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Original Article

Effect of Variable Concentration of Dissolved Oxygen (DO) on Population Growth Rate and Food Conversion Ratio in Fish: Model "Molly" [*Poecilia sphenops* (Valenciennes, 1846)]

Santi Ranjan Dey

Abstract

Commercial aquaculture is growing worldwide. With fisheries reaching a stagnating phase, India will have to look to aquaculture in different way, in the future to provide fish products that will likely be needed. In view of this, a study on water quality management was done which specifically looked at the effects of dissolved oxygen (DO) on fish population growth and increase of body mass. The study was done by using Molly (*Poecilia sphenops*) in fresh water habitat. In the case study, 120 molly of 0.5 - 1 g. in weight were reared in replicate at 40%-100% DO levels in different aquarium of 10 liter capacity. Every alternate day 5 gm of food was given. The DO was regularly measured by Wrinkler's method. The subsequent effect of oxygen saturation levels on growth and feed conversion ratios were taken in three, six, nine and twelve months. The results showed that oxygen saturation level had an effect on the reproduction, growth and food conversion ratio. Below 60%, the population growth was comparatively lower. Feed conversion ratio was higher at 60% and above, compared to lower oxygen level. However it is found that at highest DO level the body mass increase is little lower than medium DO level (75.1%). The rate of population increase is highest at DO 88 % but the body mass increase is little lower (91%) in that DO. The conclusion is that oxygen saturation level has a positive correlation with population growth and food conversion to body mass ratios of fish. But at high DO condition the fish probably increase its activity and metabolism.

Keywords: Dissolve Oxygen; Fish; FCR; Molly; Physiology; Respiration.

Introduction

The contribution of aquaculture to global supplies of fish, crustaceans, molluscs and other aquatic animals is growing more rapidly than all other animal food-producing sectors (Balarin, 1985). This production has greatly outpaced population growth, with a per capita supply from aquaculture increasing from 0.7 kg in 1970 to 7.1 kg in 2004, representing an average annual population growth rate of 7.1% (FAO 2006a). With fisheries reaching a stagnating phase, India will have to look to aquaculture in different way, in the future to provide fish products that will likely be needed. The fisheries sector alone contributes nearly a third of the world's supply of fish products (FAO, 2006b). Unlike terrestrial farming, where the bulk of the production is based on a limited number of species, aquaculture is based upon near about 220 species. India is endowed with vast freshwater consisting 45,000 Km. of rivers, 26,334 Km. of canals, ponds and tanks 2.36 million hectares and 2.05 million hectares of reservoirs, which present like harbor a rich and diversified fish fauna characterized by many rare and endemic fish species. About 21,730 species of fishes have been recorded in the world; of which, about 11.7% are found in Indian waters. Out of the 2546 species so far listed, 73 (3.32%) belong to the cold freshwater regime, 544 (24.73%) to the warm freshwater domain, 143 (6.50%) to the brackish water and 1440 (65.45%) to the marine ecosystem. The freshwaters of India have been viewed from a single perspective: that of economic production (Timmons

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et al, 2014). They are to be sources of irrigation or urban-industrial water supply or of hydro power; they are to receive sewage and industrial waste; they may produce edible fish. In view of this, a study on water quality management was done which specifically looked at the effects of dissolved oxygen (DO) on fish population growth and increase of body mass (Randolph and Clemens. 1976). Water quality may be a major factor in the high mortality rates of fry and fingerlings and therefore hopefully the knowledge obtained here can be used to monitor the water quality parameters to possibly solve this problem (Svobodova *et al*, 1993, Tom, 1998). The main objective of the study was to gain knowledge of water quality management for a particular fish population in commercialized aquaculture.

The objective of the study are divided in various questions, does oxygen saturation have any effect on population growth rate of fish? If yes, at which levels is the growth affected positively? Whether, there is any effect of the oxygen saturation on the food conversion to body mass ratio in fish? At which saturation level is the food conversion ratio best?

Water Quality in Aquaculture

Water quality is the totality of physical, physiological, biological and chemical parameters that affect the growth and welfare of cultured organisms. Quality of water is, therefore, an essential factor to be considered. Although the environment of fish aquaculture is a complex system, consisting of several water quality variables, only few of them play decisive role. The critical parameters are temperature, suspended solids and concentrations of dissolved oxygen, ammonia, nitrite, carbon dioxide and alkalinity. However, dissolved oxygen is the most important and critical parameter, requiring continuous monitoring in aquaculture production systems. This is due to fact that fish aerobic metabolism requires dissolved oxygen (Ultsch *et al*, 1978).

