EFFECTS OF DIFFERENT VALUES OF PH AND TEMPERATURE ON SURVIVAL AND GROWTH OF FRY AND JUVENILE BARBONYMUS SCHWANENFELDII AND OREOCHROMIS NILOTICUS

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Effects of Different Values of pH and Temperature on Survival and Growth of Fry and Juvenile *Barbonymus schwanenfeldii* and *Oreochromis niloticus*

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DECLARATION

I, Nik Nurul Kamila Binti Abu Rashid, final year student of Aquatic Resource Science and Management hereby declare that this thesis is my own work and effort with the guidance of my supervisor, Professor Dr. Lee Nyanti. No part of the thesis has previously been submitted for any other degree, university or institution of higher learning.

.................................................................

(Nik Nurul Kamila Abu Rashid)                      Dated:

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<td>Feed conversion ratio</td>
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<tr>
<td>SGR</td>
<td>Specific growth rate</td>
</tr>
<tr>
<td>m</td>
<td>Meter</td>
</tr>
<tr>
<td>°C</td>
<td>Degree Celcius</td>
</tr>
<tr>
<td>DO</td>
<td>Dissolved oxygen</td>
</tr>
<tr>
<td>Ammonia-N</td>
<td>Ammonia-nitrogen</td>
</tr>
<tr>
<td>pvc</td>
<td>Polyvinyl chloride</td>
</tr>
<tr>
<td>mg/L</td>
<td>Milligram per liter</td>
</tr>
<tr>
<td>cm</td>
<td>Centimetre</td>
</tr>
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Effects of Different Values of pH and Temperature on Survival and Growth of Fry and Juvenile *Barbonymus schwanenfeldii* and *Oreochromis niloticus*

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ABSTRACT

*Barbonymus schwanenfeldii* is a native species and *Oreochromis niloticus* is an exotic species in Sarawak. In order to determine the effects of temperature and pH on growth and mortality of fry and juvenile of *Barbonymus schwanenfeldii* and *Oreochromis niloticus*, the effect of water temperatures (24 and 30 °C) and pH (7.0, 6.5, 5.5, 4.5 and 3.3) were tested in two separate experiments. When juvenile was tested in different pH, the survival rate of *Oreochromis niloticus* was higher than *Barbonymus schwanenfeldii* at pH 6.5, 5.5 and 4.5. The FCR of both species were not significant different at pH 7.0, 6.5 and 5.5. However, at pH 4.5 *Oreochromis niloticus* showed higher FCR than *Barbonymus schwanenfeldii*. When fry was tested in different pH, there was no significant difference between survival rates of the two species. The FCR of *Oreochromis niloticus* was lower than *Barbonymus schwanenfeldii* at pH 7.0, 6.5 and 5.5. The survival rates of both species showed no significant different at the two different temperatures. The FCR of *Oreochromis niloticus* was lower than *Barbonymus schwanenfeldii* in both temperatures. These results showed that *Oreochromis niloticus* is more tolerant to extreme pH compared to *Barbonymus schwanenfeldii*. Juvenile stage of both species also is harder compared to fry stage. The optimum pH for both species is at pH 7.0. For temperature, results showed that both species prefer 24 °C than 30 °C and *Oreochromis niloticus* is more tolerant to temperature than *Barbonymus schwanenfeldii*.

Keywords: growth, survival, exotic species, native species.

ABSTRAK

*Barbonymus schwanenfeldii* adalah spesies asli dan *Oreochromis niloticus* adalah spesies eksotik di Sarawak. Dalam usaha untuk menentukan kesan suhu dan pH ke atas pertumbuhan dan kematian benih ikan dan juvana *Barbonymus schwanenfeldii* dan *Oreochromis niloticus*, kesan suhu air (24 dan 30 °C) dan pH (7.0, 6.5, 5.5, 4.5 dan 3.3) telah diuji dalam dua eksperimen berasingan. Apabila juvana didui di dalam pH yang berbeza, kadar survival *Oreochromis niloticus* adalah lebih tinggi daripada *Barbonymus schwanenfeldii* pada pH 6.5, 5.5 dan 4.5. FCR kedua-dua spesies ini tidak berbeza dengan ketara pada pH 7.0, 6.5 dan 5.5. Walau bagaimanapun, pada pH 4.5 *Oreochromis niloticus* menunjukkan lebih tinggi FCR daripada *Barbonymus schwanenfeldii*. Apabila benih ikan telah diuji dalam pH yang berbeza, terdapat perbezaan yang signifikan antara kadar survival kedua-dua spesies. FCR untuk *Oreochromis niloticus* adalah lebih rendah daripada *Barbonymus schwanenfeldii* pada pH 7.0, 6.5 dan 5.5. Kadar survival kedua-dua spesies menunjukkan tiada perbezaan yang signifikan di kedua-dua suhu yang berbeza. FCR untuk *Oreochromis niloticus* adalah lebih rendah daripada yang lebih rendah daripada *Barbonymus schwanenfeldii* dalam kedua-dua suhu. Keputusan ini menunjukkan bahawa *Oreochromis niloticus* lebih toleran kepada pH berbanding *Barbonymus schwanenfeldii*. Peringkat juvana kedua-dua spesies juga lebih toleran berbanding benih ikan. pH optimum bagi kedua-dua spesies adalah di pH 7.0. Untuk suhu, keputusan menunjukkan bahawa kedua-dua spesies lebih suka 24 °C daripada 30 °C dan *Oreochromis niloticus* lebih toleran kepada suhu daripada *Barbonymus schwanenfeldii*.

