Stress Physiology

Stress

Stress can be described as the physiological response to a stressor. In other words, stress is an internal physiological state that is caused by external conditions. Stress can also be described as an internal hormonal response of a living organism caused by environmental or other external factors that moves that organism out of its normal physiological resting state, or homeostasis. Stress can disturb the normal physiological equilibrium or homeostasis of fish by forcing a reallocation of energy within its system.

Stressors are those factors that cause a stress reaction

Crowding

Low dissolved oxygen levels

High carbon dioxide levels

Photo-stress

Thermal stress

Pathogens

Heavy metals

Toxins

Handling

Aggression by other fish

Electrical charges

Excessive water velocity

Nitrogenous waste

Low pH

Noise or vibration

Nutritional deficiencies

Transport stress

Improper hardness

Injury

Stress Response

Fish responses to stress can be divided into three phases: primary, secondary, and tertiary.

The primary phase refers to a generalized **neuroendocrine response** in which catecholamines **(epinephrine and norepinephrine**) and **cortisol** are released from chromaffin and interrenal cells, respectively.

In secondary phase higher circulating levels of these hormones trigger a secondary response that involves **physiologic and metabolic pathways**; examples of the secondary response include hyperglycemia due to enhanced **glycogenolysis** and **gluconeogenesis**, **vasodilation** of arteries in gill filaments, increased cardiac stroke volume, and immune function depression.

The first two phases are considered adaptive and enable fish to adjust to stressors and maintain homeostasis. In contrast, **tertiary responses** involve systemic changes in which animals may become incapable of adapting to stressors, leading to adverse effects on the animal's overall health, including their performance, growth, reproduction, disease resistance, and behavior.

Internal hormonal response to stress

- The internal hormonal response to stress in fish has many similarities to that of mammals. **The most widely accepted indicator of stress is the blood plasma cortisol level.** The two major actions of cortisol in fish are regulation of hydromineral or osmotic balance and energy metabolism. Some consider the role of corticosteriods to be protecting the body from overdoing with its own defence mechanisms.

- Corticosteroid and catecholamine hormones are released in response to stressors in an attempt to adapt or avoid the cause of stress. Although both types of stress hormones are released into the bloodstream as part of the integrated stress response to acute and chronic stressors they do play different roles. **Catecholamines or CA is the primary hormone released in the "Fight or Flight" response to acute stressors**. Corticosteriods, predominately **cortisol, are the primary hormone released in response to chronic stressors.**

Internal hormonal response to stress continued

- The catecholamine hormones epinephrine (adrenalin) and norepinephrine (noradrenalin) are associated with more immediate reactions to stress, and are released when situations requiring a fight or flight response occur. The release of catecholamine hormones into the bloodstream causes increases in cardiac output, blood sugar, respiration, oxygen uptake, and blood flow to the gills. This prepares fish to better cope with threats to territory and safety. These responses are usually short in duration and are considered acute stresses.

- Corticosteriods, primarily cortisol, are associated with chronic stress as the animal attempts to adapt. Cortisol is released in response to all stressors, but its effects become greater the longer the stress reaction continues.

- When stress is continuous or chronic and cannot be avoided, as is more likely in the confined environment of an aquarium, the hormonal and behavioral responses cease to be a tool for adaptation and survival. At this point,these responses become maladaptive.

Effect of Catecholamines on physiology of fish

Increase in blood glucose	Increase in epithelium permeability to water and ions
Increase in heart rate	Increase in calcium reabsorption in bones
Increase in cardiac output	Increase in HCl secretion in the stomach
Increase in respiratory ventilation	Increase in insulin release by pancreas
Vasodilation and vasoconstriction of arterioles	Increase in thyroxin release
Increase in number of thrombocytes	Decrease in protein synthesis in liver
Increase in gluconeogenesis in liver	Decrease in glycogen synthesis
Increase in production of steroid hormones	Smooth muscle tension

Effect of Corticosteroids on physiology of fish

Function	Effect
Protein Metabolism	Increased protein synthesis via enhanced activity of messenger RNA, the protein synthesized seem to be mostly proteolytic. Inhibition of growth Mobilization of protein from thymus, spleen and liver
Carbohydrate Metabolism	Reduced utilization of carbohydrate. Increased glucose production from tissue protein. Deposition of glycogen in liver
	Mobilization of leucocytes Reduced inflammatory response
Gills (in freshwater)	Increased retention of ions
Kidney(in freshwater)	Increased reabsorption of Na+ by kidney tubules
Testes (in freshwater)	Precocious sexual maturity in downstream migrant smolts (males only)
Gills and intestine (in seawater)	Increased production and activity of Na+/K+ ATPase, giving enhance salt absorption in gut and enhanced salt excretion by the gills

Physiological effect of hypoxia

- An obvious and dramatic effect of low ambient oxygen on an organism is a lethal response. Hypoxia may limit the energy budget or scope for growth and activity of an organism, it may cause an organism to alter its behavior, and/or it may limit the tolerance of an organism to other environmental challenges.

- **Anaerobic Metabolism:** In severely hypoxic water (low dissolved oxygen) most of the energy production is via anaerobic pathways which raise the blood pH by increased production of lactate.
- **Hypercapnic hypoxia**: Hypercapnia, independent of dissolved oxygen, can have dramatic effects on the physiology of marine organisms. An elevation of ambient C02 results in a concomitant elevation of C02 in the bodies of organisms. The direct result of hypercapnia is a decrease in the pH of tissues and body fluids, which can have profound effects on a number of functions.
- Production of Reactive oxygen species **(ROS)** also have negative effect on organism's health.