American Journal of Psychiatric Rehabilitation

Original Research Article

Effect of Seasonal Variations on Fish Disease and Mortality in Freshwater Ecosystem

Tanzila Amir Khan[1], Abdur Rahim*[1], Adan parveen[1], Rahmat Hossain[1], Shandana Qayum[1], Shagufta[2]

[1,] *Department of Zoology, University of Malakand, Chakdara, Dir Lower, Khyber Pakhtunkhwa, Pakistan. Emails;Khanamir3399@yahoo.com,rahim.cemb@yahoo.com,adanparveen9@gmail.com, rahmathossain463@gmail.com, shandanaqayum5@gmail.com,
[2.] Abdul Wali Khan University, Mardan, Khyber Pakhtunkhwa, Pakistan, Email: iammashalkhan1346@gmail.com

***Corresponding Author:** Abdur Rahim
(E-mail; rahim.cemb@yahoo.com

Abstract
The present study aimed to evaluate the effects of seasonal variations on fish disease, behavior, and mortality in semi-cold water condition. Our findings indicate that fish mortality increased with decreasing water temperature and decreased with rising temperature. In September, at 17°C, 10 % of the fish showed signs of infection, but there was 0% mortality, and the fish exhibited normal behavior. In October, at 15°C, 5% of fish became infected, with a 2% mortality rate. Most fish moved to the bottom of the pond, and bacterial infections were predominant. By December, the water temperature had dropped to 11°C. Infection rates rose to 15%, and mortality reached 4%. Fish behavior changed significantly and they moved slowly, remained near the bottom, and stopped feeding. Fungal infections were more prevalent than bacterial ones during this period. January showed the highest level of fungal infections (20%), with the lowest temperature (11°C). However, in February, although the temperature remained the same, mortality dropped to 2%, and fish began feeding again. In March, no infections were observed, fish behavior normalized, and feeding resumed, correlating with increasing water temperatures to 20°C. In conclusion, the study suggests that warm-water fish species are vulnerable to bacterial and fungal infections during colder environment and need health management during intensive aquaculture.

Key words: seasonal variation, diseases and mortality, source of protein

Introduction

Fish is the important source of protein having good source of amino acid. Fish and fish oil contain two type of fatty acid (EPA) and (DHA) which is important for Alzheimer disease (Connorwe, 2000). Fish also contain omega-3 fatty acid EPA and DHA which have positive role and helpful to reduce heart disease and mental illness (Nigam *et al.*, 2018). Fishes contain lipid, valuable protein some amount of vitamins and minerals (Badoni et al., 2021). Fish contain important fatty acid which are antioxidant and increase body resistance against cancer. (Anderson et al., 2014).

Fin fish consumption reduce insulin resistance in skeletal muscle and also reduce sudden death from heart attack (Infofish, 2002). Cod skin produced gelatin to coat photographic paper and artificial skin from fish and prawn to produce collagen chitosan membrane which is to treat burns in humans (Infofish, 2002). Fish provide phosphorus and iron as well as provide a good source of digestible animal protein and also vitamin A and D (Thilsted & Rooos, 1999). Marine fish is rich in zinc calcium magnesium and is good source of Iodine (Worldfish center, 2005). Fish contain omega- 3 fatty acids benefited for health and also for those who are suffering cardiovascular disease (Bowen *et al,* 2016). In economy of Pakistan fisheries play important role by employing 40,000 people directly and 600,000 in another industries (Ebrahim, 2014). In Pakistan deep water captured fishes contributed 1.3 % from exclusive economic zone to total marine capture (FAO., 2009). In fresh water fish, the Indus River is the main capture point along its tributaries (FAO., 2009).

Fish diseases play a significant role in the decline of fisheries production. Certain pathogens can severely infect fish, leading to serious health impacts and even death. The rapid spread of infections often results in mass fish mortality, contributing to the overall decline in fish populations (Scholz, 1999). Diseases caused by bacteria, viruses, and fungi can cause substantial losses, especially when culturing carp species in semi-cold water, where fungal infections are commonly observed. Although Pakistan is rich in aquatic resources, its contribution to global fish production remains low (Mirza *et al.,* 2011).

