Environmental Stress - induced Fish Diseases

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Diseases have been known to occur among fishes from times immemorial. However, scientific quest to understand the causes of diseases among fishes, and attempts to control them gained strength only during the last two-thirds of 20th century. Efforts to cure fish diseases require a somewhat different approach compared to measures adopted to combat or deal with diseases among terrestrial animals. The reason is that live aquatic animals live in an entirely different environment. Factors of the environment such as water temperature, pH, dissolved gases, and others come into play in the state of proliferation of disease causing organisms and their influence in causing disease among fishes.

Broadly stated, the incidence of disease may have different causes such as nutritional disorders, genetic disorders, physical injuries, co-existing organisms (agents) and negative effects due to non-living entities such as critical intensities of abiotic environmental factors and natural or man-made pollutants, including poisonous substances.

Whenever conducive environmental limits are crossed and excessive alteration in these limits take place physiological and biochemical changes occur within the fish, which are often beyond their ability to survive. The fish are either killed as a direct result of the physical alteration, or their systems are damaged to the point where they become vulnerable to other diseases.

The most common diseases of fishes related to physical factors are associated with osmotic pressure, environmental temperature, hydrogen ion concentration (pH) and dissolved air. These factors are often disregarded as causes of diseases in fishes. But when these factors move beyond critical limits, the effects can be as devastating to a fish population.

Osmotic pressure : The osmotic pressure of pure water exerts a force on living cells equal to one atmosphere. When a living cell is in a quality water environment, there is a higher osmotic pressure inside the cell than outside. The semi-permeable cell membrane may allow some substances within the cell to diffuse out, but the greatest effect is in respect of diffusion of water into the cell to equalize osmotic pressures. The result is a flooding of the cell, often until it brusts.

Subjecting the fish to external osmotic pressures which may happen to be lower than the osmotic pressure of the entire fish tends to diffuse out substances from within its body cells.

The quality of a water in which fishes live in nature or the water in which they are placed to live must have such an osmotic pressure that enables the maintenance of a relatively narrow range of osmotic pressure in the cell structure of the fishes so as to maintain the cellular water and salt there in a manner that would prevent cells from collapsing. Another important factor relating to osmotic pressure and fish survival involves ova. Eggs released by female freshwater fishes are flaccid and must absorb water (water hardening). Eggs of freshwater fishes subjected to water with a relatively high salinity cannot absorb water against the relatively high osmotic pressure within the egg and therefore die from the effect.

Diagnosis of adverse effects of osmotic pressure on fishes is difficult. Freshwater fishes subjected to high salinity concentrations become lethargic, seek the shore areas of the pond or may even attempt to leave the water. Analysis of water for total dissolved solids, salinity etc., may indicate ranges tolerated by the fish species involved.

Temperature : Each fish species has an inherent temperature range within which it can survive, grow and reproduce. Natural water which supports fish life generally has a range of temperature similar to requirements of the fish species living there. Changes in environmental temperatures beyond the normal survival range of fishes may cause thermal trauma. Disorders in fishes arising from thermal trauma include effects on the cardio-vascular system, the nervous system, changes in colloidal state of proteins and reduction or cessation of enzymatic activities. Thermal trauma may result in permanent impairment of body functions or health.

The tolerance of fish to changes in temperature is variable. It depends not only on the environment in which they have been living but also on the rapidity of the change. The duration of temperature extremes prevailing in their environment is also important. During embryonic development, marked temperature fluctuations from the optimum could lead to abnormalities (malformations of the fins, gill covers and scales, anomalies in the vertebral column etc.).

The process of thermal adaptation is largely an enzyme - mediated mechanism. Adaptation to cold condition is manifested in the biosynthesis of new variants of enzyme proteins, glycogen and fats, which are better suited for catalysis at low temperatures. Mortality due to lethal conditions of heat and cold is related to the inactivation of the enzymes.

The visible effects associated with insufficient adaptation are various. Very high temperatures affect the fish, especially when the oxygen concentrations are inadequate. Under such conditions, fishes often refuse to accept feed and may be easily prone to intestinal inflammation. If the adaptive capacity is strained, death occurs, often in conjunction with convulsive movements, dark colouration and spread out gills.

Cold shocks bring about disturbances in fish equilibrium, damage to the skin, edema, and haemolysis. Sudden drop of temperature may lead to low temperature rigor and after few hours, to death, due to paralysis of the respiratory centres.

Diagnosis of thermal trauma in fishes is difficult. It must be made primarily on records of water temperature to which the fishes have been subjected.

