Research Journal of Animal and Veterinary Sciences, 7(1) January 2014, Pages: 1-6

AENSI Journals

Research Journal of Animal and Veterinary Sciences

ISSN:1819-5458

Journal home page: http://www.aensiweb.com/rjavs.html

Diseases In Aquaculture

[1]Lee Seong Wei and [2]Wendy Wee

[1]*Unit of Aquaculture Research Cluster, Faculty of Agro Based Industry, Universiti Malaysia Kelantan Jeli Campus, 17600, Jeli, Kelantan, Malaysia.*
[2]*Department of Fisheries Science, Faculty of Fisheries and Aqua-Industry, Universiti Malaysia Terengganu Kuala Terengganu, 21030, Terengganu, Malaysia.*

ARTICLE INFO

Article history:
Received 14 November 2013
Received in revised form 24 December 2013
Accepted 28 December 2013
Available online 18 January 2014

Keywords:
diseases; aquaculture; treatment; prevention

ABSTRACT

This paper is aimed to discuss the current status of diseases as a major constraint to the development of aquaculture production in Malaysia as well as worldwide. Viruses, bacteria, fungi and parasites were reported frequently attacking and devastating aquatic animals farms in Malaysia and worldwide. Many studies were conducted to reveal on the causative agents that responsible to the disease outbreaks in aquaculture. However, the results of the studies are still left the fish farmer in limbo over looking for the solution to prevent and treat the infection diseases in farmed aquaculture species. Hence, in the present paper was also highlighted the treatment and prevention of the infection aquaculture diseases. The information of the paper may useful as baseline information on the current status of diseases in aquaculture industry.

To Cite This Article: Lee Seong Wei and Wendy Wee., Diseases In Aquaculture. **Res. J. Ani. & Vet. Sci.,** *7(1): 1-6, 2014*

INTRODUCTION

Aquaculture is defined as farming of aquatic organism including fish, mollusks, crustaceans and aquatic plants [14]. This aquatic farming activity was recorded as early as 1100 B.C where China is reported the first country that carried out common carp fish farming activity. Other examples of early fish farming activity include pearl oyster farming in Japan, tilapia farming in Egypt, raising eels in Greeks and Roman and cultivation of oyster in Europe. Aquaculture industry is expanding rapidly due to the high demand for fish protein and Asia became the main player which contributes merely 90% of the world's aquaculture production. However, diseases were reported to become the major constraint of the development of aquaculture.

Fish diseases problem was recognized as a main constraint to development of aquaculture industry globally. Most of the pathogens are opportunistic where were infected cultured fish once the environment is deteriorated and triggered the opportunistic pathogen to attack cultured fish. Bacterial is pathogen that frequently reported attacked cultured fish followed by viruses, parasites and fungi.

Bacterial diseases are recognized as the main constraint to the development of aquaculture in Malaysia and worldwide. Vibriosis disease due to *Vibrio* sp. posed a threat to the most of the marine aquaculture farms. *Vibrio harveyi*, *V. parahaemolyticus*, *V. fisherii*, *V. damsela*, *V. alginolyticus* and etc were the causative agent of vibriosis disease and responsible to disease outbreak in fish and shrimp farms.Recently, V. parahaemolyticus was identified and responsible to the early mortality syndrome in white leg shrimp that led to a significant economic loss. Aeromonas hydrophila, the causative agent of motile aeromonad septicemia and Edwardsiella tarda, the causative agent of edwardsiellosis were reported frequently attacked freshwater fish and led to significant economic loss. Virus diseases were reported devastating most of the aquaculture farms especially shrimp farm. For instance, white spot disease, yellowhead disease and taura syndrome virus were identified shrimp virus diseases that led to bankruptcy of many shimp farm company.

In so far, aquaculture diseases due to fungal and parasite do not drawn a significant economic loss. However, Epizootic Ulcerative Syndrome, a fungal disease was reported frequently infected freshwater fish and led to high mortality rate. White spot disease or *Tetrahema* sp., is well known parasite disease that frequently attack ornamental fish. Other parasite diseases are monogenean and argulus. In this paper, we were report disease outbreaks in shrimp, fish and mollusk that occurred around the world.