Gas Exchange and Oxygen Concentration in Water

Oxygen as a gas has a low solubility in water. In addition, its amount contained in water varies with temperature and salinity in a predictable manner. Less oxygen can be held in fully air-saturated warm sea water than fully air-saturated cold freshwater, while the oxygen content of water sets the absolute availability of oxygen in the water. It is the oxygen partial pressure gradient that determines how rapidly it can move from water into the fish's blood to support its metabolic rate. This is because oxygen moves by diffusion across the gills of fish. According to Fick's law of diffusion, the rate of oxygen diffusion across the gills is determined by the gill area, diffusion distance across the gill epithelia, diffusion constant and difference in partial pressure of oxygen across the gills. Consequently, partial pressure of oxygen is the most appropriate term for expressing oxygen levels in water. However, oxygen concentration is more commonly used term and, for a given temperature and salinity, the partial pressure of oxygen and oxygen content in water are linearly related (Wedemeyer, 1996).

Oxygen Uptake in and Carbon Dioxide Release from the Fish

During respiration, fish take in oxygen and give out carbon dioxide. The process is done by using gills in almost all fish although some can also use some other parts of the body in addition to gills. When a fish respires, a pressurized gulp of water flows from the mouth into a gill chamber on each side of the head. Gills themselves, located in gill clefts within the gill chambers, consist of fleshy, sheet like filaments transected by extensions called lamellae. As water flows across the gills, the oxygen within them diffuses into blood circulating through vessels in the filaments and lamellae. Simultaneously, carbon dioxide in the fish's bloodstream diffuses into the water and is carried out of the body (Verheyen *et al, 1994)*.

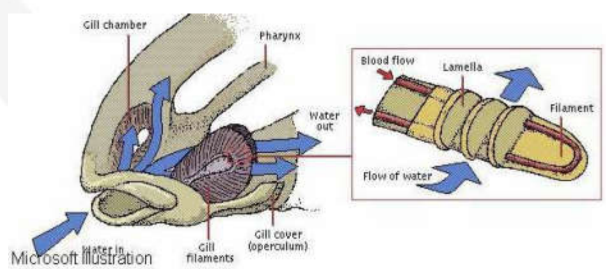

Fig. 1: Diagram showing the structure for respiration (gas exchange) in fish

Effects of Oxygen Levels on Oxygen Uptake by Fish

It is commonly thought that if there is not enough oxygen in the water, then the fish will be seen gasping at the surface but this is a last resort means to breathe. The first indication there may be a dissolved oxygen problem in the water is when the fish become unusually lethargic and stop feeding. As oxygen levels decrease, the fish do not have enough energy to swim and feeding utilises yet more oxygen. Most fish species will tolerate a drop below the minimum values for a short period of time, probably the cold water species are likely to tolerate a lower level than tropical fish (Jobling, 1995). However, the period of time during which the oxygen level drops below the required minimum level, will cause the fish to become stressed resulting fish death. Some stress related diseases such as fin rot and white spot may also occur (Crampton *et al*, 2003).

Materials and Methods

Experimental Fish

This study was done by using Molly (*P sphenops*) in fresh water habitat. *P. sphenops* is a species of fish, of the genus *Poecilia* under family Poeciliidae, known under the common name molly; to distinguish it from its congeners, it is sometimes called short-finned molly or common molly. Poeciliidae is a family of freshwater fishes of the order Cyprinodontiformes, the tooth-carps, and include well-known live-bearing aquarium fish, such as the guppy, molly, platy, and swordtail. The wild-type fish are a dull silvery color, often sprinkled black all over. The common molly can produce fertile hybrids with many *Poecilia* species, most importantly the sail fin molly. The male black mollies generally tend to be mildly aggressive. Mollies rank as one of the most popular feeder fish due to high growth rate, birth size, reproduction, and brood number. In the case study, 1000 molly of 0.5 - 1 g. in weight were reared in replica at 40%-100% DO levels in 20 different aquarium of 2′ X 1′ X 1′.

Experimental Design

The fish were exposed to different levels of oxygen saturation. The system consists of 20 different aquarium of 10 liter capacity. Each aquarium contains 50 experimental fish. Every alternate day 5 gms of food was given. The DO was regularly measured by Winkler's method (1888). The subsequent effect of oxygen saturation levels on growth and feed conversion ratios were taken in three, six, nine and twelve months.

