An Overview of Health Management, Issues and Constraints in Tilapia Diseases in Malaysia

SITI ZAHRAH, A., PADILAH, B. & AZILA, A.

National Fish Health Research Centre (NaFisH), 11960 Batu Maung, Penang

Abstract: The steadily increasing production of tilapia in recent years reflects the ever increasing interests in culturing tilapia in Malaysia. Red tilapia is favoured and cultured in ponds or cages in water bodies including ex-mining pools. When extensively cultured with intensive stocking density, disease problems become one of the limiting factors in providing better quality yields. In recent investigations it was shown that severe losses in production especially by high mortalities of caged-cultured red tilapia at Tasik Kenyir and Tasik Pergau, is due to *Streptococcus* with possible association or influence of water quality. Hence, this paper discusses the Streptococcal infection in tilapia, the main disease problem occurring after recent findings, and further research commitments required to possibly provide effective health management measures that could be implemented in helping to control further economic loss. This is essential to prevent further loss in investment potential of red tilapia culture by interested aquaculture entrepreneurs.

Keywords: tilapia culture, disease, water quality, research, health management

Abstract: Peningkatan berterusan dalam pengeluaran tilapia dalam tahun-tahun kebelakangan ini mengambarkan peningkatan minat dalam ternakan tilapia di Malaysia. Tilapia merah paling disukai dan selalunya diternak di dalam kolam atau sangkar termasuk kawasan bekas lombong. Apabila dikultur secara ekstensif dengan kepadatan stok yang intensif, masalah penyakit menjadi salah satu faktor penghad dalam menghasilkan ikan yang lebih berkualiti. Hasil siasatan baru-baru ini menunjukkan bahawa kerugian besar dalam pengeluaran ikan tilapia merah yang diternak di dalam sangkar di Tasik Kenyir dan Tasik Pergau adalah disebabkan oleh *Streptococcus* di samping pengaruh kualiti air. Justeru itu, kertas ini akan membincangkan mengenai jangkitan *Streptococcus* dalam tilapia, masalah utama penyakit dan penyelidikan yang diperlukan untuk menyediakan pengurusan kesihatan yang efektif yang boleh dilaksanakan dalam membantu mengawal kerugian seterusnya. Ini penting bagi mengelakkan kerugian jangka panjang dalam pelaburan industri ternakan tilapia merah.

Introduction

Tilapia culture and production in Malaysia

Culture of pure tilapia breed was first introduced in Peninsular Malaysia in the early 1950's. However, its culture was poorly received due to its fast breeding habit, thus of low commercial value (http://agrolink.moa.my). However, in the mid 1980's a hybrid of red tilapia (*Oreochromis niloticus*) was introduced and this gained popularity and since then have mainly been cultured in ponds, although other systems are later used (such as the floating net cages or cage-culture systems popularly practiced in ex-mining pools, natural or man-made water bodies, including rivers, example in Sungai Pahang).

With the application of various culture systems, annual yields increases as observed in the last four years, (from 1997-2000) as shown in Fig.1. It was reported that total harvest of tilapia production in the year 2000 alone, accounted for 36 % of the freshwater aquaculture production. Since tilapia is recognized as one of the freshwater fish species to be commercially produced to meet the target of National Agriculture Policy (NAP) 3, tilapia culture can be further expanded.

From Fig.1, in year 2000 alone, more than 15,000 metric tonnes (MT) tilapia were harvested, the bulk of which came from ponds, which amounts to 70% of the total yield. This is comparatively high if compared to the total yield of red tilapia in 1990, which was about 900 MT (Department of Fisheries (DOF), 1990). However, there is significant increase in yield from net cages that is, about 300 MT to 2660 MT from 1990 to 2000 respectively, which is about seven fold. At the moment, cage-culture constitutes about 10% of the total production. Though the yield is more from the ponds but with recent development, land used is limited hence giving way for the cage culture system to be further exploited.

