concentrations of ammonia, nitrites, carbon dioxide, and bacteria. Acute mortalities can thus occur either due to the toxic environment or through secondary infections. Water quality must be maintained by frequent removal (siphoning) of wastes and regular exchange of water. Cleaning and handling of cultured organisms must be done with care and minimal disturbance. Sufficient aeration is essential to provide oxygen at all times. Water temperature in a hatchery must be maintained within an optimum range with the use of heaters or by enclosing the hatchery.

High stocking densities stress the animals and make them more susceptible to infections or other disorders. Overcrowding, increased oxygen consumption, and increased production of metabolic wastes lead to deterioration of water quality. Unfortunately, hatchery operators stock at high densities to compensate for anticipated losses and thus get into a vicious cycle.

Any abnormal behavior of the fish or shrimp, particularly the inability to feed or swim, must be checked out immediately. A change in the behavior may indicate an adverse environment or an infection. The situation must be analyzed quickly and the appropriate action taken. In many situations, an incorrect diagnosis is made and inappropriate interventions are taken. Usually the first attempt to correct the situation is the 'shotgun' approach of adding chemicals or antibiotics. The problem may simply be poor water quality stressing the fish. In such case, the improvement of water quality allows the animals to feed and swim normally again.

Dead larvae and juveniles must be removed routinely. Removal of dead organisms is an effective way to prevent the spread of diseases.

Hatcheries must break cycle at regular intervals for a thorough clean-up. All tanks and floors must be disinfected and the filters back flushed and dried. The tanks are usually disinfected with either chlorine or iodine compounds or other oxidizing agents.

Transfer of shrimp postlarvae or juveniles from a hatchery to a pond is done in the early morning when there is not much difference in water temperature. For shrimp postlarvae, a sudden change of temperature of even 1°C can cause severe shock. Postlarvae for stocking must be selected to be of normal shape and size, particularly the rostrum and appendages. The abdominal muscle must be clear. Since MBV-free postlarvae are difficult to obtain, those with fewer inclusion bodies must be selected for stocking in ponds.

Health Management in Ponds and Cages

Water quality

In many large pond complexes, water is kept in large settling reservoirs (to reduce the organic and particulate load) before it is directed into ponds. Wild fish, crustaceans, and other potential disease carriers are kept out of the pond by large trap nets. Pond water is monitored regularly to detect changes at an early stage - before acute mortalities can occur. High phytoplankton and zooplankton blooms can reduce oxygen levels in a non-aerated pond, particularly at night. Algal blooms can also be followed by a sudden mass die-off due to nutrient depletion and other sudden changes in water quality.

In shrimp ponds, the water must be changed when the pH variation is more than 0.5 units per day, when there is a sudden increase in water transparency, or when a stable foam appears at the pond surface. To avoid shock to the shrimps, not more than 30% of the water may be changed in one day. Lime and fertilizer must be applied regularly to maintain the optimum condition of the pond.

Providing aeration is a common practice not only in intensive but also in extensive culture of species such as aquarium fishes that do not tolerate low oxygen levels. Ponds are aerated by paddle wheels, the placement of which is very important. Paddle wheels must be positioned so that there is a circular movement of water in the pond and the silt can gather at the pond center.

Eight paddle wheels are recommended for a one-hectare shrimp pond (Chanratchakool et al. 1994). Ponds receiving 6 hours of nightly aeration to keep dissolved oxygen above 4 mg/l gave an average catfish yield of 4,813 kg/ha compared to 3,659 kg/ha from unaerated ponds (Zhang and Boyd 1988).

Overstocking adversely affects the water quality in ponds and stresses the cultured animals. Suitable stocking densities depend on the local environment, number of farms in the area, design and structure of ponds, availability of equipment, seasonal variations in climate, desired market size, and the experience of the farm personnel (Chanratchakool et al. 1994).

Maintenance of pond bottom and net cages

Feces, uneaten feed, and silt from incoming water accumulate on the pond bottom during the grow-out period. This high organic build-up is a source of hydrogen sulfide and also encourages disease-causing organisms to grow. Animals grown in ponds with well maintained bottoms usually show better feed conversion than those in poorly managed ponds. Poor pond bottom is indicated when shrimps have black or brown gills, external fouling, and damage to the appendages. Among fishes, fin rot is a common sign of a poor pond bottom. If pond bottoms are not managed, they can lead to the outbreak of disease and severe mortalities.

The pond bottom should be dried after harvest and prepared properly before stocking. It is often difficult to convince farm operators, especially those without a technical background, of the necessity to dry ponds. This is because ponds may sometimes take more than a month to dry and this can amount to a substantial opportunity cost, especially in shrimp farming where the earnings per hectare can be substantial. Drying the pond and removing the wastes manually or by machines are possible only during dry weather. Many farms still depend on dry weather to crack the pond bottom. Pressure pumps can be used to flush out wastes during any weather and is more convenient in places with lots of rain. However, pressure pumps carry out suspended wastes that pollute the receiving waters, and thus must be used carefully.

Once the pond has been cleaned, it must be flushed twice to get rid of debris and to stabilize the water pH. Then the pond is dried and limestone ($CaCO_3$) or quicklime (CaO) is applied to disinfect the pond bottom. After liming, ammonium sulfate can be applied at a rate of 10 g/m^2 in wet areas. The lime raises the pH and causes the fertilizer to release free ammonia (NH_3) which kills any remaining fish or potential pest in the pond. Organic fertilizer is then added to encourage the growth of natural food organisms. Chicken or other manures must be completely dried before use as fertilizer. Animal manures have high levels of organic carbon and total nitrogen; when they decompose, they use up oxygen and produce hydrogen sulfide, methane, and ammonia.

