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IMPORTANCE OF OPTIMUM WATER QUALITY INDICES IN SUCCESSFUL ORNAMENTAL FISH CULTURE PRACTICES

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ABSTRACT

Ornamental fish keeping is the second most preferred hobby in the world and the number of hobbyists for ornamental fish keeping is rising day by day because it provides a great opportunity for entrepreneurship development and income generation. Aquatic ecosystems are dynamic and even in small rearing water tanks, physical and chemical parameters are interrelated. Thus, physical and chemical parameters of water should be considered and analyzed together because all of these factors have a direct impact on the culture systems.Ornamental fish production unit required higher level of expertise for better water quality management as ornamental fishes are more sensitive to poor water quality. As ornamental fish are kept in tanks more numbers than their food fish counterparts, water quality is most critical. Where large numbers of fish are kept in small spaces, the build-up of nitrogenous wastes, most notably ammonia, requires the producer to implement measures to manage it properly. Regular water exchange along with proper aeration overcomes this type of problem in the tanks.This review discussed the relationship between the health and better rearing conditions of fishes.

KEYWORDS: Disease resistance, Fishes, Health, Ornamental, Parameters, Water Quality.

Introduction

Ornamental fish culture ensures socially equitable distribution of benefits along the value chain as this activity is time bound, labour intensive and livelihood options of vulnerable sections of the society like house-wives and unemployed youth (Ghosh *et al.,* 2003). In India, the practice of ornamental fish keeping started in 1951 with the opening of the Taraporevale Aquarium, 'the pride of the nation' at Mumbai and the establishment of several aquarium societies in the city. Since then the practice has become widespread in India, with more than hundred varieties of indigenous species and even more of exotic ones. The trade in live aquatic ornamental animals for the aquarium trade is a global multi-million dollar industry, which can provide economic incentives for habitat conservation. The breeding and culture of freshwater ornamental fishes could generate great employment in almost all parts of India and develop into a local trade. This is an area for employment of women and school dropouts who would find it convenient to indulge in these exercises in their spare time. With increasing supply of ornamental fishes, the demand for aquaria would also go up and production of aquarium tanks could be developed as a small scale entrepreneurship or cottage industry which will be an additional source of employment (Sreeya, 2012).

Aquarium fish often live in suboptimal conditions involving limited volumes of water in aquarium systems with a restricted capacity to maintain adequate water quality. Unlike feral fish, they cannot escape a potentially harmful environment. Even the best-equipped aquarium, combined with rigorous surveillance of water quality parameters, can never truly mimic natural conditions in the wild. Thus, the keeping of fish in aquaria is a compromise that usually has a negative influence on the fish's well-being. In this respect, Snieszko (1981) developed the frequently quoted graphic of three overlapping circles representing the host (i.e., the fish), the pathogens and the environment to show the single and combined influences of infectious agents and non-infectious parameters on fish health. Therefore, only multidisciplinary studies involving the characteristics of potential pathogenic microorganisms for fish, aspects of the biology of the fish hosts as well as a better understanding of the environmental factors affecting such cultures, will allow the application of adequate measures to prevent and control the major diseases limiting the production of fishes.

Water Quality and Fish Diseases

The success of ornamental fish culture depends on the health status of thecandidate species (Lipton, 2006). Being aquatic, and secondarily being forced toremain under crowded conditions, the ornamental fishes are subjected to differentdiseases of varying nature (Bright and Sreedharan, 2009). Bacterial infections areconsidered as the major cause for diseases and mortality (Grisez and Ollevier, 1995). A complete understanding of the aetiological agent, the pathogenesis, antigenicity, epizootiology and the inter-relationship of stress-related and environmental factors is essential for successful management and control.The water easily spread most of the pathogens. It is necessary to have anunderstanding of water quality in order to successfully diagnose and correct aquarium diseases. Stress has been linked as the primary contributing factor of fish disease and mortality in aquaculture (Petric*et al.,* 2006).

Temperature

Several biotic and abiotic factors influence the growth of fish (Jobling, 1996). Among the various physical factors affecting the aquatic environment, temperature is of paramount importance and is considered as the "abiotic master factor" for fishes (Brett, 1971). Global climate change is suggested to potentially affect freshwater fisheries by lowering productivity in wild fish populations and in intensive aquaculture systems worldwide (Ficke *et al.,* 2007). As fishes are poikilotherms, drastic change in their surrounding water temperature will influence their metabolic processes, behaviour, migration, growth, reproduction, and survival (Fry, 1971; Portner, 2001). Researchers are makingcontinuous efforts to define thermal tolerance of various fish species of aquaculture importance (Rishikesh *et al.,* 2009). Long-term changes in the environmental temperature induce ectothermic animals to display compensatory responses (which include changes in the metabolic enzymes and tissue chemistry) that are suggested to mitigate the effect of temperature on metabolism (Hazel and Prosser, 1974; Hochachka and Somero, 1971).