Importance of Oxygen (Stress due to oxygen deficiency and excess carbon dioxide)

Oxygen: Oxygen deficiency occurs due to various deteriorating phenomena caused by the chemical and biological activities. The ability to fully utilise the oxygen supplied by the blood depends on its concentration in the water. Under favourable conditions, cyprinids can fully utilize about 60% of the oxygen supply but only 20 - 30% under unfavourable circumstances. A sudden fall in the oxygen content always acts as a stress. Acclimatization to some extent can occur when there is a gradual decrease.

During conditions of unfavourable oxygen supply fish shows signs of : a) More or less increased intensity of respiration, b) Considerably enhanced absorption of oxygen from water, c) More or less highly disturbed functioning of organs, d) Considerable reduction in food intake, e) Decline in weight, and f) More or less poor state of health.

Furthermore, when there is a deficiency of oxygen, the functioning of the defence mechanism suffers and it is no longer maintained at the optimum level. The possibility of parasite infection increases, especially since these mostly reside in the body cavity and are therefore adapted to an environment poor in oxygen. Also the number of erythrocytes rises at first and drops thereafter. The content of plasma proteins and the ability to form antibodies also decreases.

When oxygen content becomes critically low, fish might display a behaviour referred to as 'floating'. They rise to the upper water layers and break the surface with their heads, with the mouth gasping. Permanent deformity of the buccal region may result due to frequent floating, a result of overstretching and hypertrophy of the maxillary skin folds associated with spasmodic gasping.

Carbon-dioxide: Carbon-dioxide can act as a limiting factor during transport and in maintaining fish in closed systems with recycled freshwater for intensive fish production. The sensitivity of different species of fish to a rise in the CO_2 content is variable. If, however, the fish are active, what happens will be that, as the CO_2 concentration increases, the metabolic rate declines, i.e., Oxygen consumption goes down. Since CO_2 decreases the affinity of blood for oxygen and reduces its O_2 carrying capacity, an increased CO_2 content of water raises the asphyxiation threshold of the fish.

Gas-bubble Disease

Abnormally high oxygen content may be detrimental to fish health. It is suspected of causing "bubble disease". (Mixing of atmospheric air and water under pressure increases solubility of all gases. Sudden release of pressure on the water - gas mixture allows the gases to gradually escape back to the atmosphere until the pressure and gas solubility are equalized. Fish living in water during the period of dissolved gas pressure equalization may develop gas bubble disease.)

A sudden reduction of the gas pressure in water is generally the cause of gas-bubble disease. This situation originates not only as a result of supersaturation of oxygen but also of nitrogen in the water and the subsequent decrease in the pressure. Since the blood of the fish is still at higher pressure because it is nearly saturated with gas, supersaturation occurs when there is a rapid drop in the gas pressure in water. If the gas tension in the blood of the fish is significantly higher than in the water, there follows the escape of gas in the form of bubbles. The chemical composition of the gas bubbles formed largely resembles that of atmospheric air.

The most important physiological effect of the gas bubble disease is that the fish attacked by this disease constantly keep moving restlessly on the surface of the water. Bubbles of air form around the mouth margins, on and the fin bases and in the walls of the alimentary canal. Affected fry swim in the head-down position. In severe cases the skin may peel, causing haemorrhages. (If numerous bubbles have appeared, fish rapidly becomes apathetic and die when the blood vessels are blocked by the gas bubbles (gas emboly).

Nitrogen content above 130% air saturation produces another form of gas bubble disease. Dissolved nitrogen is absorbed during normal respiration and, upon reaching a critical blood level, becomes dissociated and forms bubbles, the presence of which can be fatal. Gas bubbles form within the tissues and in the orbits. The eyeballs protrude, sometimes giving the first indication of bubble disease.

Another form of bubble disease results from the accumulation of gas bubbles in the intestine. Excessive application of unfermented fertilizers leads to gas bubble formation in the water. In the nearly anaerobic water at the pond bottom, these fertilizers undergo partial decomposition and release small bubbles of acetylene and sulphur dioxide. Fish try to ingest the bubbles mistaking them for small planktonic organisms. A comparatively large gas bubble forms in the intestine and upsets equilibrium, forcing the fish to the surface of the pond and preventing normal swimming movements. The way to prevent this type of bubble disease is to avoid use of unfermented fertilizers. When fish begin to show signs of the disease, addition of fresh water is the best control. Gas-bubble disease can also be prevented by avoiding sudden difference of gas tension. One must proceed very carefully when sup plying pure oxygen in fish transport. The fishes should be immediately transferred after reaching the destination, to water with the gas pressure always remaining more or less uniform.