Corresponding Author: Lee Seong Wei, Unit of Aquaculture Research Cluster, Faculty of Agro Based Industry, Universiti Malaysia Kelantan Jeli Campus, 17600, Jeli, Kelantan, Malaysia.

Research Journal of Animal and Veterinary Sciences, 7(1) January 2014, Pages: 1-6

Current Status Fish Diseases In Aquaculture Industry:

Diseases in Shrimp Farming Industry:

The first report of disease in shrimp was recorded in Thailand by the year of 1992 where the farmed shrimp was infected with yellowhead disease and cause loss USD 30.6 M [19]. This disease together with white spot diseases were continuing attacked shrimp farms in Thailand and lead to the total loss of USD 650 M in 1994 and shrimp production decline from 250,000 tons to 220,000 tons in 1995. Furthermore, the combination of these two diseases caused loss of half of the shrimp total production in Thailand by the year of 1997 [8]. In the year of 1993, several shrimp diseases were reported devastated shrimp farms in China and lead to shrimp production declined from 210,000 tons to 87 tons. A total loss of USD 420 M was recorded [25,26]. At the same year, several shrimp diseases like baculovirus (MBV), white spot disease (WSD) and yellowhead disease (YHD) were reported attacked shrimp farms in Vietnam and caused loss about USD 100 M [16].

In Australia, mid crop mortality syndrome (MCMS) and gill associated virus (GAV) were reported infected black tiger shrimp, Penaeus monodon, from 1994 to 1998 and cause total loss of USD 32.5 M [24]. During the period from 1994 to 1998, a new emerging shrimp disease known as taura syndrome virus (TSV) was reported infected shrimp farms in Honduras and lead to shrimp production decline up to 25% of the total shrimp production in Honduras [10]. This disease was also claimed spread to neighbor countries, Panama and Costa Rica. Taura syndrome virus outbreak was reported occurred in shrimp farms in Panama where reduced 30% of total shrimp production in Panama whereas only 15% of the crops survive from the taura syndrome outbreak in Costa Rica [18,23].

White spot syndrome disease outbreak was continue attacked shrimp farms in America Latin countries like Ecuador [3], Honduras [10], Nicaragua [12] and Panama [18]. This disease was reported devastating shrimp farm in these countries and lead to reduction of labour force due to the shrimp end their business, low of shrimp production. It is estimated the total loss was reported as high as USD 500 M by the year of 2000.

Subsequently, fish farmer was struggle to find new species of shrimp to alternate black tiger shrimp that no longer can be used as aquaculture species. In spite of the fact, white leg shrimp, *Penaeus vannamei* was introduced in aquaculture as a new candidate to replace problematic black tiger shrimp, *Penaeus monodon*. White leg shrimp became popular among fish farmer due to the shorter culture duration and high demand from the market compared to black tiger shrimp. Shrimp farmer was started to farm white leg shrimp intensively and this shrimp became best candidate for aquaculture industry throughout the world till the first outbreak of early mortality syndrome (EMS) occurred by the early of 2010. The causative agent that responsible to the early mortality syndrome was finally identified as *Vibrio parahaemolyticus* and collapse of the *Penaeus vannamei* industry. The infected white leg shrimp will appear slow growth, corkscrew swimming, loose shells and pale coloration. Mass mortalities were observed for the first 20 to 30 days. Close examination of the hepatopancreas of the infected shrimp became shrunken, small, swollen and discolored. The countries that affected by this diseases were China, Vietnam, Thailand and Malaysia. EMS was blamed for the hundred millionlosses and almost collapses shrimp farming industry in most of the affected countries.There are several cases of EMS outbreak reported in China, Vietnam and Malaysia. For instance, EMS became a serious disease in shrimp farming in China and lead to 80% loss of total shrimp production. In another case, EMS was reported attacked Vietnamese shrimp and cause 330 M shrimp died in 2010 whereas in Malaysia, EMS was recognized responsible to the poor production of white leg shrimp in 2010.