Temperature beyond the optimum limits of a particular species, however, adversely affects fish health by increasing metabolic rate and subsequent oxygendemand, invasiveness and virulence of bacteria and other pathogens which in turnmay cause a variety of pathophysiological disturbances in the host (Wedemeyer *et al.,* 1999). Temperature affects virtually all biochemical, physiological activities of fishes. The survival and growth of poikilo thermal teleports are immediately influenced by temperature fluctuations in their environments. All teleost species have developed their own specific adaptive mechanism, both behavioural and physiological, to cope up with temperature fluctuations (Prosser and Heath, 1991). These adaptive capabilities enable them to survive through acclimation and adaptation to stressful temperature conditions (Hazel and Prosser, 1974). Identifying the range of temperatures tolerated by a species is important to determine the viability of its growth. Up to a species-specific maximum, fish growth rates will accelerate with increasing temperature, after which they sharply decline (Fielder *et al.,* 2005; Jobling, 1996).

Stocking Density

Crowding is a factor involved in physiological stress (Barton, 2002). Theincrease in stocking densities can alter the immunological responses and physiological processes, mainly those related to metabolism and behavior (Vijayan *et al.,* 1990; Irwin *et al.,* 1999; Barcellos *et al.,* 2004; Kristiansen *et al.,* 2004 and Schram *et al.,* 2006). It has been noticed that inappropriate stocking densities can alter lipid metabolism, mainly of triglycerides, in brook charr, Salvelinusfontinalis (Vijayan *et al.,* 1990). In gilthead sea bream, *Sparusaurata*, different stocking densities altered fatty acid metabolism, with a decrease in hepatic oleic acid, a monounsaturated fatty acid important as energy source, mainly in higher stocking densities (Montero *et al*, 1999). Also, crowding is responsible for the increase in plasma cortisol, which plays an important role in the low efficiency of immunological responses under these conditions (Mommsen *et al.,* 1999; Di Marco *et al.,* 2008).

Water pH

Water pH affects metabolism and physiology of fish. Alkaline pH 7 to 8 ishighly suitable for better growth of fish. Robert and William (1986) found that inchannel catfish, excretion of ammonia at pH 6 increased; whereas, it decreased with increased pH.Saha *et al.* (2002) and Scott *et al*., (2005) indicated that ammonia excretion increased with increasing pH (alkalinity), while growth decreased.

Total Alkalinity

Total Alkalinity is the measure of the capacity of water to neutralize or buffer acids using carbonate, bicarbonate ions, and in rare cases, by hydroxide, thus protecting the organisms from major fluctuations in pH. Without a buffering system, free carbon dioxide will form large amounts of a weak acid (carbonic acid) that may potentially decrease the night-time pH level to 4.5. During peak periods of photosynthesis, most of the free carbon dioxide will be consumed by the phytoplankton and, as a result, drive the pH levels above 10.0.

Dissolved Oxygen

Dissolved oxygen is the most important and critical parameter, requiringcontinuous monitoring in ornamental fish culture systems. This is due to the fact that fish aerobic metabolism requires dissolved oxygen (Timmons *et al.,* 2001). Optimum level of dissolved oxygen recommended is 4 to 5 mg/l for warm water fishes (Wedemeyer and Goodyear, 1984). Studies of freshwater teleosts indicated that low dissolved oxygen concentrations also can modify juvenile and adult growth rates, feeding rates, habitat use and susceptibility to predation, as well as adult reproductive activities (Magnuson *et al.,* 1985; Suthers and Gee, 1986; US-EPA, 1986; Kramer, 1987; Poulin *et al.,* 1987; Saint-Paul and Soares, 1987).

The physiological activities of fish are also subjected to changes in environmental factors such as dissolved O_2 level (Jordan and Steffensen, 2007;The physiological activities of fish are also subjected to changes in environmental factors such as dissolved O_2 level (Jordan and Steffensen, 2007;Petersen and Gamperl, 2010). A recent study found that environmental temperature had profound effects on the metabolic competition mode of southern catfish (*Silurusmeridionalis* Chen), possibly due to the increased oxygen demand and decreased availability of environmental dissolved oxygen at high temperatures (Pang *et al.,* 2010). Conformers, such as the Adriatic sturgeon (*Acipensernaccarii*), cannot maintain their resting O_2 consumption rate during hypoxia, and it will decrease linearly with decreasing dissolved O_2 content (Mc Kenzie *et al.,* 2007).

