Southern Regional Aquaculture Center

SRAC Publication No. 474
September 2015
Revision

The Role of Stress in Fish Disease

Christopher Green[1] and Alf Haukenes[2]

The environmental conditions and handling practices of aquaculture can be stressful to fish. Fish reared in commercial aquaculture are confined to ponds, pens, tanks, or raceways and are routinely stressed by intensive production management practices. A stressor can be short-term but severe, such as seining, handling, or transport. Or, a stressor can be a long-term culture condition that is sub-optimal, such as increased fish density, poor water quality (i.e., low dissolved oxygen; undesirable temperature or pH; or increased levels of carbon dioxide, ammonia, nitrite, hydrogen sulfide, or organic matter in the water), inadequate nutrition, or poor sanitation.

Stress may cause a physiological response ("stress response") that compromises a fish's ability to maintain stable internal conditions and/or defend against disease (Fig. 1). As fish encounter stressful conditions (e.g., physical or chemical insult or perceived threat) the central nervous system reacts to release stress hormones (cortisol, adrenaline, and noradrenaline). These hormones can change behavior, alter blood flow, increase heart rate, and liberate energy stores (e.g., formation of new sugar from liver glycogen stores, mobilization and metabolism of lipid). These responses to alarming stimuli help a fish escape from or survive the stressor in the near-term, but frequently come at a cost to long-term maintenance, growth, reproduction, or other internal processes. The consequence of prolonged stress within an aquaculture setting is a general decrease in production efficiency, especially decreased growth and disease resistance.

[1]Louisiana State University
[2]University of Arkansas at Pine Bluff

Stress and the Mechanisms of Disease Resistance

Fish have multiple layers of defense against infections. Some of these layers, such as surface mucus, skin, and scales, help prevent pathogens from entering the body. Others, including inflammation and other kinds of immune response, create an internal environment less likely to allow pathogens to survive and proliferate.

Barriers to Infection

Surface mucus (the slime layer) is the first physical barrier that inhibits the entry of disease organisms from the environment into the fish. It contains enzymes and antibodies that can kill disease-causing organisms. Mucus also assists in maintaining ion gradients between the external and internal environment (osmoregulation). The handling associated with capture and transport, the deterioration of water quality, or chemical treatments can damage the mucus and reduce its effectiveness at blocking pathogens. Removing the mucus layer also can lead to in excessive uptake of water by the tissues in freshwater fish and dehydration in saltwater fish. Under certain stressful conditions, some fish produce excess mucus that can smother gills and skin, thus altering ion/water balance and respiration.

Scales and skin are also often injured by the handling and crowding associated with routine fish culture activities. Aggressive behaviors that may become magnified by overcrowding, or even reproductive behaviors, can lead to injuries. Any damage to the scales and skin of the fish can increase its susceptibility to infection by providing a point of entry for a pathogen. Damage to scales and skin also makes osmoregulation more difficult because it leads to excessive uptake of water by freshwater species and loss of water by marine species.

Inflammation and Other Non-Specific Features of the Immune Response

Inflammation is a fish's natural response to a foreign protein, bacterium, virus, parasite, or fungus. Overall, inflammation can be viewed as a non-specific response that protects fish by creating an internal environment less likely to allow a pathogen to proliferate. During a stressful event, the stress hormone cortisol is released. Cortisol is an anti-inflammatory agent that can suppress the immune system and cause a fish to be more susceptible to infection. Non-specific immune activity also includes enzymes and other chemical constituents that act directly on pathogens, as well as cells designed to consume foreign materials. While further research is needed on all of the ways stress hormones affect the immune system, a linkage among stress, non-specific immunity, and a diminished disease resistance can be inferred from the available information.

Specific Immune Responses

While fish rely heavily upon non-specific immune activity, antibodies and other specific cellular mechanisms are also extremely important in preventing infections. These immune responses recognize the surface features of pathogens and mobilize the immune system against them. Stress hormones appear to impede the development of highly specific receptors that recognize pathogens. As a result, the immune system fails to produce antibodies to fight the disease. Stress can reduce the overall effectiveness of the specific immune system function and increase the likelihood that an invading pathogen could proliferate.