As fishes are coldblooded animal they are more sensitive to their surrounding water temperature which effects growth rate, behavior, food consumption and body temperature. (Mouton *et al.*,

2013). In Tasmania (Australia), Norway, Scotland (UK), South Africa and Chile a connection between AGD prevalence and increasing water temperature has been noted in several studies that report outbreaks in Atlantic salmon farms (Adams & Nowak, 2003; Bustos et al., 2011; Clark & Nowak, 1999; Douglas-Helders *et al*., 2003; Douglas-Helders *et al*., 2001; Douglas-Helders *et al*., 2005).

Temperatures of 15°C or above has also been associated with non- optimal rate of growth and a metabolic depression of Atlantic salmon in terms of thermal growth coefficient (TGC), when compared to fish at 13°C, indicative of a chronic stress response (Olsvik *et al*., 2013). However, in lower latitude production areas, at temperatures of 15 °C Atlantic salmon can be cultured and other studies revealed a larger range of growth temperatures for Atlantic salmon (Oppedal *et al*.,2011; Stehfest *et al*., 2017) up to a maximum of 22°C (Elliott & Elliott., 2010).

Temperature also affects the body composition by controlling, metabolic rate, enzymatic rates and feed consumption (Blaxter., 1992). On immune response effect of temperature is highly species dependent, but in some fish immune functions clearly varies with season (Kumari *et al.*, 2006). The present study aimed to evaluate the effects of seasonal variations on fish disease, behavior, and mortality in semi-cold water condition.

Materials and Methods

Site Selection

Our study area was Malakand Division, Khyber Pakhtunkhwa, Pakistan. In this region, seasonal variations and temperature fluctuations are considerably higher as compared to other areas. Many warm water fish species were stocked at the ponds present at university of Malakand. Therefore, to study fish behavior, infections, and mortality, the university fish ponds were selected for this research.

Infection and Mortality

The fish pond was visited on daily basis and the infected fishes were checked and their mortality was also noted. Fish having symptoms of disease were collected and were examined with the help of magnifying glass. Fish gills and skin were examined to evaluate the infection and samples from the fish were taken for further microscopic examination.

Fish Feeding and Mortality

Fish were fed daily with artificial diet. Their feeding behavior and movement were also monitored. It was observed that the fish exhibited normal movement and feeding at 20°C. However, after October, changes in behavior were noted the fish reduced their movement and stopped feeding. Feeding resumed after February as temperatures began to rise.

Water Quality Parameter

Water quality parameter such as pH, dissolved oxygen and temperature was regularly checked with the help of water quality meters. Especially temperature was recorded on daily basis with the help of underwater thermometer. Dissolved oxygen was measured with the help of DO meter. pH was determined with the help of pH meter. We found that temperature have significant effects on fish physiology.

Treatment and Health management

The infected fish were collected and placed in different aquaria in the Fisheries and Aquaculture Laboratory, Department of Zoology, University of Malakand. The infected fishes were exposed to Nacl solution. Dead fish from the pond was removed and mortality of fish was recorded regularly.

Results and Discussion

Temperature Variation and Fish Response

Temperature of the aquatic environment plays a crucial role in the survival, distribution, and normal metabolism of fish. Throughout the year, by observing fish behavior, feeding patterns, and mortality rates, we found that during the months of September, October, December, January, February, and March, temperature fluctuations led to increased infections and significant changes in fish movement. The inability of fish to adapt to such temperature variations often results in increased mortality (Cnaani, 2006).

Mortality Rate

In the present study we recorded that at the water temperature was 17C° in the month of September and mortality of fish was 0%. Similarly in the month of October at 15 C° the observed mortality was 2%. According to Bly and Clem (1992) the immunological, non-permissive temperature has been suggested at 14C° in carps. Temperature below the optimum limits adversely affected the fish in the month of December at temperature of 11C° in this study. Fish mortality increased and reached up to 4% in December, this indicate the adverse effect of temperature decline on fish health (table1). Significantly higher mortality of fish was recorded in the month of January (5%) at the temperature of 10C° this might be due to low intake of food or due to some non-immune response.