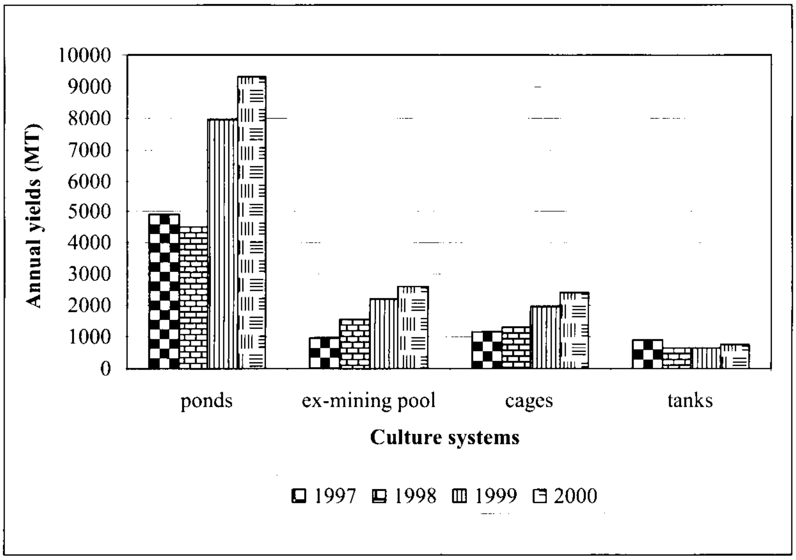

Figure 1: Annual yields of Red Tilapia in various culture systems from 1997 - 2000

In view of this, DOF has identified man-made lakes and reservoirs for cage-culture farming covering a total surface area of 87,660 hectares of which 25,496 hectares are potential areas for cage-culture development (http://agrolink.moa.my). At the moment, tilapia cage-culture has already been operating in Empangan Timah Tasoh (Perlis), Tasik Kenyir (Terengganu) and Tasik Pergau (Kelantan). Ex-mining pools can also be considered to be another option for culture of tilapia, which is abundant in the state of Perak. The tilapia production from ex-mining pools accounted 13% (3,155 MT) of the total yield in year 2000.

With increase in the production of tilapia, there is therefore a rapid growth of cultured tilapia industry in Malaysia. However, intensification of culture systems has resulted in an increase in the incidence and severity of disease agents present in tilapia, which has been otherwise reported to be `hardy', or more resistant to disease agents than many other cultured fish (Roberts and Sommerville, 1982), as evidenced by the very few reports of disease incidences from the 1980's till 1996.

However, by 1997-1998, high mortalities of tilapia were observed in floating cages in Sungai Pahang at Temerloh. The mortalities at the time were observed to be occurring in larger size fishes weighing more than 300-400 g. Investigations revealed that the chronic high water temperature, together with low water level during the dry season in the sandy river-bed magnified the stress conditions which pre-disposed the fish to disease problems (Siti-Zahrah *et al.*, in press). Hence, disease again becomes a constraint to better yield.

Common diseases of tilapia

a. Protozoans Parasites

i. Ichthyopthirius multifiliis

White spot or *Ich* is one of the most important protozoan or ciliated parasites of tilapia, known to be distributed throughout the world (Hoffman, 1978) and was first described in wild tilapia. *Ich* has a direct life cycle and requires a fish host to survive. The infective stage is the the theront and infection is characterized by white spots where the *Ich* organisms live in the epithelium of skin and gills of the infected fish (Ewing and Kocan,1992).

Subasinghe and Sommerville (1992), demonstrated that the most susceptible life stage of the tilapia is the fry. Significant mortality can result and the parasites were found in the nares, pharynx, gills and skin of the young fry (Roberts and Sommerville, 1982). It is one of the most important pathogens in recycled water tank systems because of the density at which the fish are raised and the potential for rapid 'fish to fish' transmission in these systems. Optimum temperature for *Ich* is 20-26°C. As such, Plumb (1997) has suggested that because the optimum temperature for tilapia production is 5-10°C warmer than the optimum for *Ich*, this may limit the severity of this disease. There are no FDA-approved chemotherapeutic agents effective against the encysted trophozoites in the fish epithelium.