In a cage culture system, the nets are frequently cleaned and dried in the sun. Excessive fouling of nets impedes the water movement through the cages and leads to deterioration of water quality.

Health monitoring

The health status of the shrimps or fishes in ponds or cages can be easily monitored at feeding time. Healthy fish will immediately come to get the feed. To monitor shrimp feeding, a net (about 1 m^2) with a handful of feed is set at the bottom at feeding time. The net is lifted after one hour to check the feed consumption. Active feeding is an indication of healthy fish and shrimp.

Chemotherapy

Antibiotics are commonly used in most hatcheries. Without the use of antibiotics and other chemicals, many hatcheries do not have good yields. However, it must be understood that the adverse effect of antibiotics can be felt only after several culture cycles when even high doses no longer prevent or control diseases. Failed runs usually lead to a temporary shutdown of the hatchery and frequently a change of ownership. One of the factors that caused the collapse of the Taiwan shrimp industry in the late 1980s was the heavy use of antibiotics (Liao 1989). The rampant use of antibiotics has also been linked to the development of resistant bacteria in the region (Baticados and Paclibare 1992, Aoki 1992, Supriyadi and Rukyani 1992).

Among the antibiotics and antibacterial compounds commonly used in aquaculture in Southeast Asia are oxytetracycline, sulphonamides, chloramphenicol, oxolinic acid, erythromycin, furazolidone, nitrofurazone, flumequin, and enrofloxacin (Baticados and Paclibare 1992, Aoki 1992, Supriyadi and Rukyani, 1992, Tonguthai and Chanratchakool 1992). Neomycin is commonly used when packing aquarium fishes. Other chemicals commonly used in the tropics are benzalkonium chloride, copper sulfate, dipterex, formalin, malachite green, methylene blue, potassium permanganate, trifuralin, and common salt.

The use of immunostimulants or enhancers is now being promoted, particularly in the farming of high-value shrimps and marine fishes (Raa et al. 1992, Sakai et al. 1992). Vaccines are also being developed for bacterial diseases like edwardsiellosis (Iida and Wakabayashi 1992).

In marine cage culture, the usual treatment for parasitic and bacterial diseases is by reversing the salinity. Juveniles infected with protozoan and monogenean ectoparasites or those with fin rot are dipped in freshwater for 15 minutes then returned to the cages. Reversing the salinity is particularly effective against myxobacteria, which can cause up to 100% mortality (Leong 1992). This treatment is also done on new arrivals. Therapeutic regimes for infected fish call for two or more treatments at weekly intervals.

There are still many farmers who use traditional methods to treat fish diseases. Tobacco plant stems are introduced into ponds for the treatment of Copepod (*Lernaea*) infection. Various natural herbs and products derived from plants are being used in China for the treatment of various fish diseases. However, these herbal or plant products are not readily available in southeast Asia. Sometimes these traditional methods do not work effectively because the correct dose is not known or not applied accurately.

Handling and Transport

Careful handling of animals is crucial to high survival at all stages of the life cycle. Care must be taken to minimize stress during handling for sampling, treatment of diseases, and transport. Minor injuries on the body can lead to secondary infection with bacteria or fungi.

Fishes have natural protection - a mucus layer with antibacterial activity (Austin and Mcintosh 1988), but any form of handling that removes the mucus layer leads to secondary infection. Anaesthetics at the correct dose allow easier and less stressful handling, but at an incorrect dose may kill the fish.

Live fishes and shrimps for market are usually transported in chilled water in insulated containers, preferably at night or in the early morning. The animals may also be transported in plastic bags in insulated containers. Recently, anaesthetics, ammonia-absorbing substances, and buffer solutions have been used in the transport of fish. To reduce metabolic activity and the production of feces, fishes are starved 12 hours before transport.

Nutrition

Proper nutrition is essential for good health and optimal growth and reproduction of the cultured animal. Since the animals are raised under confined conditions, the diet must be well balanced and the essential vitamins and nutrients provided in the right proportions. Vitamin deficiencies can cause disease syndromes and deaths. Poor-quality 'trash' fish and other wet feeds can also lead to an increased susceptibility to bacterial infection.

Pelleted feeds must be stored in an appropriate facility to ensure that there is no loss of nutritive value. Most vitamins biodegrade with time, a process that is accelerated by high temperatures. Feeds must be purchased and used fresh. Feeds stored for more than three months lose their nutritive value and may become infected with fungi and other pathogens.

Conclusion

There is room for further improvement of health management in tropical aquaculture systems. For example, the transfer of pathogens must be prevented by ensuring that fish for export or import are free of pathogens. Quarantine procedures must be stringently observed.

Indiscriminate use of antibiotics like chloramphenicol must be banned in aquaculture. Chloramphenicol is the only effective drug against typhoid fever, and its use in aquaculture may produce resistant typhoid bacteria. Similarly, absolute care must be taken in the use of hazardous drugs and chemicals such as malachite green. New health management technologies must be examined closely before being adopted or used. New technologies may have adverse effects on the environment in the short or long term. One example is the use of organochlorines to treat parasites; this chemical persists in the environment and also gets into the food chain and to the fish consumers.

Another important point in the use of chemicals in aquaculture is the withdrawal period. Scientists have to work out the withdrawal periods for different drugs used in tropical aquaculture. Most of the available data are for temperate Fishes and shrimps.

More work must be done to investigate locally available natural products that are environment-friendly and have high safety margins for fishes and shrimps. Vaccines that can be used as prophylactics must be developed.

Fish health scientists must frequently highlight their findings that apply to the aquaculture industry. Findings in scientific journals do not easily reach the people in the field. Scientists must use other forms of media to make the public aware of issues in fish health management, including the hazards of antibiotics, drug residues, and the transfer of diseases through transport and introduction of animals to new places.

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