Environment and Life History Influences on Immune Responses

The environment can play a dual role in the likelihood of infection. For example, rapid changes in surrounding water temperature (either hot or cold extremes) are a stressor that affects non-specific and specific immune responses. Fish are poikilotherms, meaning their body temperature is similar to the surrounding water temperature. When exposed to rapidly cooling water, biological processes—including immune responses—occur more slowly. This can allow a pathogen to proliferate. At higher temperatures, biological processes within fish, as well as the growth rate of pathogens, occur more rapidly. However, near the upper thermal limits of the fish the immune system becomes impaired while pathogen growth is unhindered.

Other factors that can contribute to, or directly influence, the immune response are natural rhythms of hormonal activity and growth. For example, some reproductive hormones suppress the immune system. Also, as fish grow their immune system continues to develop and becomes more efficient and better able to ward off pathogens. Therefore, when fish are spawning or when they are very young, they are particularly vulnerable to infection following stressors such as seining or other handling practices.

BMPs for reducing stress

Preventing stress to fish requires planning. Long-term stressors such as poor water quality should be avoided and a monitoring program of water quality parameters should be maintained. Stressors during harvest, handling, and transport are unavoidable, but their impact can be signifi-

Figure 1. Unavoidable stressors during aquaculture production include crowding, handling, and transport.

cantly reduced with a few simple management practices. The following are best management practices that can help reduce exposure to stressors, mitigate the stress response, and subsequently reduce the likelihood of disease.

Water Quality

1. Monitor and maintain dissolved oxygen concentrations in culture systems at adequate levels for the species of fish. Sub-optimum concentrations of dissolved oxygen, while not immediately lethal, may stress fish and result in delayed mortality, poor growth, or diminished reproduction.
2. Minimize crowding and do not exceed the maximum carrying capacity of fish in culture systems. While some fish can reside at high densities in certain systems, some species are acutely sensitive to stress caused by crowding.
3. The daily cyclic fluctuations of dissolved oxygen concentrations and pH in ponds need to be taken into account when feeding and seining fish.
4. Avoid overfeeding to prevent the rapid accumulation of organic debris, nitrogenous wastes (ammonia and nitrite), carbon dioxide, and hydrogen sulfide.
5. Other water quality parameters such as alkalinity, hardness, and temperature should be monitored and recorded to ensure they are within appropriate levels for the culture species.

Handling and Transport

1. Use capture methods that minimize physical injury and stress. When possible, use knitted mesh dip-nets rather than knotted nets to reduce injury and scale loss. Reduce the water volume in tank systems, if possible, to prevent prolonged chasing during capture.
2. Minimize the number of times the fish are removed from the water, and work as quickly as possible when transferring fish. Speed and gentleness when handling fish are of utmost importance.
3. When handling fish for long periods of time (such as strip spawning or tagging), consider using an *approved* anesthetic that will reduce stress when fish are excessively handled. Anesthetics may require a withdrawal period.
4. When transporting fish, maintain a stable temperature the entire time fish are in transit, or make a very slow transition from one temperature to another during transport or tempering.
5. In some cases, selective grading devices have been used to reduce handling time, minimize stress, and subject fewer fish to stress during sorting and harvest.
6. Maintaining adequate oxygen during transport, or within temporary holding tanks, is imperative. Providing aeration immediately after seining and capture is critical as fish are recovering from the handling stress.
7. In freshwater fish, salt (1.0 to 3.0 ppt) may be used in transport water to minimize any osmotic imbalance induced by stress and help remove nitrogenous waste from the body. Marine species may benefit from a small reduction in transport water salinity compared to that of the culture water.

Conclusion

It is impossible to entirely eliminate stress or disease within fish culture. However, the impact of stress and subsequent susceptibility to disease can be significantly reduced through best management practices. Mitigating stress can improve a number of production characteristics such as growth and reproduction. A better understanding of the connections between stress and the mechanisms of disease resistance will help in avoiding future problems that can arise from acute and chronic stressors.

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2010-38500-21142. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

SRAC fact sheets are reviewed annually by the Publications, Videos and Computer Software Steering Committee. Fact sheets are revised as new knowledge becomes available. Fact sheets that have not been revised are considered to reflect the current state of knowledge.

USDA United States Department of Agriculture National Institute of Food and Agriculture

The work reported in this publication was supported in part by the Southern Regional Aquaculture Center through Grant No. 2010-38500-21142 from the United States Department of Agriculture, National Institute of Food and Agriculture.