Diseases in Fish Farming Industry:

The early disease in fish farming was 1932 in Indonesia where white spot disease due to Ichthyophthirius was infected in Java barb, kissing gourami, common carp and giant gourami [6,21]. In the year of 1983, Lernaea cyprinacea was attacked almost 30% of hatchery in Indonesia mainly in Java, Sumatra and Sulawesi led to the lost USD 11 M and merely 1.5 billion of fish fry were lost [11]. By the year of 2000, Indonesia aquaculture was affected with Koi Herpes Virus (KHV) which 100% mortality of larvae in national hatcheries was reported [27].

In Malaysia, the first documented fish diseases outbreak was in 1989 where affected cage cultured grouper, snapper and seabass. A total loss of USD 1.3 M was recorded. By the year of 1990, vibriosis was reported attacked marine fish in Malaysia and caused USD 7.4 M loss [22]. In the year of 2008, Malaysia freshwater fish especially tilapia culture was attacked with fungal disease and reduce almost half of the total tilapia production. No treatment was found to overcome the disease and the disease disappeared after devastating most of tilapia farm in Malaysia. In the year of 2012, parasite infection was reported in Asian seabass in the brackish culture system lead to the serious mortality. However, the disease was stopped by using potassium manganese to overcome the parasite problem.

There are some reports on the fish disease outbreak in Thailand and China. In the year of 1989, disease outbreak was reported in seabass and grouper farming and caused almost USD 2 M loss [1]. In China, bacterial

Research Journal of Animal and Veterinary Sciences, 7(1) January 2014, Pages: 1-6

diseases due to *Aeromonas hydrophila*, *Yersinia ruckeri* and *Vibrio fluvialis* were reported infected fish farms and led to the total loss USD 120 M from 1990 to 1992 [25]. At the same period, Thailand catfish farm was devastated with jaundice diseases and caused total loss USD 21.3 M [9]. Virus diseases were reported attacked marine fish farm in Asia and caused a significant economic loss. Virus diseases were found infected grouper farms in Philippines, Singapore [7] and China [28]. Viral nervous necrosis was identified as the causative agent that infected and devastated farmer grouper in China and led to 100% mortalities.

Diseases in Mollusk Farming Industry:

The first report of disease outbreak in mollusk farming was 1959 in Chesapeake, USA. The causative agent was identified as *Haplosporidium nelson*. This disease caused almost 90% of the mortalities of Eastern oyster, *Crassostrea virginica* [4]. By the year of 2002, *Haplosporidium nelson* was reported responsible to the 80% mortalities of Eastern oyster in Canada. *Perkinsus* sp. is recognized as the pathogen that frequently attacked Manila clam, *Ruditapes philippinarum*. In 1997, *Perkinsus* sp. responsible to the 80% mortalities of Manila clam in Korea [20].

Virus diseases were reported attacked Japanese pearl oyster, *Pinctada fucata*, and caused mass mortalities in 1994 in Japan. The virus disease led to the 50% production of pearl oyster loss in Japan [17]. Virus diseases were also reported responsible to the several cases of mass mortalities of mollusk farming and significant economic loss throughout the world. For instance, herpes type virus disease was found devastated pacific oyster, *C. gigas*, and cause almost 90% mortalities in Australia [5]. Scallop acute viral necrotic disease was reported responsible to the loss of USD 0.1 B in China in scallop, *Chlamys farreri*, farming by the year of 1998. Abalone, *Haliotis diversicolor*, farming was also affected with virus diseases in Taiwan in 2003 where the mortality was almost reached 100%. Till present, the causative agent was not able to identify.

Other diseases that caused a significant mortality and economic loss were *Marteilia sydneyi*,*Marteilioides chungmuensis* and withering syndrome of abalone. *M. sydneyi* was reported attacked rock oyster, *Saccostrea glomerulata*, farming in Australia and caused the total loss USD 30 M [2] whereas *M. chungmuensis*responsible to the several disease outbreaks in Pasific oyster farming in Japan [15]. Withering syndrome of abalone was reported responsible to the 100% mortality of Black abalone, *H. cracherodii*, in California, USA.