White spot disease

White spot disease (Not to be confused with White Spot Syndrome Virus that infects shrimps) is also known as yolk coagulation disease and has so far been observed exclusively in salmonids and particularly embryos of the eyed stage and in larvae with yolk sacs.

The external signs of the disease are the appearance of small white spots in the yolk sacs. They are coagulated proteins. This is due to abnormal physiological processes caused by various unfavourable environmental conditions (possibly the temperature and oxygen concentration have a role to play) (Steffens, 1964). The control of this disease is possible by providing optimum physico-chemical conditions during rearing.

Stress due to variations in pH values (Acidosis and Alkalosis)

Most fish species find neutral or slightly alkaline water (pH 6.5 - 8) to be the optimum for living. Marked shifts to the acid (pH < 6.0) or alkaline range (pH > 8.5) bring about severe effects, mostly irreversible and leading to death if long acting.

Acidosis: The reasons for water being or becoming acidic can be because of natural causes, but this can also be brought about by the environmental pollution. Fishes in water with a low pH may show signs of acidaemia; a brown coating on the gills caused by coagulative necrosis of the living tissues (produced by denaturation of protein by acid). A copious quantity of mucus is produced. Secondary infections are common (fungal attack, severe attack by *Costia* and other skin parasites). As the disease progresses, the skin assumes a muddy appearance and sheds layers of thick mucus, occasionally reddening, especially on the abdomen. To avoid this disease, correct pH levels must be maintained.

Alkalosis: Redness, "eating away" of the gills and fraying of the fins are the symptoms of alkalosis i.e., disease caused by excessive alkalinity. Severely damaged fishes die.

Yolk Sac Dropsy

Yolk sac Dropsy, also designated the blue sac disease, is widespread among the salmonid larvae. This disease is typical for trout and salmon, but also occurs among hatchlings of other freshwater species of fish, who have a relatively large yolk sac.

The causes of yolk sac dropsy can be diverse, but in most cases, they comprise environmental stress. Dieterich (1938), ascribed the principal causes to the progeny of weak and late spawners. There is also a view that yolk sac dropsy could occur mainly as a result of the accumulation of the products of metabolism in the hatchery waters. The longer the eggs remain under unfavourable conditions of higher concentrations of ammonia and urea, the more frequent is the incidence of the disease. This is often observed particularly after eggs are packed in small containers.

The external sign of the disease is a marked distension of the yolk sac due to the content of bluish fluid between the yolk, gut and the liver on one hand and the membrane of the yolk sac on the other. The initial signs of yolk sac dropsy can appear even at the time of hatching. The accumulation of fluid can first be observed in the region of the heart and at the posterior tip of the yolk sac. The initial sign becomes clear, in most cases, on the fourth day after hatching. The affected larvae are generally restless. The yolk sac is generally less transparent than that of normal larvae.

The control of yolk sac dropsy must be oriented towards preventing its initial cause. Care should be taken mainly about cleanliness. pH value should not rise beyond 7.5. If the water is repeatedly utilized in a closed recirculation system during hatching, filters must be introduced, in which the products of metabolism, dissolved in water are oxidised and hence are rendered harmless.

Effect and Damage due to Electricity

Electrical fishing has become an established component of the fishing gear operation in the industry in several countries. Devices for electrical fishing with which it is possible to kill fish quickly and painlessly, have aroused much interest, especially since it is known that, assoicated with this, there is an improvement in the storage of catch and maintenance of fish quality. The electric current when employed for short period of action, leads neither to killing nor permanent damage to fish or fish larvae. If the fish come into direct contact with the trapping electrodes for a long time, severe damage can occur. There is appearance of dark stripes running vertically over the body caused by blood clot spots under the skin, which arise from the rupture of blood vessels as a result of cramped body movements. The cramps can give rise to vertebral injuries, displacements of vertebra and ruptures. Sometimes, in aquaria, when water is electrically heated, such defects can occur.

Stress due to light and Radioactivity

Some species of fish (salmonids) are very sensitive to light during the development of the eggs and larvae. The longer and more intensive the light, the higher the damages and losses. The embryos during the developing phase before the eyed stage are most sensitive. Premature hatching of salmon eggs under the action of light results in increased mortality of eggs and larvae, retardation of development, severe liver damage, and malformations of the vertebral column. The larvae easily become exhausted (Leitritz, 1947). Young fish exposed to bright sunlight, may show symptoms of sunburn, loss of equilibrium, necrotic spots behind head and dorsal fins as well as darkening.