Hypoxia can cause physiological stress and cellular damage as well as inhibit repair mechanisms (Jones, 1985). Spot and pinfish can detect a variety of DO concentrations but they do not necessarily avoid hypoxia (Wannamaker and Rice, 2000). Wannamaker and Rice (2000) suggested that these fishes may have relatively lower physiological costs when occupying hypoxic areas. Shultz *et al.,* (2011) recommended that the dissolved O_2 concentrations during holding of bonefish in the context of live-release angling tournaments do not deviate from that of ambient sea water, which was typically 6 mg/l. Similar studies on live-release bass tournaments have recommended to the anglers and tournament organizers to monitor DO concentrations so as to maintain their required levels of dissolved O_2 for recovery (Suski *et al.,* 2006; Furimsky *et al.,* 2003; Suski *et al.,* 2003).

Ammonia

Ammonia is the principal nitrogenous waste product of fishes that represents60% to 80% of nitrogenous excretion of fish (Handy and Poxton, 1993; Salin and Williot**,** 1991). It is also, the main nitrogenous waste material excreted by gills beside urea and amines and an end product of the protein catabolism (De Croux *et al.,* 2004). Among all the water quality parameters, which affect fish, ammonia is considered as one of the most important after oxygen (Francis – Floyd and Watson, 1996). Under intensive rearing conditions, and particularly when effluent is reused, ammoniaconcentrations may reach levels that limit fish survival and growth (Haywood, 1983). Ammonia can cause reductions in growth or even death (EPA, 1998; Meade, 1985; Salin, and Williot, 1991).

In water, total ammonia consists of non toxic (ionized ammonia) referred to as ammonium (NH_4+) and toxic un-ionized ammonia (NH_3). The equilibrium between these two forms is dependant on the pH and temperatures. Ammonia is measured as total ammonia nitrogen (TAN) which represents the sum of NH_4+ and NH_3. The NH_3 molecule is soluble in lipids which is 300 to 400 times more toxic than NH_4+ (Haywood, 1983; Thurston *et al*, 1981). Un-ionized ammonia (UIAN) can readily diffuse across the gill membranes due to its lipid solubility and lack ofcharge (Aysel and Koksal, 2005). When ammonia accumulates to toxic levels, fish cannot extract energy from feed and will fall into a coma and die (Hargreaves and Tucker, 2004).

Ammonia tends to block oxygen transfer from the gills to the blood and can cause both immediate and long term gill damage (Joel and Amajuoyi, 2010). Also it can cause impairment of cerebral energy metabolism, damage to gill, liver, kidney, spleen and thyroid tissue in fish, crustaceans and mollusks (Smart, 1978). Chronic un-ionized ammonia exposure may affect fish and other organisms in several ways, e.g. gill hyperplasia, muscle depolarization, hyper excitability, convulsions and finally death (Ip *et al.,* 2001). Toxicity of ammonia to fish has been intensively investigated in numerous fish species (Aysel and Koksal, 2005; El-Shafai *et al.,* 2004; Lamarie *et al.,* 2004). The acute and chronic toxicities of ammonia have been reviewed for fresh water species (Tomasso, 1994; Handy and Poxton, 1993; Russo and Thurston, 1991; Haywood, 1983; Ruffier *et al.,* 1981). Uncontrolled level of ammonia in culture environment may not only lead to mortality but may prevent the fish from achieving its full genetic potential in terms ofgrowth and reproductive capability. At the sub-lethal value of ammonia, it can compromise the well being of fish by jeopardizing its health (Ajani, 2008).

Smith and Piper (1975) and Smart (1976) found that the most characteristic feature for chronic exposure of rainbow trout to ammonia was the appearance of swollen, rounded secondary gill lamellae or telangiectatic capillaries in the secondary lamellae. Also, Kirk and Lewis (1993) reported that the gills of rainbow trout exposed to 0.1 mg/l ammonia for 2 h exhibited deformation of the lamellae. Ammonia concentrations of above 0.2 mg/l in fish ponds have a tendency to harm the fishes and is recommended that the UIA-N concentrations be maintained below 0.1 mg/l (Abdalla and Heba Allah, 2011).

