Article AR2152a
DOI: HTTPS://DOI.ORG/10.23910/1.2020.2152a

International Journal of Bio-resource and Stress Management

December 2020

Crossref
Print ISSN 0976-3988
Online ISSN 0976-4038

IJBSM 2020, 11(6):607-612

Research Article
Stress Management

Management of Stress in Culture Fish

T. Suguna

Fisheries Research Station, S. V. Veterinary University, West Godavari, Andhra Pradesh (534 199), India

Open Access

Corresponding Author

T. Suguna
e-mail: tummala.suguna@gmail.com

Citation: Suguna, 2020. Management of Stress in Culture Fish. International Journal of Bio-resource and Stress Management 2020, 11(6), 607-612. HTTPS://DOI.ORG/10.23910/1.2020.2152a.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Funding: The funds for this research work are provided by Sri Venkateswara Veterinary University, Tirupati, India.

Conflict of interests: The authors have declared that no conflict of interest exists.

Acknowledgement: I am very much thankful to the Vice-chancellor, Sri Venkateswara Veterinary University, Tirupati for making this to happen.

Abstract

Over the last three decades, the commercial aquaculture has experienced spectacular growth. Many species have gone from small scale regional production to large scale global production. Concomitant with the rapid growth there also has been the increased occurrence of problems that accompany all agricultural endeavours. All the problems are stress influenced leading to diseases, impacting the profitability of the industries. In aquaculture also inspite of the unprecedented development of the intensified culture practices many economical problems have arise that are threatening the sustainability of culture systems. The root cause for all is stress. The word, "stress" is very common butreflects vast effective results. It is an invisible factor, influencing the survivality, growth, reproduction, production in culture fish especially. It is much easier for diseases to proliferate in the culture environment than in wild. Defining what levels of stressors are normal and acceptable is not easy. A level of stressor that is problematic under one set of environmental conditions might not be the same under another. The susceptibility of disease occurrence differs within species and age groups. Different stress factor such as inadequate physico chemical and microbial quality of culture water, poor nutritional stems and high stocking density can cause infection by opportunistic pathogens. In aquaculture, the stress plays major role on production, productivity, sustainability of the culture, economic loss and degradation of economic standards. A summation of causes for the acute and chronic stressors will enlighten the aqua farmers, scientists and fishery officials in designingenvironmentally friendly controlling measures, in obtaining higher yields.

Keywords: Fish, stressors, impact, economic loss, controlling measures

1. Introduction

The aquaculture has been the fastest growing food production system since four decades. Besides acquiring crores of income through foreign exchange it also provides the nutritional security, globally. The aquatic animals, fish and prawn promote human health. Consumers have become more and more critical about fish, shrimp quality, fish welfare and the negative effects of the aquaculture production sector on the environment. In the last decade the expansion and intensification of culture practices made way to the stress factor. The welfare aspects such as the impact of chronic stress on aquatic animals (fish and shrimp) have gained interest. Stress is defined as physical or chemical factors that cause bodily reactions, that may contribute to disease and death. There are many examples in fin fish culture where specific stressors are associated with disease outbreaks (Plumb, 1999). Many potential fish disease pathogens are continually present in the water, soil, air or fish (Rattmann et al.,

Article History
RECEIVED in 16th September 2020 RECEIVED in revised form 29th November 2020 ACCEPTED in final form 30th December 2020

1992). In nature fish are often resistant to these pathogens, and they are able to seek the best living conditions available (Bagum et al., 2013). Food fish reared under commercial aquaculture conditions are confined to the production unit and are weakened by stress conditions. Usually it is impossible, for life to exist without stress. Fish under stress are sluggish, don't feed and exhibit slow growth. Stressors that are present in combinations pose a far greater threat as they are present together (Newman, 2014). The list of environmental stressors is very large and affect the immune response leaving the animals more susceptible to disease (Moullac and Haffner, 2000; Dunier and Siwicki, 1993). Some of the stressors impacting aquaculture are: 1) high stocking densities and deteriorated water quality (low dissolved oxygen, undesirable temperature, pH, increase levels of carbondioxide, unionized ammonia, nitrite, hydrozen sulphide, organic matter in water, 2) Injury during handling (i.e. capture, sorting, shipping), 3) Inadequate nutrition, 4) poor biosecurity measures 5) poor sanitation, and 6) environment.