Sampling and Measurements

The body mass and population growth performance were measured every two weeks, while oxygen saturation, temperature and salinity were recorded daily. Population rate of the experimental fishes of each aquarium were taken in every two weeks to obtain the Specific Population Growth Rate (SPGR). Both the initial and final number of total fish population were used to calculate in terms of SPGR. The fish were fed manually in every alternate day. Approximately 5 gms of food were given every times.

The Food Conservation Ratio is calculated as: FCR = Total amount of feed consumed/increase in population during the same time.

Result

The results showed that oxygen saturation level had a great effect on the reproduction, growth and food conversion ratio. Below 60% of the normal DO, the population growth was comparatively lower. Feed conversion ratio was higher at 60% and above, compared to lower oxygen level. However, it is found that at highest DO level the body mass increase is little lower than medium DO level (75.1%). The rate of population increase is highest at DO 88 % but the body mass increase is little lower (91%) in that DO.

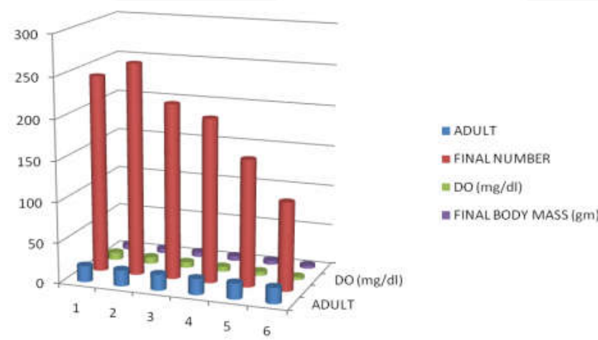

Fig. 2: Relation between rate of increase of number of fish, DO and body mass

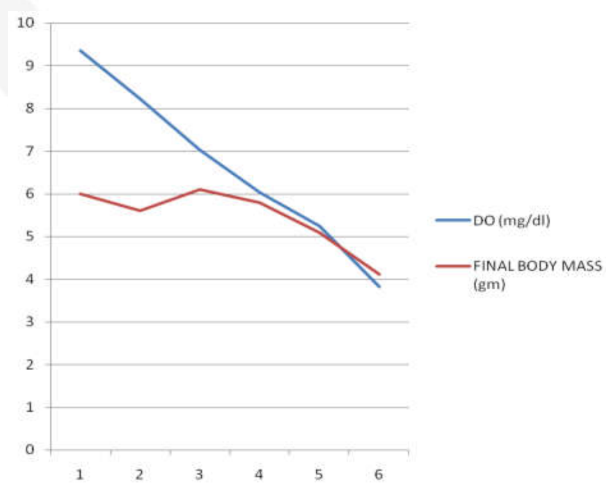

Fig. 2: Relationship of body mass increase and the DO level of water
(Y axis = Percent of dissolved oxygen, 1 unit equivalent to 10% X axis = final body mass in gram weight)

Discussion

The results of the experiment under different oxygen levels clearly showed that growth is affected by the level of oxygen saturation. During this period, the SPGR was highest at 88% saturation. The best FCR was obtained in the groups with highest growth rate although there was no significant ifference in FCR of fish reared at different oxygen saturation levels. However, this species appear to be more sensitive to oxygen saturation that increases its growth rate with increasing saturation up to 100%. It is recommended that in Tropical freshwater fish- 5 mg per litre (80% saturation) is necessary and most effective. Mallya (2007) showed that oxygen saturation level had a positive effect on the growth and feed conversion ratio when it was set at 80%-120% saturation. At 140% the growth was slightly lower and the feed conversion ratio was higher at 60% and 140% compared to the other groups. The conclusion was that oxygen saturation level has an effect on growth and feed conversion ratios of fish, and in the case of Atlantic halibut, the growth rate is higher when the oxygen level is between 80% and 120%. The feed conversion ratio for halibut was lower at 120% oxygen saturation.

Conclusions

The results suggest that oxygen saturation levels affect both growth performance and feed conversion ratios of fresh water molly. The maximum population growth rate and lowest feed conversion ratio in this species can be attended at higher oxygen saturation levels between 90% and 120%. However, more research is needed in order to know at which saturation point the population growth is maximized.

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