Ammonia induces detrimental changes in tissue structure, cell function, bloodchemistry, osmoregulation, disease resistance, growth and reproductive capacity (Jeney *et al.,* 1992). Chronic exposure can result in the deterioration of severalphysiological functions any one of which may be the ultimate cause of death (Russo, 1985). Ammonia may affect gill structure (Smart, 1976), respiratory function (Chen and Lin, 1992; Knoph, 1996) and oxygen consumption (Smart, 1978) in aquatic animals. Keeping animals healthy in intensive aquaculture depends on preventing accumulation of toxic waste products such as ammonia. Ammonia concentration of 1–2mM is common in the blood of marine invertebrates (Haberfield *et al.,* 1975). Higher concentrations are presumably toxic because they perturb acid–base balance with too much alkalinity (Hammen, 1980).

Nitrite

Nitrite (NO_2-) is a potential contaminant in aquatic environments that receivenitrogenous waste (Grosell and Jensen, 1999). Nitrite is formed from ammonia and may accumulate in aquatic systems as a result of imbalance of nitrifying bacterial activity (*Nitrosomonas sp*. and *Nitrobacter*sp.) (Masser *et al.,* 1999). High levels ofnitrite in the water is a potential factor triggering stress and cause high mortality in aquatic organisms (Ferreira da Costa *et al.,* 2004; Wang *et al.,* 2004; Jensen, 2003; Martinez and Souza, 2002). Several studies have examined the toxicity and physiological effects of NO_2^- in fish (Das *et al.,* 2004; Knudsen and Jensen, 1997; Doblander and Lackner, 1996). When NO_2^- reaches the blood, it crosses the erythrocyte membrane and oxidizes haemoglobin to methaemoglobin.

The toxicity of nitrite may result from a combination of effects rather than from a simple effect, such as methaemoglobinaemia, in particular. An elevated ambient nitrite concentration is problematic for freshwater fish, asnitrite is actively taken up across the gills in competition with chloride (Eddy andWilliams, 1987). The principal effect of such nitrite loading is a progressive oxidation of haemoglobin to methaemoglobin, but several other physiological changes occur (Jensen, 1990).

The interference with branchial ion exchange together with methaemoglobinemia and likely tissue hypoxia suggests that major changes may arise in blood O_2 transport and respiratory properties resulting in perturbations of electrolyte and acid–base status (Jensen *et al.,* 1987). Knudsen and Jensen (1997) showed that nitrite interferes with K+ homeostasis in carp leading to an extracellular hyperkalaemia. Aggergaard and Jensen (2001) have shown among rainbow trout exposed to nitrite increased in plasma K+ with a concomited decrease in plasma Cl^-. This rise in plasma K+ is suggested due to the release of K+ from intracellular compartments (Knudsen and Jensen, 1997). Nitrite binds competitively to haemoglobin oxidising it to meet Hb, a variant causing the blood to appear brown in colour (hence the name "brown blood disease") and vastly reduce the ability to bind and transport oxygen (Jensen, 2003; Martinez and Souza, 2002; Hargreaves,1998).

Nitrate

Acute and chronic effects of nitrate have been reported in several fresh waterfish species (Hamlin, 2006; Camargo *et al.,* 2005) and marine invertebrates (Kuhn *et al.,* 2010; Romano and Zeng, 2007; Camargo *et al.,* 2005; Hirayama, 1974). Themechanisms of nitrate toxicity to aquatic animals are due mainly tomethemoglobinemia, caused by the oxidation of hemoglobin (Hb) to methemoglobin (MetHb) in blood (Camargo *et al.,* 2005) consequently reducing oxygen binding capacity and ultimately resulting in respiro-circulatory constraints.

In fish a MetHb reductase system compensates for MetHb formation by conversion of MetHb to Hb (Freeman *et al.,* 1983). Nitrate is taken up via the branchial system in fishes. However due to the low permeability of the gills to nitrate, uptake is limited and other mechanisms are suggested (Stormer *et al.,* 1996). Another possible pathway might be trans-dermal uptake of nitrate in the gastro intestinal tract, as was reported for nitrite in European flounder, *Platichthys flesus* (Grosell and Jensen, 2000).

CONCLUSION

Water quality affects affect growth and well-being of fish, therefore, water quality should be of great importance to the aquaculturist. The disease management in ornamental fish sector requires focus on preventive measures related to water quality and other husbandry activation. It is equally important to know how to interpret the water quality parameters that are measured to maintain the health and well-being of their fish stock. Exploration and implementation of prophylactic measures in aquaria are essential to prevent induction and spreading of disease and minimize the loss of valuable fish stock.

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