These conditions result in decreased resistance by the fish, resulting in the spread of disease and parasite infestation (Snieszko, 1974; Walker and Winton, 2010). Stress and injury initially trigger an alaram reaction, which results in a series of changes (Racotta and Palacios, 1998) within the fish. A blood sugar increase occurs in response to hormone secretion from the adrenal gland as liver glycogen is metabolized. This produces a burst of energy which prepare the animal for an emergency situation. In addition, inflammatory response, a defence used by fish against invading disease organisms, is suppressed by hormones released from the adrenal gland. Water balance in the fish (ormoregulation) is disrupted due to changes in the metabolism of minerals. Under these circumstances, freshwater, salt water fish lose water to the environment (dehydrate) fish absorb excessive amounts of water from the environment (over dehydrate). This disruption increases energy requirements for osmoregulation (Lignot et al., 2000). Respiration increases, blood pressure increases and reserve red blood cells are released into the blood stream. The actions of stressors are varied and not widely studied (Newman, 2014).

Fish will adapt to stress for a period of time, they may look and act normal. However, energy reserves are eventually depleted and hormone imbalance occurs, suppressing their immune system and increasing their susceptibility to infectious diseases (Raa, 1996). The aquaculture sector is frequently affected by the occurrence of the infectious diseases, which are mostly due to intensive stocking practices (Mukharjee, 2002; Ayyappan, 2004). The awareness in causatives of stress and the preventive measures are enlightened in this paper, to arrest the huge economic loss due to mortality and low yields.

2. Materials and Methods

The data is documented from July 2019 to May 2020 from the observations of experimental ponds of Fisheries Research Station (SVVU, Undi, West Godavari) of Andhra Pradesh, India. Carp (Catla and rohu) fish seed measuring 2±0.02 cm and 0.2±0.23 g is stocked in 4.8×3.8×0.67 m^3 size tanks @ 5 / sqm in two such tanks. They are fed with pelleted feed as per 3% of body weight. The controlled tank (T_1) is left unmanaged where as the tank T_2 (T_2: T_{2a}, T_{2b}, T_{2c}) in triplicate are well managed keeping all parameters in optimum level. The data of the parameters like water quality, mortality, growth rate, growth performance, FCR and production levels are documented from April 2019 to May 2020.

Fish samples were sampled using cast nets during fortnightly intervals to observe their body length and weight using the specific growth rate formula

[(LnFBW–LnIBW)/day]×100

Where FBW: Final body weight; IBW: Initial body weight; Ln: Natural logarithm; Day: Duration of experiment

The survival percentage were calculated using the following formula

(Total survived/Total stocked)×100

Feed conversion ratio (FCR) was calculated as per the formula

Feed given (dry weight)/Body weight gain (wet weight)

Water sample were collected in the early morning and the water quality parameters like pH, temperature (°C), dissolved oxygen (DO) (mg l^{-1}); Total ammonia (ppm), nitrate (ppm), alkanity, hardness was regularly monitored. pH and temperature was measured using digital pH and temperature meter; DO was measured by using the titrimetric Winkler's method and total ammonia and nitrite was measured by using the titrimetric method. Alkanity and hardness was measured by using the kits. Salinity was measured by using the refractometer.

3. Results and Discussion

3.1. Water quality parameters

The water quality parameters are recorded fortnightly from unmanaged (T_1) and Managed (T_2) tanks are mentioned in Table 1, 2 and 3.