Under certain conditions fish are exposed to the danger of radioactive irradiation as a result of radioactive atmospheric precipitation or from radioactive contamination of waters caused by atomic power stations. The effects of irradiations are - low hatching rate, delayed and anomalous body development of fry, partial or complete sterility of fish and increased mortality.

Poisoning

Modern civilization is capable of bringing about the most complex kinds of environmental changes. The release of substances, foreign to nature, has increased greatly during the on-going industrial age. Various substances entering the waters may produce alterations in survivability of aquatic organisms residing within such polluted environment, because many are highly toxic. Thus, fishes are in the unenviable position of being within a constantly changing ecosystem which may at some time either alter their physiology or biochemistry or induce changes in their bodies resulting in increased susceptibility to other disease causing agents.

Poisons are substances with special mechanisms of action which have harmful effects on organisms, even in small quantities. Some act as medicines in small doses but become poisonous in larger quantities. For a poisonous substance, concentration, duration of action, possibility of excretion by the fish, nature and condition of the fish are important. The poisonous action can be irreparable. The ability to recover depends on the concentration of the poison and its duration of action. The poisons infiltrate either through the gills, skin, injuries or the alimentary canal. Nature of action of the poison on the body may be -

1. Local effects (corrosive poisons and superficial effects of ions and salts. Eg., acids, alkalis)
2. Resorptive effects (Symptoms of ailments after the poison is absorbed in the blood).

Types of poisons : a) *Blood poisons*, which modify blood pigments and interfere with oxygen exchange. Viz., hydrocyanic acid; b) *Nerve poisons*, which primarily act on the nervous system and cause cramps viz., NH_3, DDT or herbicides; and c) *Cardiac poisons*, which act on the functioning of heart viz., Alkaloids etc.

The following symptoms can be observed during the course of fish poisoning : i) Changes in position. (Leaning sideward, lying laterally, upside down position); ii) Abnormal movements (Remaining or lying still, whirling, increased or decreased respiratory frequency); iii) Effects on nervous system (Narcosis, cramps, over or under sensitivity to touch.); and iv) Body changes. [Discolouration of the skin, fins, gills, secretion of slime, changes in blood (haemolysis) secondary parasite attack.]

Gill Necrosis (GN)

GN is a non-contagious ailment caused by environmental stress. It is brought about by an anti-ion toxication (self poisoning) or intoxication due to ammonia, as a result of increased pH values or unionised ammonia concentrations of the water.

Heavy Metal Poisoning

The visible effects of poisoning by metal ions in fish is characterised by restlessness, increased or markedly decreased frequency of opercular beatings, secretion of slime, reduced sensitivity to stimulation, exhaustion, lateral disposition, and death due to asphyxiation. If lateral disposition has set in, it is generally no longer possible for fish to recover even if it is transferred to freshwater (Liobmann, 1960). The toxicity of the salts of heavy metals to fish is intensified by a drop in the oxygen content of water.

Zinc ions are fairly to highly poisonous to aquatic organisms. Zinc impairs the growth and survival rate. Fish culturists must be warned against using galavanized transport containers with no protective coating, as zinc may leach out in quantities, lethal to sensitive fish fry in them.

High concentrations of iron salts can be deadly to fish in low pH values. When fish or their eggs are kept in such water, a thick layer of brown ferric oxide can form on the gills or on the surface of the eggs. Thereby, the absorption of oxygen is suppressed and at the same time, irritation, reddening and superficial corrosion of the epithelium, may be caused especially due to the fact that secondary iron bacteria colonize *(Leptothrix* spp.). This can be prevented by liming and aerating the water.

Algae

Algal colonies can form surface or hair like matted filaments suspended in water. An overabundance of algae might result in clogging of gills and serious respiration difficulties, and may lead to distress and even death. However, more important and apparently more common are 'algal toxicosis' and 'disturbance of the oxygen content', both resulting from the metabolic products produced by massive algal blooms.

Conclusion

The environment of fish is virtually synonymous with water. Everything that effects water has a profound impact o: the fish, determining its general well being and existence. If the water quality is altered beyond acceptable limits, it may predispose or actually cause fish mortality. So, an all round effort has to be made by fish culturists to maintain a healthy aquatic environment for ensuring adequate health conditions for the cultured fish species.

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