ii. Other ciliates

Trichodina spp., *Trichodinella* spp., *Chilodonella* and *Epistylis* are ciliates that attach to tilapia. *Trichodina* spp. is probably the most reported (Natividad *et al.*,1986; Plumb,1997) and observed to be most common in fry in tanks at the nursery stage in our local hatcheries. The parasite is saucer shaped and usually causes damage to the skin and gills. Signs of disease include respiratory distress, loss of appetite, de-pigmentation or loss of scales. This may later result in secondary infection due to damage of the host skin. These parasites may be treated with formalin or other approved parasiticides. It may take multiple treatments to effectively control the ciliates.

iii. Flagellated protozoa

Ichthyobodo necatrix was reported to be the most important flagellated parasite of tilapia by Plumb (1997), but commonly found in young fry. They are similar to *Ich* in that they need a fish host for survival. Its transmission is by direct fish to fish contact. Effective treatments include copper sulfate and formalin. Parasitic examination so far conducted on local tilapia, did not show its presence.

iv. Metazoan Parasites

Monogenetic trematodes

Shoemaker *et al.* (2000), reported that the most common monogenean are *Gyrodactylus* sp. and *Dactylogyrus* sp. in tilapia which are found on the skin and gills of the tilapia respectively. However, Paperna and Thurston (1969) described *Cichlidogyrus* as the main group of monogenea specific to the gills of cichlid fish including tilapia. *Cichlidogyrus sclerosus* and *Cichlidogyrus tubicirrus* minutus were also reported to show site-specificity on the gills of tilapia by Shaharom (1985).

The monogenetic trematodes have a direct life-cycle and thus must have a fish host to survive. Transmission is by fish to fish contact or water. These parasites are not a problem unless they increase to tremendous numbers and thus result in partial suffocation (Post, 1987). Plumb (1997) also suggested that parasite attachment sites on gills and/or skin of the fish may act as portals of entry for primary or secondary bacterial and fungal pathogens.

Digenetic trematodes

Natividad *et al.* (1986) and Roberts and Sommerville (1982) reported the presence of variety of digenean parasites in tilapia, but of less frequently encountered. Similarly, there are not many reports of these parasitic infections on the locally reared tilapia, especially those cultured in floating net cages, as these parasites involve three hosts: a snail, a fish and a fish eating vertebrate.

v. Tapeworms, Acanthocephalans and Nematodes

Plumb (1997) reported these to be not much of a problem in cultured tilapia. These parasites are yet to be reported in Malaysia.

b. Viral diseases

Two viral diseases have been reported as observed by Shoemaker *et al.* (2000). One agent is an Iridovirus causing lymphocystis which was first described by Paperna (1973) in wild tilapia. This is characterized by hyperthrophied cells which forms clusters or bumps on the skin and or the fins of infected fish. This virus was however, not identified in cultured tilapia as reported by Plumb (1997). The second viral agent was reported by Avtalion and Shlapobersky (1994) that has yet to be identified and larval tilapia was found to be highly susceptible. The viral particles about 100 nm in size were contained in brain cell endoplasmic reticulum. Clinical signs include whirling in water followed by darkening of the skin and anorexia.

There are no effective treatments for viral agents in tilapia, however the best approach is quarantine of larval fish and avoidance of fish with reported history of viral disease problem to avoid introduction into culture facilities.

c. Fungal infections

El-Sharouny and Badran (1995) recovered seventeen fungal species from tilapia. Of those recovered, *Saprolegnia parasitica* and *S. ferax* resulted in mortalities in experimental animals. As suggested by Plumb (1997) most problems with fungus arise when water temperatures are near the lethal level for tilapia. Spores of the fungus usually attach to damaged or unhealthy tissue of fish and become established by producing mycelium (fuzzy or cotton like on the surface of the fish). *Branchiomyces* spp. was also reported in the gills of tilapia (Roberts and Sommerville,1982) which may cause high levels of mortality (Plumb,1997). *Branchiomyces* spp. favor organically rich water and thus, may become established in water re-use systems.