3.2. Dissolved oxygen

Dissolved oxygen (DO) is critical most factor for the survival and growth of fishes. DO in the T_1 and T_2 was ranged from 4.3 ± 0.23–5.4±0.153 and 4.59±0.22–6.8±0.01 respectively. DO fluctuates in a day due to one or other factors associated to photosynthesis, biological organisms, chemicals, and weather. During the morning time, the DO level rises due to the presence of phytoplankton undergoing photosynthesis process by utilising the sunlight. During the night the DO levels reduces due to the consumption of phytoplankton and also biological organisms. In addition to this, application of any chemicals also reflects on the DO content. Low DO content in the pond was considered to be the stress factor and causing poor appetite, slow growth, disease susceptibility and

Table 1: Mean Water quality parameters recorded during culture period

Sl. No.	Parameter	Unmanaged (T_1)	Managed (T_2)
1.	pH	7.83±0.163–8.17±0.02	7.95±0.08–8.32±0.017
2.	Dissolved oxygen (mg l^{-1})	4.3±0.23–5.4±0.153	4.59±0.22–6.8±0.01
3.	Ammonia	0.39±0.004–2.80±0.012	0.085±0.003–0.005±0.002
4.	Nitrite	0.035±0.011–0.65±0.003	0.210±0.005–0.59±0.004
5.	Salinity	8.0–3±0.061	0–3.8±0.017
6.	Hardness (mg l^{-1})	90.40±0.12–180±0.061	140±0.04–480±0.024
7.	Temperature	27.7±0.21–32±0.12	27.74±0.11–29.75±0.16

Table 2: Month wise water quality parameters of managed

Sl. No.	Parameter	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
1.	pH	7.6	7.8	8.2	7.9	8.3	8.0	8.1	8.3	8.0
2.	Dissolved oxygen (mg l^{-1})	4.0	6.8	6.6	5.0	4.9	5.5	5.9	6.3	6.4
3.	Ammonia	0.02	0.06	0.03	0.16	0.19	0.04	0.08	0.04	0.02
4.	Nitrite	0.12	0.08	0.01	0.04	0.02	0.10	0.14	0.01	0.04
5.	Salinity	1.3	1.8	0.7	1.6	2.1	3.3	3.6	2.8	2.2
6.	Hardness (mg l^{-1})	140	138	252	166	320	346	490	488	420
7.	Temperature	27.4	23.0	27.0	28.0	28.6	26.4	27.5	30.0	29.6

Table 3: Month wise water quality parameters of unmanaged

Sl. No.	Parameter	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
1.	pH	8.1	8.8	8.0	8.5	8.8	9.2	8.8	8.5	8.6
2.	Dissolved oxygen (mg l^{-1})	3.28	3.04	3.51	3.03	3.75	3.41	3.26	3.46	4.02
3.	Ammonia	2.25	2.28	1.36	1.22	3.0	2.02	1.8	2.6	3.2
4.	Nitrite	0.05	0.03	0.15	0.21	0.60	0.83	0.82	0.90	0.6
5.	Salinity	6.7	8.3	5.8	9.5	7.2	8.25	6.40	7.6	6.25
6.	Hardness (mg l^{-1})	180	176	158	162	180	140	200	110	285
7.	Temperature	27.5	28.3	29.5	30.0	29.0	28.0	26.0	27.0	28.8

mortality. The DO content plays a major role in the culture of aquaculture systems. Especially in the early hours before the sunrise, if the DO content is low, immediately the fishes comes to the surface and keeping the head on the surface and trying to gulping the atmospheric oxygen. At that particular time, the DO need to be monitored and precautions to be taken to increase the DO content. The different methods for increasing the DO content in the ponds by using the mechanical aerators, water pumping using motors, movement of boats and usage of DO tablets.