Strategies in Aquatic Animal Health Management:

Aquatic animal health management is crucial and key of success of an aquaculture operation. It is estimated total value of the aquatic animal health market worth merely USD 1 B and expected will grow gradually in the near future. Aquatic animal health products can be antibiotics, drugs, nutraceuticals, vaccine and many more.

There are several strategies that can be applied in the aquaculture operation. Fish farmers are urged to concentrate only well established aquaculture species instead of many species. The established aquaculture species information and database was well recorded, therefore, fish farmer can be used the suitable formulated feed as well as established technology to grow up the aquaculture species. Furthermore, the history of disease profile of the aquaculture species was documented well and fish farmer can access and manage well the aquaculture species health management.

It is advisedly to having aquaculture operation by using closed system. This meaning that fish farmers have to establish their own aquaculture broodstock and seed instead of collected from wild. This can avoid the introduction of disease to the aquaculture system. Furthermore, the genetic property of the aquaculture species will not be alternated with the genetic from wild. Hence, fish farmer can maintain the quality of the aquaculture species production.

Vaccination is not widely applied in aquaculture due the high cost and inconsistent result. However, in the near future, vaccination is encouraged to use in aquaculture species health management. Through vaccination, disease outbreak in aquaculture can be minimized and avoid the spreading of disease from aquaculture activity to environment. Till present, antibiotics and chemicals are widely used in aquaculture operation in order to maintain health of crop as well as to save the crop from devastated by diseases. However, the intensive uses of antibiotics and chemicals lead to the increasing of the antibiotic resistance case among pathogens. The occurrence of the incidence of antibiotic resistant case among the pathogen led to the most antibiotics that available in the market was not longer effective in controlling diseases. The excessive usage of chemicals and antibiotics led to the contamination and pollution of the chemicals and antibiotics residues in the natural environment. Thus, it’s may pose a threat to public health as well as environmental. In spite of the fact, vaccination is the best well to maintain the health of the aquaculture species.

Research Journal of Animal and Veterinary Sciences, 7(1) January 2014, Pages: 1-6

REFERENCES

[1] ADB/NACA, 1991. Fish health management in Asia-Pacific. Reportof a Regional Study and Workshop on Fish Disease and FishHealth Management. ADB Agricult. Dep. Rep. Ser. No. 1, Network of Aquaculture Centres in Asia-Pacific, Bangkok,Thailand, pp: 627.

[2] Adlard, R., S.J. Weshe, 2002. Zoning for marteiliosis in commercialrock oysters in Australia. In: Book of Abstracts, Fifth Symposiumon Diseases in Asian Aquaculture (DAAV), 25–28 November2002. Fish Health Section, Asian Fisheries Society,Goldcoast, Australia, p: 105.

[3] Alday de Graindorge, V., D. Griffith, 2001. Ecuador: nationalreview on management strategies for major diseases in shrimpaquaculture, pp. 17–19. In: Subasinghe, R., Arthur, R., Phillips,M.J., Reantaso, M. (Eds.). WB/NACA/WWF/FAO. ThematicReview on Management Strategies for Major Diseases in ShrimpAquaculture. Proceedings of a Workshop held in Cebu, Philippines on 28–30 November 1999. The World Bank (WB), Networkof Aquaculture Centres in Asia-Pacific (NACA), WorldWildlife Fund (WWF) and Food and Agriculture Organizationof the United Nations (FAO) Consortium Program on ShrimpFarming and the Environment. Work in Progress for PublicDiscussion. Published by the Consortium, pp: 135.

[4] Andrews, J.D., 1968. Oyster mortality studies in Virginia. VII.Review of epizootiology and origin of Minchinia nelsoni. Proc.Natl. Shellfish. Assoc., 58: 23-36.

[5] Berthe, F.C.J., 2002. The paradox of health management in mollusk hatcheries. In: Book of Abstracts, Fifth Symposium on Diseasesin Asian Aquaculture (DAA V), Fish Health Section, AsianFisheries Society, 25–28 November 2002. Goldcoast, Australia, pp: 95.