Similarly according to (Ainsworth *et al*.1991) the innate immune response of channel cat fish was influenced by low temperature (10C°) as phagocytic

activity of neutrophil was reduced. An another study shafland and pstrak (1982) reported that the lethal temperature for fish mortality is 9.4C° in florida. However the mortality of fish decreased as the temperature increased and only 2% fish mortality was recorded in the month of February at 11C°. While in the month of March 0% fish mortality was recorded as shown in table1.

Rate of Infection and Infection Types

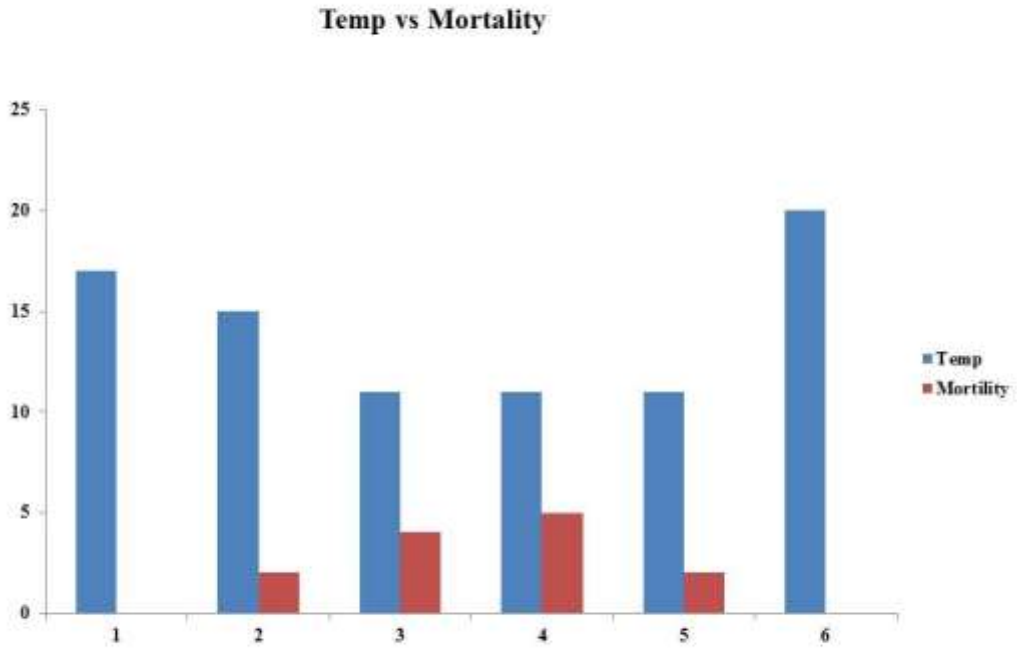
During the observation period, it was found that seasonal fluctuations significantly impacted fish health, leading to infections and physiological changes. In September, no fish were found to be infected at a water temperature of 17°C. In the October, as the temperature dropped to 15°C, 2% of the fish became infected, and most of the infections were bacterial and some fungal infections. As the temperature continued to decrease, the infection rate increased. Similar results were also reported by Albert *et al.,* (2013) while working on marine organisms. In December at 11°C, 15% of the fish showed signs of infection, predominantly fungal, with a few bacterial cases. The risk of infection was highest in January, when the temperature fell to 10°C. At this point, 20% of the fish were infected, with fungal infections being most prevalent. These infections severely affected the gills, skin, and fins, leading to high mortality, as shown in Table 4.1.

Table, 1. Mortality rate, infected fish, infection type, water temperature and fish behavior of fishes during the study period.

Months	Mortality rate	Infected fish	Infection type	Water Temperature	Fish behavior
September	0 % fishes	0 %	Not infected	17°C	Normal behavior
October	2% fishes	0 %	Most infections were bacterial with few fungal infections.	15°C	Normal behavior
November	2 % fishes	5%	Most infections were bacterial with few fungal infections	15°C	Fish majority move to bottom
December	4 % fishes	15%	Most fungal infections with few bacterial infections	11°C	Slow movement in fish
January	5 % fishes	20%	Most fungal infections with few bacterial infections	10°C	abnormal movement and stop feeding
February	2% fish	15%	Most fungal infections with few bacterial infections	11°C	Move slowly and start feeding
March	0 % fish	0%	No infection	20°C	normal movement