3.3. *pH*

pH in the T_1 was ranged from 7.83±0.163–8.17±0.02 and T_2 was ranged from 7.95±0.08–8.32±0.017. In water quality parameters, pH plays a crucial role, and pH is characterised as the negative logarithm of the concentration of hydrogen ions. Water pH It is a dimensionless number suggesting an acidic or a simple solution's power. In fact, water pH is a measure of the acidic/basic quality of water. Extra hydrogen ions (H^+) are found in acidic water and extra hydroxyl (OH^-) ions are contained in simple water. With 7 being neutral, the pH varies from 0 to 14. Acidity is indicated by a pH of less than 7, whereas a pH greater than 7 suggests a base solution. Pure vapour, with a pH similar to 7.0 at 25°C, is neutral. Standard precipitation, due to ambient carbon dioxide gas, has a pH of around 5.6 (slightly acidic). Due to this, in rainy season the pH of water in the pond fluctuates. Photosynthesis also influences the daily fluctuations of pH in the pond. The fishes can tolerate the daily fluctuations of pH of not more than 0.5. If the fluctuations are more, then it influences on the stress on the fishes and sometimes it causes mortality.

3.4. *Temperature*

Temperature of T_1 and T_2 was ranged from 27.7±0.21–

32±0.12 and 27.74±0.11–29.75±0.16. Of all ecosystems, animals including fish species, which are also susceptible to water temperature, temperature plays an important role in biodiversity and suitability. It regulates the dissolved compounds and even the water's dissolution features. Hot water can very easily remove the compounds. Temperature plays an important role in assessing the solubility of oxygen in water, the rate of photosynthesis of algae and higher plants, the metabolic rate of marine species and the susceptibility of organisms to radioactive waste, pests and diseases. In cooler water, the DO content will be more and vice versa in hot or warm waters. In the acceptable temperature range (23-29^{o}C), fish show considerable diversity in thermal tolerance and a fish can develop easily and rapidly.

3.5. Ammonia

The ammonia in the unmanaged and managed were 0.39±0.004–2.80±0.012 and 0.085±0.003–0.005±0.002 respectively. The accumulation of ammonia in the ponds is due to the faecal matter produced and over feeding of feed in the aquaculture systems. Since the high protein rich feed is being used in the aquaculture systems generates the ammonia. Within the nitrogen cycle in every marine system, ammonia plays an essential role. Two forms of ammonia are available i.e. ionised (NH_4^+) and unionised forms (NH_3). Among these two forms, unionsed form is more toxic than ionised form. The conversion of unionised to ionised forms depends on pH and temperature of the water. This is the oxidative mechanism in which, through naturally occurring Nitrosospira and Nitrosomonas bacteria in the water, ammonia is first transformed into nitrite (NO_2), before more bacterial species Nitrospira and Nitrobacter convert the nitrite into nitrate (NO_3). The final form N_2 directly enters into the atmosphere. This method of nitrification happens either on the surface of the mud substrate and plants or inside a tank-based system's biofilter. Nitrite form is more harmful than the nitrate form. Nitrobacter helps in conversion of nitrite to nitrate (Hargreaves and Tucker, 2004). Aquatic plants, phytoplankton and higher plants consume the nitrate and some other bacteria converts into the nitrogen form. The nitrogen cycle is directly determined by the levels of oxygen and alkalinity, with a drop in either stopping the cycle and thus once again increasing the level of ammonia and nitrite (YSI 2010). It should be remembered that ammonia levels favour the development of unique species of phytoplankton and algal species that change the ecosystem's aquatic biodiversity and dynamics (Residi et al., 2013). Based on the levels present, ammonia impacts fish both directly and indirectly, with some animals more sensitive than others to ammonia toxicity. Un-ionized ammonia is toxic to fish species at lower concentrations of about 0.05 mg l^{-1} and can result in poor growth and feed conversion rates, decreased reproduction and fertility, and increased stress and vulnerability to bacterial infections and diseases. Ammonia causes gill and tissue injury, severe lethargy and mortality at higher doses, above 2.0 mg l^{-1} (Ip and Chew 2010). Ammonia levels can be higher in winter as decreased feeds are delivered and the reduction in temperature decreases the rate of algal photosynthesis such that less ammonia is removed by this means (Chris, 2014).