[6] Buschkiel, A.L., 1935. Neue Beitra¨ge zur Kenntnis desIchthyophthirius multifiliis Fouquet. Arch. Ne´erland. Zool., 2: 178-224.

[7] Chang, S.F., 2001. Grouper viral diseases and research in Singapore,pp. 66–67. In: Bondad-Reantaso, M.B., Humphrey, J., Kanchanakhan,S., Chinabut, S. (Eds.). Report and Proceeding of APECFWG Project 02/2002 ‘‘Development of a Regional ResearchProgramme on Grouper Virus Transmission and Vaccine Development’’,18–20 October 2000. Bangkok, Thailand. Asia-PacificEconomic Cooperation (APEC), Aquatic Animal HealthResearch Institute (AAHRI), Fish Health Section of the AsianFisheries Society (FHS/AFS) and the Network of Aquaculture Centres in Asia-Pacific (NACA). Bangkok, Thailand.

[8] Chanratchakool, P., D.F. Fegan, M.J. Phillips, 2001. Thailand:national review on management strategies for major diseasesin shrimp aquaculture, pp. 85–90. In: Subasinghe, R., Arthur, R.,Phillips, M.J., Reantaso, M. (Eds.). WB/NACA/WWF/FAO.Thematic Review on Management Strategies for Major Diseasesin Shrimp Aquaculture. Proceedings of a Workshop held inCebu, Philippines on 28–30 November 1999. The World Bank(WB), Network of Aquaculture Centres in Asia-Pacific (NACA),World Wildlife Fund (WWF) and Food and Agriculture Organizationof the United Nations (FAO) Consortium Program onShrimp Farming and the Environment. Work in Progress forPublic Discussion. Published by the Consortium, pp: 135.

[9] Chinabut, S., 2002a. Jaundice disease in catfish, as case studydemonstrating a decline in incidence as a result to researchoutput, pp. 77–80. In: Arthur, J.R., Phillips, M.J., Subasinghe,R.P., Reantaso, M.B., MacRae, I.H. (Eds.) Primary AquaticAnimal Health Care in Rural, Small-Scale, Aquaculture Development.FAO Fish. Tech., pp: 406.

[10] Corrales, H.L., C.L. Watson, J. Wigglesworth, 2001. Honduras:National Review on Management, Strategies for Major Diseasesin Shrimp Aquaculture, pp. 20-23. In: Subasinghe, R., Arthur,R., Phillips, M.J., Reantaso, M. (Eds.). WB/NACA/WWF/FAO.Thematic Review on Management Strategies for Major Diseasesin Shrimp Aquaculture. Proceedings of a Workshop held inCebu, Philippines on 28–30 November 1999. The World Bank(WB), Network of Aquaculture Centres in Asia-Pacific (NACA),World Wildlife Fund (WWF) and Food and Agriculture Organizationof the United Nations (FAO) Consortium Program onShrimp Farming and the Environment. Work in Progress forPublic Discussion. Published by the Consortium, pp: 135.

[11] Djajadiredja, R., T.H. Panjaitan, A. Rukyani, A. Sarono, D. Satyani, H. Supriyadi, 1983. Country reports: Indonesia. In: Davy,F.B., Chouinard, A. (Eds.). Fish quarantine and fish diseases inSoutheast Asia, pp: 19-30. Report of workshop held in Jakarta,Indonesia, 7–10 December 1982. International DevelopmentResearch Centre Publication IDRC-210e, Ottawa.

[12] Drazba, L., 2001. Nicaragua: national review on managementstrategies for major diseases in shrimp aquaculture, pp. 24–28. In: Subasinghe, R., Arthur, R., Phillips, M.J., Reantaso, M.(Eds.). WB/NACA/WWF/FAO. Thematic Review on ManagementStrategies for Major Diseases in Shrimp Aquaculture.Proceedings of a Workshop held in Cebu, Philippines on 28–30 November 1999. The World Bank (WB), Network of AquacultureCentres in Asia-Pacific (NACA), World Wildlife Fund(WWF) and Food and Agriculture Organization of the UnitedNations (FAO) Consortium Program on Shrimp Farming and theEnvironment.Work in Progress for Public Discussion. Publishedby the Consortium, pp: 135.