Fungal problems may be more prominent in hatcheries producing fry. The best way to avoid is to remove the injured or non-fertilized eggs, hence avoiding establishment of fungal infections in healthy eggs.

d. Bacteria

i. *Motile Aeromonads and Vibriosis*

Because the disease symptoms seen in tilapia for both *Aeromonas* and *Vibrio* infections are similar, they will be described together. As mentioned by Plumb (1999) bacteria responsible for *Aeromonas* septicemia include *Aeromonas hydrophila*, *A. sobria*, *A. caviae*, *Pseudomonas* sp. and other related species. *Vibrio* sp. described from tilapia include *V. parahaemolyticus* by Hubert (1989) and *V. mimicus* by Plumb, 1997. Other *Vibrio* sp. may occur in saltwater. These bacteria species are short, negative, and highly motile rods, and all members of *Vibrionaceae* are cytochrome oxidase positive. *Vibrio* sp. are Gram negative comma shaped or curved short rods and are sensitive to *vibriostat* 0/129, whereas the *Aeromonas* sp. are resistant and occur as short rods.

Most researchers believed that motile *Aeromonas septicemia* and *vibriosis* are secondary infections that occur following stressful conditions (Plumb,1997). The bacterial isolations typically occurred following changes in water temperature or after handing and/or transport of fish. Hence, management practices to minimize water temperature changes and reduce handling will be the best solutions to these problems.

ii. Edwardsiella tarda

Plumb (1997) described *E.tarda* infections as a septicemia in tilapia especially if cultured at high densities and adverse conditions. In the United States, *E. tarda* has been isolated and resulted in losses to producers raising tilapia in water re-use systems. Until now, this bacterium has not been isolated as yet in our local conditions. *E. tarda* is an enteric, Gram-negative motile rod, which is presumptively identified as oxidase negative and producing an alkaline over acid plus gas and H_2S on triple sugar iron (TSI) agar (Plumb,1999). Infected tilapia showed signs of lethargy, enlarged abdomen, exophthalmia and hemorrhagic eyes. Necrosis and gas filled pockets may be observed in the muscle in some cases.

Treatment for *E. tarda* is by the application of medicated feeds, however, this may or may not be effective. Development of an effective vaccine will help to prevent this infection. Currently, a modified live vaccine is being evaluated by Shoemaker *et al.* (2000), that shows promises for protection against disease caused by *E.tarda* in tilapia. Care should be taken when handling fish known to be infected with this pathogen because there has been reported cases in humans following puncture wounds (Shoemaker *et al.*, 2000).

iii. Columnaris disease

The causal agent is *Flavobacterium columnare* (*Flexibacter columnaris*), that has also been reported in other fishes. This is often difficult to grow on media and initial identification of the bacteria is from wet mount of the fish skin and /or gills. Long slender rods often forming haystacks in wet mounts is a presumptive identification of the disease (Plumb, 1999). Clinical signs include frayed fins, de-pigmented lesions on skin and necrotic lesions in gills. Often, the margins of the lesions will have a yellow appearance because of the pigment in the bacteria. Isolated bacterial colonies are yellow in color with rhizoid margins. Up to date, this condition has not been identified to be a problem in our local conditions.

Amin *et al.*, (1988) described columnaris in cultured Nile tilapia (*O. niloticus*) and observed that the pathogenecity of the tested isolates were different. They were only able to experimentally induce mortality, if the gills were damaged or if the fish were held in water with elevated ammonia. In another study by Klesius *et al.* (1999), on channel catfish it was demonstrated that nutrition influenced *F. columnare* induced mortality, where fish that had been withheld food for a period of more than a week exhibited significantly higher mortality than fish that were fed. They suggested that the innate resistance was negatively influenced by poor nutrition.

Presently, there are no effective treatments for *F. columnare*. Shoemaker *et al.*, 2000, reported that work is in progress to develop an effective killed *F. columnare* or modified live vaccine for use in food fish.

iv. Streptococcal disease

Gram positive bacteria which have a worldwide distribution have been reported to cause significant problems in over 22 species of marine and freshwater fish including tilapia (Shoemaker *et al.*, 2000). Ringo and Gatesoupe (1998) have published a review of lactic acid bacteria in fish and reported that the pathogenic bacterial species including *Streptococcus, Enterococcus, Lactobacillus, Carnobacterium* and *Lactococcus* have been isolated from ascites fluid, kidney, liver, heart and spleen of sick fish.