Fish Behavior and Food intake

Observations on fish behavior revealed that physiological processes such as food consumption, digestion, and movement are significantly influenced by seasonal fluctuations. These behavioral changes were primarily associated with temperature variation, although other environmental factors may also contribute to physiological processes. During the months of September and October, fish displayed normal movement and feeding behavior. In September, at a water temperature of 17°C, fish showed healthy growth and consistent feeding, as presented in Table1. Similarly, in October, with a slight drop in temperature to 15°C, feeding remained normal, although slight changes in movement were observed. However, as the temperature continued to decrease, the physiological activity of fish declined. In December, reduced temperatures led to slower movement, and fish were observed resting near the bottom of the pond. According to Olsvik et al. (2013), temperatures of 15°C or higher are associated with metabolic depression and suboptimal growth rates (measured by the Thermal Growth Coefficient) in Atlantic salmon at 13°C.



Fig,1: Impact of temperature on fish mortality in the freshwater ecosystem.

Conclusion

It was concluded from the current study that warm water species could be culture in semi-cold freshwater ecosystem after adaptation. But during fish culture, disease in fish may increase in winter (October to February) with decrease in water temperature. Highest mortality rate of fish were observed in the month of January at temperature of 10C°, while there was no (0%) mortality and no disease in the month of September and March in fish. It is suggested that suitable health management is i.e plant extract, organic and environmental friendly remedy is required for fish disease management when intensively cultured in semi cold freshwater ecosystem.

References

1. Adams, M. B., & Nowak, B. F. (2003). Amoebic gill disease: Sequential pathology in cultured Atlantic salmon, Salmo salar L. *Journal of Fish Diseases*, 26(10), 601-614.
2. Ainsworth , A.J., C. Dexiang ,P.R. Waterstrat and T. Greenway. (1991). Effect of Temprature on the immune system of channel catfish (Ictalurus punctatus)-I. Leucocyte distribution and phagocyte function and the anterior kidney at 10 °C. *Comparative physiology and biochemistry* 100:907-912.
3. Anderson, E. J., Thayne, K. A., Harris, M., Shaikh, S. R., Darden, T. M., Lark, D. S., ... & Rodriguez, E. (2014). Do fish oil omega-3 fatty acids enhance antioxidant capacity and mitochondrial fatty acid oxidation in human atrial myocardium via PPARγ activation?.
4. Albert, V. and Ransangan, J., 2013. Effect of water temperature on susceptibility of culture marine fish species to vibriosis. International Journal of Research in Pure and Applied Microbiology, 3(3), pp.48-52.
5. Badoni, P., Nazir, I., Aier, M., Maity, P. B., Samanta, S., & Das, A. (2021). Significant role of fish nutrients with special emphasis to essential fatty acid in human nutrition. *Int. J. Curr. Microbiol. Appl. Sci*, *10*, 2034-2046.
6. Blaxter, J. H. S. (1992). The effect of temperature on larval fishes. *Netherlands Journal of Zoology* 42:336–357
7. Bly, J.E. and L.W. Clem. (1992). Temprature and teleost immune function. Fish and Shellfish *Immunology* (2)159-171.
8. Bowen, K. J., Harris, W. S., & Kris-Etherton, P. M. (2016). Omega-3 fatty acids and cardiovascular disease: are there benefits?. *Current treatment options in cardiovascular medicine*, *18*, 1-16.
9. Bustos, P. A., Young, N. D., Rozas, M. A., Bohle, H. M., Ildefonso, R. S., Morrison, R. N., & Nowak, B. F.

(2011). Amoebic gill disease (AGD) in Atlantic salmon (Salmo salar) farmed in Chile. *Aquaculture*, 310(3-4), 281-288.