Research Journal of Animal and Veterinary Sciences, 7(1) January 2014, Pages: 1-6

[13] Food And Agriculture Organization Of The United Nations (FAO). 2000. The State of World Fisheries and Aquaculture 2000. Rome, Italy.
[14] Food And Agriculture Organization Of The United Nations (FAO). 2002. The State of World Fisheries and Aquaculture 2002. Rome, Italy
[15] Itoh, N., O. Tadashi, K. Ogawa, 2002. Marteilioides chungmuensis(paramyxea), an intracellular parasite of the ovocyte of Pacificoyster Crassostrea gigas: isolation and sequencing of smallsubunit ribosomal DNA. In: Book of Abstracts, Fifth Symposiumon Diseases in Asian Aquaculture (DAA V). Fish HealthSection, Asian Fisheries Society, 25–28 November 2002. Goldcoast,Australia, p: 95.
[16] Khoa, L.V., N.V. Hao, L.T.L. Huong, 2001. Vietnam: nationalreview on management strategies for major diseases in shrimpaquaculture, pp. 91–94. In: Subasinghe, R., Arthur, R., Phillips,M.J., Reantaso, M. (Eds.). WB/NACA/WWF/FAO. ThematicReview on Management Strategies for Major Diseases in ShrimpAquaculture. Proceedings of a Workshop held in Cebu, Philippineson 28–30 November 1999. The World Bank (WB), Networkof Aquaculture Centres in Asia-Pacific (NACA), WorldWildlife Fund (WWF) and Food and Agriculture Organizationof the United Nations (FAO) Consortium Program on ShrimpFarming and the Environment. Work in Progress for PublicDiscussion. Published by the Consortium.
[17] Miyazaki, T., K. Goto, T. Kobayashi, M. Miyata, 1999. Massmortalities associated with a virus disease in Japanesepearl oysters Pinctada fucata martensii. Dis. Aquat. Org., 37: 1-12.
[18] Morales, R., L. Becerra, C. Lara, 2001. Panama: national review onmanagement strategies for major diseases in shrimp aquaculture,pp. 29–31. In: Subasinghe, R., Arthur, R., Phillips, M.J., Reantaso,M. (Eds.). WB/NACA/WWF/FAO. Thematic Review onManagement Strategies for Major Diseases in Shrimp Aquaculture.Proceedings of aWorkshop held in Cebu, Philippines on 28–30 November 1999. The World Bank (WB), Network ofAquaculture Centres in Asia-Pacific (NACA), World WildlifeFund (WWF) and Food and Agriculture Organization of theUnited Nations (FAO) Consortium Program on Shrimp Farmingand the Environment. Work in Progress for Public Discussion.Published by the Consortium.
[19] Nash, G., A. Arkarjamon, B. Withyachumnarnkul, 1995. Histologicaland rapid haemocytic diagnosis of yellow-head disease inPenaeus monodon. In: Shariff, M., Arthur, J.R., Subasinghe, R.P. (Eds.), Diseases in Asian Aquaculture II. Asian FisheriesSociety, Manila, pp: 89-98.
[20] Park, K.-I., K.-S. Choi, 2001. Spatial distribution and infectionintensity of the protozoan parasite Perkinsus sp. in the Manilaclam Ruditapes philippinarum in Korea. Aquaculture, 203: 9-22.
[21] Sachlan, M., 1952. Notes on parasites of fresh-water fishes inIndonesia. Contrib. Inland Fish. Res. Stations., 2: 1-60.
[22] Shariff, M., 1995. Fish health: an odyssey through the Asia-Pacificregion. Syarahan inaugural. Univ. Pertanian Malaysia, Serdang, Malaysia, pp: 25.