3.6. Salinity

Salinity is one of the environmental factors that has a significant impact on fish development. Awareness of the optimal salinity of particular organisms can lead to the expansion of aquaculture development by the use of a broad variety of communities, including brackish waters). Fish physiology is specifically affected by insufficient salinity levels for both freshwater and marine fish species, resulting in decreased growth, reproduction, immune response and disease tolerance. Fish are thus continually adapting to their external environments and preserving the correct balance of salt solutions within their bodies by osmoregulation (isosmotic). Nevertheless, the mechanism of osmoregulation is energy-demanding processes, with lower metabolic rates consuming between 20 to 50% of the overall energy available (Table 4).

Table 4: Other parameters

Sl. No.	Parameter	Unmanaged (T_1)	Managed (T_2)
1.	Growth performance	C: 2.0 g–472 g±0.72 R: 2.0 g–360 g±0.18	C: 2.0 g–780 g±0.81 R: 2.0 g–640 g±0.04
2.	FCR	2.98±0.122	1.29±0.0171
3.	Survivality	63%–76%	93%-99%
4.	Production	2.5 t acre^{-1}	4.6 t acre^{-1}
5.	% of disease occurrence	65% of bacterial (Red, bacterial gill disease) 35% of parasitic (Argulus, paradactylogyrosis, dactylogyrosis)	3% (Parasitic)

3.7. Mortality

Mortality percentage from stocking in the pond to till the end of the experiment is mentioned in the Figure 1. The highest mortality percentage 17.7% was noticed in the month of December 19 in the T_1 and 4.2% in the T_2. This may be due to the influence of environmental factors that cause the mortality of fishes. The lowest percentage of mortality in managed ponds and unmanaged ponds was observed in the month of September and July respectively.

The mortality caused may be depending on the environmental factors, stocking density and feed. Ultimately it correlates with the stress. Stress is defined as physical or chemical factors that cause bodily reactions, that may contribute to disease and death. There are many examples in fin fish culture where