In tilapia, pathogenic Streptococci that had been reported to cause disease included the two most important, non-hemolytic *Streptococcus* spp. (Chang and Plumb,1996), *Streptococcus iniae* (Klesius *et al.*, 1999), *S. difficle* (Eldar *et al.*,1994) and the alpha hemolytic *Streptococcus* sp. (Bunch and Bejerano, 1997). However, Ringo and Gatesoupe (1998) did not indicate the brain and nare as sites of isolation in diseased fish. Evans *et al.* (2000) instead, demonstrated that tilapia and hybrid striped bass could be infected with *S. iniae* following inoculation via the nares but not by inoculation of the eyes. They further demonstrated that dissemination of *S. iniae* in the fish following inoculation of the nares was wide, in this case, organs of the nares, brain eye blood anterior kidney and heart where bacterial culture was attempted in diseased fish were positive for *S. iniae*.

Typical signs of the disease early in the infection process include slow to no feeding response followed by darkening of the pigment, erratic swimming, lethargy, exophthalmia and death. Most often, exophthalmia and eye opacity are the final signs observed. Eye opacity or cloudiness appears to be more associated with chronic disease. The above described clinical signs are apparently the obvious symptoms observed in the cage-cultured tilapia in Tasik Kenyir, Terengganu. The cage-culture operators have reported tilapia mortalities since 2000. The significantly high mortalities were observed annually since then, especially during the months of April, May, and June while sometimes until July, which probably could be associated with the change of dry to wet seasons. This year however, high mortality of cage-cultured tilapia in Tasik Kenyir was reported much earlier, that is in early March (4-11th March 2003).

The investigations conducted earlier, confirmed the diagnosis with the presence of *Streptococcus* spp. cultured from in the eye, brain, kidney, liver and spleen of the diseased tilapia. Hence, at present further investigations and studies are being conducted in cage-cultured tilapia at Tasik Kenyir and Tasik Pergau, Kelantan to determine the extent of disease outbreak, the main pathogen particularly *Streptococcus* sp. and its pathogenicity and possible relationships with water quality parameters and rainfall associated with seasonal changes in a year. The study started in September last year with the co-operation of the cage-culture operators, state fisheries and research centre in Tanjung Demong, Terengganu.

Preliminary findings showed that Streptococcal disease persist in the later months but with a minimal degree of mortality. Almost all sizes of tilapia are affected, but most are within the range of 100 - 400 g, showing typical signs of erratic swimming, eye abnormalities (exophthalmia, corneal opacity /cloudiness, blindness or hemorrhagic eyes), lethargy and no feeding. *Streptococcus* spp. and *S. agalactiae* has been identified from the eye, kidney and brain apart from *Aeromonas* sp. in most of the samples even though the tilapia were seemingly healthy, possibly asymptomatic carriers. Occasionally, bacteria were not isolated at all from tilapia showing serious clinical signs. Histopathological changes showed general septicemia with cellular infiltration and numerous bacterial cocci in most organs. The lesion is non-specific, however, the present of numerous cocci in brain, spleen, liver and kidney together with *Streptococcus* isolation in the laboratory indicated Streptococcal infections. This phenomenon of Streptococcal dissemination throughout the fish was demonstrated by Evans *et al.* (2001). Non-suppurative meningo-encephalitis was also observed in the brain, while in the cerebrum meningeal vessels were prominent due to congestion and hypertrophy of the endothelium, hence, resulting in the erratic swimming observed in diseased tilapia, due to these pathological changes. Shoemaker *et al.* 2000 reported that most often the final signs observed are the corneal abnormalities such as exophthalmia and eye opacity.

Management and environmental factors that have been studied associated with Streptococcal infections in tilapia include stocking density (Shoemaker *et al.*, 2000), water temperature, dissolved oxygen and nitrite level (Bunch and Bejerano, 1997). These factors were found to have direct effect on causing and aggravating Streptococcal infections. Hence, it is pertinent to determine the effect of other contributing factors on cage-cultured tilapia exposed to the extreme weather changes from dry to rainy seasons in the problem areas of Tasik Kenyir, Terengganu as suspected.