Kata kunci: pertumbuhan, survival, spesies eksotik, spesies asli.
1.0 INTRODUCTION

Many physical and chemical water quality parameters affect directly and indirectly on the survival, growth, reproduction and distribution of aquatic animals (Ivoke et al., 2007). Fish growth, mortality and behavior of fish differs according to which developmental stage the fish are; larva, fry, fingerling and adult (Ivoke et al., 2007). Exogenous factors such as temperature and pH contribute greatly in these processes. According to Celikkale (1992), for better feed conservation ratio and growth of fish, the optimal water temperature plays crucial role. Almost all species of juvenile fishes show a rapid increase in growth rate when the temperature raises until it reaches the peak of optimum temperature and decrease rapidly as temperature become adverse (Brett, 1979; Imsland et al., 1996). This is because the temperature has close relation with metabolism of fishes. As the temperature is lower, the development of juvenile fishes gets slower (Karabulut et al., 2010). As mention earlier, high water temperature will increase the metabolic rates of fish thus the food demand also increased. The increased of feed intake will result in better growth of fish and also feed conversion ratio (Kausar and Salim, 2006). Others than temperature, pH also plays an important role in fish growth and survival (Miron et al., 2008). According to Kilmmel (1993), high or low pH is not directly lethal to the fish, however its affects their growth and reproduction.

This study will be done to investigate the effects of temperature and pH on fry and juvenile of *Barbonymus schwanenfeldii* and *Oreochromis niloticus*. In Peninsular Malaysia, *Barbonymus schwanenfeldii* is known as “lampam sungai” while in Sarawak it is known as “tengadak” (Kamarudin and Esa, 2009). The distribution of *Barbonymus schwanenfeldii* is Mekong River and Chao Phraya, Borneo and Sumatra (Mohsin & Ambak 1983). A study by
Christensen (1992) stated that *Barbonymus schwanenfeldii* lives in lakes and rivers at pH range between 6.5 and 7.0 and at 20.4 – 33.7 °C. *Oreochromis niloticus* an African Cichlid, is a tropical freshwater and estuarine species. They are native species to central and North Africa and the Middle East (Boyd, 2004). They can be found at shallow, still waters on the edge of lakes and wide rivers with sufficient vegetation (Picker & Griffiths 2011). According to Noor et al. (2010), *Oreochromis niloticus* have wide range of tolerance to pH, temperature, ammonia and dissolved oxygen. However, as the origin of *Oreochromis niloticus* is tropical and subtropical, they can tolerate high temperature and not low temperature (Pandit and Nakamura, 2010).

As the natural ecosystem keeps changing everyday due to many human activities, the habitat of fish also changes. This will affect water quality of river such as temperature and pH. Due to limited information about effect of habitat changes on *Barbonymus schwanenfeldii* and *Oreochromis niloticus*, this study will be done to achieve better understanding of the changes in environmental factors.
The objectives of this study were:

i. To determine the survival rate, growth performance and feed conversion ratio of fry and juvenile stages of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* at different water temperatures and pH,

ii. To record the behavioral characteristics (movement, avoidance and feeding impairment) of the two species when exposed to different water temperatures and pH, and

iii. To determine the optimum water temperature and pH for growth and survival of fry and juvenile stages of the two species.
2.0 LITERATURE REVIEW