[23] Vargas, R., 2001. Country Paper: Costa Rica, pp. 100–101. In:APEC/FAO/NACA/SEMARNAP. Trans-boundary Aquatic AnimalPathogen Transfer and the Development of HarmonizedStandards on Aquaculture Health Management. Report of theJoint APEC/FAO/NACA/SEMARNAP Workshop, Puerto Vallarta,Jalisco, Mexico, 24–28 July 2000. Network of AquacultureCentres in Asia-Pacific, Bangkok, Thailand.
[24] Walker, P., 2001. Australia: national review on management strategiesfor major diseases in shrimp aquaculture, pp. 39–44. In:Subasinghe, R., Arthur, R., Phillips, M.J., Reantaso, M. (Eds.). WB/NACA/WWF/FAO. Thematic Review on ManagementStrategies for Major Diseases in Shrimp Aquaculture. Proceedingsof a Workshop held in Cebu, Philippines on 28–30 November1999. The World Bank (WB), Network of AquacultureCentres in Asia-Pacific (NACA), World Wildlife Fund(WWF) and Food and Agriculture Organization of the UnitedNations (FAO) Consortium Program on Shrimp Farming and theEnvironment.Work in Progress for Public Discussion. Publishedby the Consortium.
[25] Wei, Q., 2002. Social and economic impacts of aquatic animalhealth problems in aquaculture in China, pp. 55–61. In: Arthur,J.R., Phillips, M.J., Subasinghe, R.P., Reantaso, M.B., MacRae,I.H. (Eds.). Primary Aquatic Animal Health Care in Rural,Small-Scale, Aquaculture Development. FAO Fish. Tech., pp: 406.
[26] Yulin, J., 2001. China: national review on management strategies formajor diseases in shrimp aquaculture, pp. 74–78. In: Subasinghe,R., Arthur, R., Phillips, M.J., Reantaso, M. (Eds.).WB/NACA/WWF/FAO. Thematic Review on ManagementStrategies for Major Diseases in Shrimp Aquaculture. Proceedingsof a Workshop held in Cebu, Philippines on 28–30 November 1999. The World Bank (WB), Network of AquacultureCentres in Asia-Pacific (NACA), World Wildlife Fund(WWF) and Food and Agriculture Organization of the UnitedNations (FAO) Consortium Program on Shrimp Farming and theEnvironment.Work in Progress for Public Discussion. Publishedby the Consortium.
[27] Yuasa, K., I. Koersharyani, 2001. Present situation of occurrence ofviral nervous necrosis (VNN) in Indonesian grouper hatcheriesand control measures for VNN, pp. 86–94. In: Bondad-Reantaso,M.G., Humphrey, J., Kanchanakhan, S., Chinabut, S. (Eds.).Report and Proceeding of APEC FWG Project 02/2002 ‘‘Developmentof a Regional Research Programme on Grouper VirusTransmission and Vaccine

Research Journal of Animal and Veterinary Sciences, 7(1) January 2014, Pages: 1-6

Development'', 18–20 October 2000.Bangkok, Thailand. Asia-Pacific Economic Cooperation(APEC), Aquatic Animal Health Research Institute (AAHRI),Fish Health Section of the Asian Fisheries Society (FHS/AFS)and the Network of Aquaculture Centres in Asia-Pacific(NACA). Bangkok, Thailand.

[28] Zhang, H., 2001. Status of grouper culture, fry production andgrouper diseases in Guangdong, China P.R., pp. 55–57. In:Bondad-Reantaso, M.G., Humphrey, J., Kanchanakhan, S., Chinabut, S. (Eds.). Report and Proceeding of APEC FWGProject 02/2002 ''Development of a Regional Research Programmeon Grouper Virus Transmission and Vaccine Development'',18–20 October 2000. Bangkok, Thailand. Asia-Pacific Economic Cooperation (APEC), Aquatic AnimalHealth Research Institute (AAHRI), Fish Health Section ofthe Asian Fisheries Society (FHS/AFS) and the Network ofAquaculture Centres in Asia-Pacific (NACA). Bangkok, Thailand.