10. Clarke, S.C., Milner-Gulland, E.J., Bjørndal, T. (2007) Social, economic, and regulatory drivers of the shark fin trade. *Marine Resource Economics* 22: 305–327.
11. Cnaani, A. (2006). Genetic perspective on stress and disease resistance in aquaculture. Israeli *Journal of Aquaculture* – Bamidgeh 58:375-383.
12. Douglas-Helders, G. M., O'Brien, D. P., McCorkell, B. E., Zilberg, D., Gross, A., Carson, J., & Nowak, B. F. (2003). Temporal and spatial distribution of paramoebae in the water column - A pilot study. *Journal of Fish Diseases*, 26(4), 231-240.
13. Ebrahim Z., (2014), Inter press service, News Agency http://www.ipsnews.net/2014/11/inside-pakistans-untapped-fishing-ind ustry/
14. Elliott, J. M., & Elliott, J. A. (2010). Temperature requirements of Atlantic salmon Salmo salar, brown trout Salmo trutta and arctic charr Salvelinus alpinus: Predicting the effects of climate change. *Journal of Fish Biology*, 77(8), 1793-1817.
15. FAO, Fishery and Aquaculture Profile, (2009) ftp://ftp.fao.org/FI/DOCUMENT/fcp/en/FI_CP_PK.pdf
16. INFOFISH. (2002b). Artificial skin from fish to treat burns and gelatine from cod skin to coat photographic paper. 4/2002, 73 p. July/August.
17. Kumari, J., P. K. Sahoo, T. Swain, S. K. Sahoo, A. K. Sahu, and B. R. Mohanty. (2006). Seasonal variation in the innate immune parameters of the Asian catfish Clarias batrachus. *Aquaculture 252:121–127.*
18. Mirza, ZS, Mirza M, Mirza MA and Sulehria, AQ K (2011). Fish diversity of River Swat Pakistan. *Biologia (Pakistan)* 57 (1 & 2), 23-30.
19. Mouton, A., Crosbie, P., Cadoret, K., & Nowak, B. (2013). First record of amoebic gill disease caused by Neoparamoeba perurans in South Africa. *Journal of Fish Diseases*, 37, 407-409.
20. Nigam, D., Yadav, R., & Tiwari, U. (2018). Omega-3 fatty acids and its role in human health. *Functional food and human health*, 173-198.
21. Olsvik, P. A., Vikeså, V., Lie, K. K., & Hevrøy, E. M. (2013). Transcriptional responses to temperature and low oxygen stress in Atlantic salmon studied with next-generation sequencing technology. *BMC Genomics*, 14(817)
22. Oppedal, F., Vågseth, T., Dempster, T., Juell, J., & Johansson, D. (2011). Fluctuating sea-cage environments modify the effects of stocking densities on production and welfare parameters of Atlantic salmon (Salmo salar L.). *Aquaculture,* 315, 361-368
23. Raida, M. K., & Buchmann, K. (2007). Temperature-dependent expression of immune-relevant genes in rainbow trout following Yersinia ruckeri vaccination. Diseases of Aquatic Organisms, 77(1), 41-52
24. Robinson, E. H., and M. H. Li. (2001). A practical guide to nutrition, feeds, and feeding of catfish. *Mississippi Agricultural and Forestry Experiment Station Technical Bulletin* 1113.
25. Scholz,T.(1999): Parasites in cultured and feral fish.*Vet.Parasite*;84,317-335.
26. Shafland, P.L. and J.M. Pestrak. (1982). Lower lethal temprature for fourteen non-native fishes in Florida *Environmental Biology of Fishes* 2:149-156.
27. Stehfest, K. M., Carter, C. G., McAllister, J. D., Ross, J. D., & Semmens, J. M. (2017). Response of Atlantic salmon Salmo salar to temperature and dissolved oxygen extremes established using animal-borne environmental sensors. *Scientific Reports*, 7(4545)
28. Steinum, T., Kvellestad, A., Rønneberg, L. B., Nilsen, H., Asheim, A., Fjell, K., & Dale, O. 924 B. (2008). First cases of amoebic gill disease (AGD) in Norwegian seawater farmed Atlantic salmon, Salmo salar L., and phylogeny of the causative amoeba using 18S cDNA sequences. *Journal of Fish Diseases*, 31(3), 205-214.
29. Thilsted, S. H. and N. Roos. (1999). Policy issues on fisheries in relation to food and nutrition security. 61-69. M. Ahmed, C. Delgado, S. SverdrupJensen, and R.A.V. Santos. (eds.) *Fisheries policy research in developing countries*: issues, priorities and needs. ICLARM Conf. Proc. 60, 112.
30. World Fish Center. (2005). Fish and Food Security in Africa. *World Fish Center, Penang, Malaysia.*