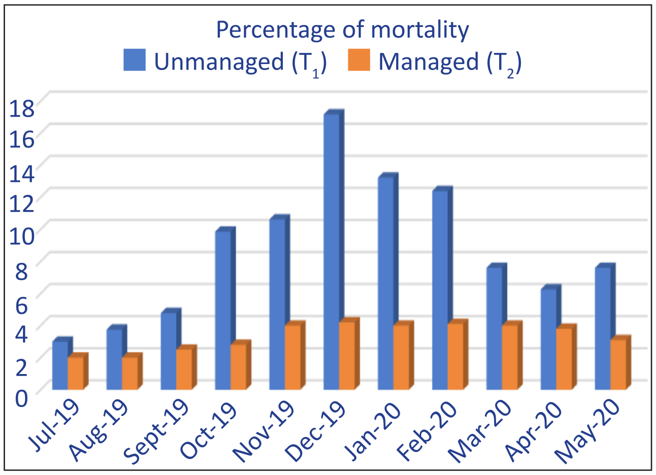

Figure 1: Percentage of mortality from stocking to till harvest

specific stressors are associated with disease outbreaks (Plumb, 1999). Many potential fish disease pathogens are continually present in the water, soil, air or fish (Rattmann et al., 1992). In nature fish are often resistant to these pathogens, and they are able to seek the best living conditions available (Bagum et al., 2013). Food fish reared under commercial aquaculture conditions are confined to the production unit and are weakened by stress conditions. Usually it is impossible, for life to exist without stress. Fish under stress are sluggish, don't feed and exhibit slow growth. Stressors that are present in combinations pose a far greater threat as they are present together (Newman, 2014). The list of environmental stressors is very large and affect the immune response leaving the animals more susceptible to disease (Moullac and Haffner, 2000; Dunier and Siwicki, 1993). Some of the stressors impacting aquaculture are: 1) high stocking densities and deteriorated water quality (low dissolved oxygen, undesirable temperature, pH, increase levels of carbondioxide, unionized ammonia, nitrite, hydrogen sulphide, organic matter in water, 2) Injury during handling (i.e. capture, sorting, shipping), 3) Inadequate nutrition, 4) poor biosecurity measures 5) poor sanitation, and 6) environment.

These conditions result in decreased resistance by the fish, resulting in the spread of disease and parasite infestation (Snieszko, 1974; Walker and Winton, 2010). Stress and injury initially trigger an alaram reaction, which results in a series of changes (Racotta and Palacios, 1998) within the fish. A blood sugar increase occurs in response to hormone secretion from the adrenal gland as liver glycogen is metabolized. This produces a burst of energy which prepare the animal for an emergency situation. In addition, inflammatory response, a defence used by fish against invading disease organisms, is suppressed by hormones released from the adrenal gland. Water balance in the fish (ormoregulation) is disrupted due to changes in the metabolism of minerals. Under these circumstances, freshwater, salt water fish lose water to the environment (dehydrate) fish absorb excessive amounts of water from the environment (over dehydrate). This disruption increases energy requirements for osmoregulation (Lignot et al., 2000). Respiration increases, blood pressure increases and reserve red blood cells are released into the blood stream. The actions of stressors are varied and not widely studied (Newman, 2014).

Fish will adapt to stress for a period of time, they may look and act normal. However, energy reserves are eventually depleted and hormone imbalance occurs, suppressing their immune system and increasing their susceptibility to infectious diseases (Raa, 1996). The aquaculture sector is frequently affected by the occurrence of the infectious diseases, which are mostly due to intensive stocking practices (Mukharjee, 2002; Ayyappan, 2004). The awareness in causatives of stress and the preventive measures are enlightened in this paper, to arrest the huge economic loss due to mortality and low yields (Table 5).

Table 5: Mortality of fish in culture ponds

Month	Unmanaged (T_1) (%)	Managed (T_2) (%)
July 2019	3	2
August 2019	3.75	2
September 2019	4.78	2.5
October 2019	9.86	2.8
November 2019	10.62	4.0
December 2019	17.17	4.2
January 2020	13.23	4.0
February 2020	12.39	4.1
March 2020	7.60	4.0
April 2020	6.26	3.8
May 2020	7.6	3.1

4. Conclusion

All the water quality parameters are within optimum range in tank managed tank, whereas it is reverse in unmanaged tank. The disease occurrence, mortality rate and feed conversion ratio are very low in managed tank and the survivality, growth performance and production are high. Water quality parameters in the pond influenced the stress to the animals and causes the mortality influencing the production and productivity of the farm.

5. Acknowledgement

I am very much thankful to the Vice-chancellor, Sri Venkateswara Veterinary University, Tirupati for making this to happen.

6. References

Allam, G.L., Maquire, G.B., 1991. Lethal levels of dissolved oxygen and effects of short term oxygen stress on subsequent growth of juvenile *Penaeus monodon,* Aquaculture 94, 27−37.

Ayyappan, S., 2004. Enhancing global competition. Survey of Indian agriculture. The Hindu, 97−100.

Bagum, N., Monir, M.S., Khan, M.H., 2013. Present status of fish diseases and economic losses due to incidence of disease in rural freshwater aquaculture of Bangladesh. Journal of Innovation and Development Strategy 7, 48-53 (http//ggf journals.com / assets / uploads / MIN – 412 (48-53) _ FINAL _ (ok). Pdf.