Impacts of disease occurrences

Most of the disease problems experienced by the farmers are very much related to the pre-disposing stress factors related to management and environmental conditions in the specified areas of culture, apart from the existing opportunistic pathogens and the condition of the fish itself. The stress factors induced favourable conditions for increased susceptibility of fish to pathogens, hence magnifying disease problems. Some of the disease impacts included:-

i. Economic loss- that depends on the rate of mortality during the time of outbreak and less saleable products of the remaining fish, also reduced demand and supply of fish.

ii. Increased expenditure on treatment and prevention if available, which definitely increased cost of production. The problem also brings about the cost of disposal of diseased fish during the outbreak to ensure safety and contain disease from spreading.

iii. Low quality yield due to stunted growth or possible latent and asymptomatic carriers. The carriers harbour the pathogens and become the potential nucleus of disease transmission or dissemination in any future cycle of drastic environmental changes and stress.

iv. Negative influence to interested entrepreneurs on the potential culture viability of so called `hardy' tilapia. Commercial viability and sustainable culture will be questionable and as such market potential is unattractive enough to invest.

v. Positive effect at the hatchery level; hatchery operators will try to produce quality and healthy fry to ensure continuous and reliable market demand.

Less demand on tilapia and their products by consumers will not be a good sign to the industry because reduced consumption might hinder sustainable growth below the expectation projected.

Tilapia diseases, prevention and treatment

Certainly, most of the diseases encountered in tilapia could be prevented and in some cases can be treated. Parasitic diseases usually can be controlled and prevented through treatment and proper management practices. For example, the *Trichodina* sp. infection in tilapia can be easily treated or controlled using formalin at 20-30 ppm, 3 times at regular interval of 3 days after diagnosis. However, there are cases like Streptococcal infection that are more complicated and hence, control of Streptococcal disease has to be considered with other related factors such as:-

i) Management practices - with good, proper practice and due consideration of the health status of the growing tilapia during culture period

ii) Avoidance of stress due to poor water quality, overfeeding or unnecessary handling during critical periods should be practiced as drastic water temperature fluctuations are observed during seasonal changes

iii) Prompt removal of carcasses and seriously infected fish from culture units to control *Streptococcus* spp. from being disseminated to healthy fish during disease outbreak

Iv. To treat the suspected fish or those infected fish using Erythromycin at 25-40 mg/kg of body weight/ day for 4-7 days

v. Source of the tilapia fry is to come from reliable hatcheries with good record keeping to ensure only healthy and quality fry are being produced

Issues and constraints

1. Disease epizootics

At the moment, the main concern is identifying all the possible causes in the present disease epizootics in tilapia culture, especially those that are causing high mortalities and severe economic losses. In view of this, Streptococcal disease is one that have to be considered seriously and management strategies for short and long term measures, such as identifying the critical period of disease outbreak and avoiding tilapia culture during that particular period should be available. The long term strategy is definitely aimed at the control or prevention of its occurrence through effective control measure using developed vaccine through systematic research. This can be accomplished through R&D to choose the best candidates for vaccine development which could either be whole bacterial cells, recombinant proteins or modified recombinant bacteria.

2. Management factors

Stocking density influences the health status of cultured tilapia as reported by Shoemaker *et al.* (2000) in the case of Streptococcal disease. Low density stocking will be less susceptible to disease pathogens that have already been identified to be pathogenic to tilapia.

Record keeping enable the farm operators to detect the source of quality and healthy fry, awareness of the seriousness of the particular disease occurrence, appropriate time of antibiotic treatment or time of intervention as well as duration of treatment, reliable data that provide the true extent of economic loss and any relation to feeding regime and feeding rate.

3. Environmental factors

Water quality parameters

Monitoring the important parameters, example, DO, temperature, pH, turbidity, nitrite and nitrate level, phosphate, ammonia, etc, will help to indicate the quality of water that is associated with disease problems.

Weather conditions

The two distinct dry and wet seasons seemed to have certain effect on the water temperature of the localities as observed in the tilapia culture in cages in Tasik Kenyir, Terengganu and Tasik Pergau in Kelantan. This is obvious especially during the sudden change from wet to dry season and throughout the dry season, where the temperature is higher than normal.

4. Research support and commitment

- Identification of the source of disease problems; identifying the possible source and pre-disposing stress factors leading to disease occurrence is the responsibility of the research group. Certainly, the factors pointed above will have to be taken due considerations, and at present the sampling of both tilapia and water are relevant to arrive at any reasonable conclusion.