Chris, S., 2014. The management of ammonia levels in an aquaculture environment. www.pollutionsolutions-online.com

Das, B.K., 2011. Bacterial disease of fish. In: Fish Health Management, National Training programme. CIFA, Bhubaneswar, India.

Devresse, B., 2000. Nucleotides–a key nutrient for shrimp immune system. Feed Mix 8(3), 20−22.

Dunier, M., Siwicki, A.K., 1993. Effects of pesticides and other pollutants in the aquatic environment on immunity of fish: a review: Fish and Shellfish Imm 3, 423 – 438.

Hargreaves, J.A., Tucker, C.S., 2004. Managing ammonia in fish ponds. Southern Regional Aquaculture Centre.

Lignot, J.H., Spanings-Pierrot, C., Charmantier, G., 2000. Osmoregulatory capacity as a tool in monitoring the physiological condition and the effect of stress in crustaceans, Aquaculture 191, 209−245.

Merchie, G., Kontara, E., Lavens, P., Robles, R., Kurmaly, K., Sorgelors, P., 1998. Effect of vitamin C and astaxanthin on stress and disease resistance of post larval tiger shrimp, *Penaeus monodon* (Fabricius) Aquaculture Research 29(8), 579−585.

Merchie, G., Lavens, P., Sorgeloos, P., 1977. Optimization of dietary vitamin C in fish and crustacean larvae: a review; Aquaculture 155(1-4), 169−185.

Mishra, S.S., Dhiman, M., Swain, P., Das, B.K., 2015. Fish diseases and health management issues in aquaculture. ICAR – CIFA. Training manual No. 18, CIFA, Bhubaneswar, India.

Moullac, G.I., Haffner, P., 2000. Environmental factors affecting immune responses in crustacean. Aquaculture. 191, 121−131.

Mukharjee, S.C., 2002. Fish diseases in India, their causes and control measures – winter school on recent advances in diagnosis and management of disease in maricutlure, 7th to 27th November 2002. Course Manual. Central Marine Fisheries Research Institute, Cochin, India.

Newman, S.G., 2014. Management of stress in aquaculture with a focus on farmed shrimp (http // www. Aqua – in tech.com).

Newman, S.G., 1999. Recent advances in the prevention of disease in shrimp with emphasis on LPS based on specific immune stimulants 1999. Presented at the regional conference of shrimp farming October 1999 Ganyaquil, Ecuador.

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

Rattmann, R.W., Francis-Floy, R., Durborow, R., 1992. Regional conference proceedings. Florida February 1992.

Raa, J., 1996. The use of immunostimulatory substances in Fish and shell fish farming. Reviewers in Fishery Science 4(3), 229−288.

Racotta, I.S., Palacios, E., 1998. Hemolymph metabolic variable in response to experimental manipulation stress and serotonin injection in *Penaeusvannmei*. Journal of the World Aqua Society 29(3), 351−356.

Sahoo, P.K., Mohanty, J., Garnayak, J.S.K., Mohanty, B.R., Kar, B., 2013. Estimation of loss due to argulosis in carp culture ponds in India. Indian Journal of Fisheries 60, 99−102.

Smith, V.J., Chisolm, J., 1992. Non cellular immunity in crustaceans. Fish and Shell Fish Immunology 2, 1−31.

Snieszko, S.F., 1974. The effects of environmental stress on the outbreak of infectious diseases of fish. Journal of Fish Biology 6: 197-208 (http // online library. Wilay.com / doi / 10.1111 / j.1095 – 8649. 1974.tb04537.X / abstract).

Walker, P.J., Winton, J.R., 2010. Emerging viral diseases of fish and shrimp. Veterinary Research 41, 51 (https / www.ncbi.nlm.nih. gov /pmc /articles / PMC 2878170).

YSI, 2010. Understanding ammonia in aquaculture ponds. http://www.ysi.com/media/pdfs/A585-Understanding-Ammonia-in-Aquaculture-Ponds.pdf.