- Identification of the source of disease problems; identifying the possible source and pre-disposing stress factors leading to disease occurrence is the responsibility of the research group. Certainly, the factors pointed above will have to be taken due considerations, and at present the sampling of both tilapia and water are relevant to arrive at any reasonable conclusion.

- Diagnosing the disease and its etiology, the pathogenic mechanism associated with the host after infection and the pathological effects leading to mortality.

- Database build-up in understanding further related information on the causal effects of the disease. identified, hence helping in strategic planning for the prevention or control of repeated yearly disease outbreak.

- Institutional support in slowly building up manpower expertise and well trained human resource in dealing with disease diagnosis or outbreak.

- Strong and continuous financial and moral support for determining any disease problems in fish culture systems for the benefit of the industry, whilst putting the confidence back in aquaculture farming to responsible fish farmers.

- Collaborative research with higher institution and government agencies of similar interests to buildup linkages as well as enhancing expected outcomes with strong foundation.

- Two-way swift transfer of information and technology to the aquaculture operators and vice-versa for easy assessment of the accomplished result or the field trials conducted.

- Dissemination of relevant scientific or technical information through workshop or seminars to interested parties.

Conclusions

From the discussions, it is reasonably fair to say that tilapia practice in Malaysia is less likely to have major diseases of importance. However, as mentioned, Streptococcal disease is of critical concern to the culturing of tilapia culture especially those cultured in floating net cages at Tasik Kenyir. The economic losses through high mortality of tilapia are worrisome to all the cage-culture operators. Even though no reports were received as yet from tilapia pond culturists, it is a matter of time and it is not impossible for Streptococcal infection to be detected and infect tilapia in ponds and hatcheries. Thus, the ongoing study to determine the possible source of infection and pre-disposing factors which enhances the disease outbreak is timely and appropriate.

Changes in the environmental factors between seasons, particularly water quality parameters at the culture sites were suspected to have strong influence or association with the disease occurrence. High mortality was usually observed after the disease outbreak.

Data base compilation of the Streptococcal disease in tilapia with relation to the size /weight of fish affected, clinical symptoms, prevalence of *Streptococcal* sp. and other bacteria isolated, water quality parameter and seasonal changes will provide essential analytical information during the course of the disease outbreak and its persistence throughout the year.

The analysis of the relevant data will certainly provide a true picture of the Streptococcal disease prevalence in caged tilapia which could help in determining the short and long term practical measures in controlling and preventing the disease.

Continuous research support and commitment on the financial and technical collaborative programmes between research centres and higher institutions will definitely build-up the expertise and experience to the health research team in tackling other disease problems encountered later. Technical guidance by the personnel of the higher institution on determining the true pathogens and their mechanism of infection and thus using latest molecular diagnostic technique to diagnose, control and prevent the disease is to the advantage of both the research team as well as to the industry at large.

References

Amin, N.E., Abdallah, I.S., Faisal, M., Easa, M., Alaway, T. and Alyan, S.A. 1988. Columnaris infection among cultured Nile Tilapia *Oreochromis niloticus. Antonie van Leeuwenhoek* **54**: 509-520.

Avtalion, R.R. and Shlapobersky, M. 1994. A whirling viral disease of tilapia larvae. *The Israeli Journal of Aquaculture Bamidgeh* **46**: 102-104.

Bunch, E.C. and Bejerano, I. 1997. The effect of environmental factors on the susceptibility of hybrid tilapia (*Oreochromis niloticus X O.aureus*) to Streptococcosis. *The Israeli Journal of Aquaculture Bamidgeh* **49**: 67-76.

Chang, P.H. and Plumb, J.A. 1996. Histopathology of experimental *Streptococcus* sp. Infection in tilapia, *Oreochromis niloticus* and Channel Catfish, *Ictalurus punctatus* (Rafinesque). *Journal of Fish Diseases* **19**: 235-241.

DOF. 1990. Annual Fisheries Statistics 1990. Department of Fisheries Malaysia, Ministry of Agriculture.

DOF. 2000. Annual Fisheries Statistics 2000. Department of Fisheries Malaysia, Ministry of Agriculture.

Eldar, A., Bejerano, Y. and Bercovier, H. 1994. *Streptococcus shiloi* and *Streptococcus difficle*: Two new streptococcal species causing meningoencephalitis in fish. *Current Microbiology* **28**: 139-143.

El-Sharouny, H.M. and Badran, R.A.M. 1995. Experimental transmission and pathogenicity of some zoosporic fungi to tilapia fish. *Mycopathologia* **132**: 95-103.

Evans, J.J., Shoemaker,C.A. and Klesius, P.H. 2001. Distribution of *Streptococcus iniae* in Hybrid Striped Bass (*Morone chrysops X Morone saxatilis*) following nare inoculation. *Aquaculture* **194** (2001): 233-243.

Evans, J.J., Shoemaker, C.A and Klesius, P.H. 2000. Experimental *Streptococcus iniae* infection of Hybrid Striped Bass (*Morone chrysops X Morone saxatilis*) and tilapia (*Oreochromis niloticus*) by nares inoculation. *Aquaculture* **189**: 197-210.

Ewing, M.S. and Kocan, K.M. 1992. Invasion and development strategies of *Ichthyophthirius multifiliis*, a parasitic ciliate of fish. *Parasitology Today* **8**: 204-208.

Hoffman, G.L. 1978. Ciliates of freshwater fishes. Parasitic protozoa: Intestinal Flagellates, Histomonads, Trichomonads, Amoeba, Opalindas and Ciliates. Academic Press Inc., New York . 583-632 pp.

Hubert, R.M. 1989. Fish culture in warm water systems: Problems and trends. CRC Press, Boca Raton, Florida. 187-194 pp.

Klesius, P., Lim, C. and Shoemaker, C. 1999. Effect of feed deprivation on innate resistance and antibody response to *Flavobacterium columnare* in Channel Catfish, *Ictalurus punctatus*. *Bulletin of the European Association of Fish Pathologist* **19(4)**: 156-158.

Natividad, J.M., Bondad-Reantaso, M.G. and Arthur, J.R. 1986. Parasites of Nile Tilapia (*Oreochromis niloticus*) in the Phillipines. First Asian Fisheries Forum, Manila, Philllipines. 255-259 pp.

Paperna, J. 1973. Lymphocystis in fish from East African Lakes. *Journal of Wildlife Diseases* **9**: 331-335.

Paperna, J. and Thurston, J.P. 1969. Monogenetic trematodes collected from cichlid fish in Uganda; including the description of five new species of *Cichlidogyrus*. *Rev. Zool. Bot. Afr.* **79**: 15-33.

Plumb, J.A. 1997. Tilapia aquaculture in the Americas, Vol.1. World Aquaculture Society, Louisiana. 212-228 pp.

Plumb, J.A. 1999. Health maintenance and microbial diseases of cultured fishes. Iowa State University Press, Ames, Iowa.

Post, G. 1987. Textbook of fish health. T.F.H. Publications, Inc. New Jersey.

Ringo, E. and Gatesoupe, F.J. 1998. Lactic acid bacteria in fish: A review. *Aquaculture* **160**: 177-203.

Roberts, R.J. and Sommerville, C. 1982. The biology and culture of Tilapias. *In*: ICLARM Conference Proceedings 7. Manila, Phillipines. 247-268 pp.

Shaharom, F.H. 1985. The site-specificity of *Cichlidogyrus sclerosus*, its juveniles and *Cichlidogyrus tubicirrus minutus* on the gills of tilapia species. *Tropical Biomedicine* **2**: 107-112.

Shoemaker, C.A., Klesius, P.H. and Evans, J.J. 2000. Diseases of tilapia with emphasis on economically important pathogens. Big Island Aquaculture Newsletter, Sept. 2000. 565-574 pp.

Siti-Zahrah, A., Zulkafli, R., Rokiah, A.L. and Zahari, A. (In press). A case study of red tilapia mortalities in cages along Sg. Pahang, Temerloh, Pahang. *In*: First National Symposium, 1999, on Aquaculture. USM, Penang.

Subasinghe, R.P. and Sommerville, C. 1992. Diseases of Asian Aquaculture. Fish Health Section, Asian Fisheries Society, Manila , Phillipines. 335-360 pp.