2.1 Fish habitat changes

Physical and chemical factors play an important part in fish habitat. For each stage of fish’s life cycle which are egg, larvae, juvenile and adult, the habitat requirement may be different within the same water body (Ivoke et al., 2007). In degraded fish habitat, many fish species that are sensitive to environmental changes have declined in numbers or have been replaced by other species that are able to persist with the habitat changes. This proved that habitat condition play an important part in fish community at various spatial and temporal scales (Frissell et al., 1986). A study by Matthews and Styron (1981) stated that changes in fish habitat affected water quality of the river. This is supported by Klein (1979) that water quality is often degraded in urban areas due to the occurrence of many anthropogenic activities. Many studies show that human activities affect the aquatic life habitat thus resulted in loss of aquatic species and declines the aquatic population (Cross and Moss 1987; Hughes et al., 2005). A study by Cross and Moss (1987) also stated that human activities can give directly and indirectly effect to the fish community. There are many anthropogenic activities that affect fish habitat. The waters and substrates that comprise fish habitat are subject to effect of human activities that are unrelated to fishing. Anthropogenic activities include mining, dredging, fill, impoundment, discharges, water diversions, thermal additions, actions that contribute to nonpoint source pollution and sedimentation, introduction of potentially hazardous materials, introduction of exotic species, and the conversion of aquatic habitat that may remove, reduce, or disturb the functions of fish habitat (Ammann et al., 2005).
2.2. Human activities that affect temperature of fish habitat

There are many factors that cause changes in temperature including the removal of stream bank vegetation that provides shade, construction of dams and other impoundments and discharge of heated water from industry. Historically, land use activities and logging affect fish habitat and their population. Logging activities, removal of streamside vegetation causing an increase in temperature of water by exposing the water directly to solar radiation as stream vegetation provides shade and help buffer the effects of temperature changes (Gibbons and Salo, 1973). According to Beschta et al. (1987), streams are heated mostly by direct solar irradiation of the water surface and only minimally by convection or conduction. They also stated that removal of the tree canopy have a dramatic effect on increasing water temperature as much as 10 °C. Water temperature can induce fish mortality, influences level of dissolved oxygen and nutrients, affects growth and behaviour of fish. High temperature of water also contributes to the growth of bacterial species that can affect fish population. Temperature fluctuation also can alter early developmental stage of fish mainly egg and juvenile which will inhibit growth, reduce survival and affect timing of life history events (Beschta et al., 1987). Therefore, alteration in temperature regime also can alter the species dominant due to the change in habitat. A study by Ward and Stanford (1987) stated that construction of dams affect the migratory fishes which blocked the fish passage and also reduce migration of fish at upstream of river. Other than that, fish population at downstream also affected by the dams because the changing of water quality and fish habitat conditions. These changes not only affect the migratory fishes but it also affects the fish that live in the stream (Lessard and Hayes, 2003).
2.3. Human activities that affect pH of fish habitat

Changes in pH of fish habitat are mainly because of activities that happen in the watershed. These includes human activities such as accidental spills, agricultural runoff (pesticides, fertilizers, soil leachates), and sewer overflow. Changes in pH play an important aspect in water quality. For example in acid mine drainage area, the pH of water bodies tend to be lower. A study by Hill (1974) showed that the receiving water of acid mine drainage have low pH range from 2.0 to 4.5 which many of aquatic life cannot tolerate. According to Earle and Callagan (1998), lower abundance and biodiversity of fish are found in acid waters compared to neutral pH waters. This is because as pH levels rise in waters with acid mine drainage, iron, aluminium and others metals precipitation can coat substrate and suffocate fish (Martin and Platts, 1981). Hildrew et al. (1984) found that in less acidic water, diversity and species richness increased, indicating that greater range off food resources available. Besides that, fish species that cannot tolerate with the changes in pH may be eliminated and species that can tolerate changes in pH may proliferate (Meehan, 1991). Higher pH will also affect fish behaviour, impaired the reproductive capacity of adults fish and the viability of eggs and fry is reduced. Low pH of water often increases the toxicity of pollutants to fish. According to Sorenson et al. (1971) low pH levels triggers released of metals contained in waste rock or suspended sediment that eventually increase the toxic pollutant in fish habitat. Balm et al. (1996) showed that in acidic water, rainbow trout acquired heavy infections of the gill parasite, Trychophyra intermedia and this suggests that the parasite may have a primary effect on gill function under acid conditions. This indicates that low pH cause stress, gill damage, ionic imbalance, harmful agents and disease that can increase mortality in fish populations.
2.4 Effects of ammonia on fish

Ammonia is the natural degradation product in the breakdown of feed in culture system. Ammonia is excreted through fish gills and in their faeces. According to Durborow et al. (1997), ammonia also enters the culture system from bacterial decomposition of organic matter such as uneaten feed or dead algae and aquatic plants. Harris et al. (1998) stated that ammonia is toxic to many aquatic organisms including fish. This is because un-ionized ammonia is readily diffuse through the cell membrane of fish and highly soluble in liquids. According to Smart (1978), un-ionized ammonia will cause impairment of cerebral energy metabolism, damage to gill, liver, kidney, spleen and thyroid tissue of fish. Additionally, Ip et al. (2001) stated that un-ionized ammonia exposure may affect fish and other organisms in several ways, for example gill and kidney damage, reduction in growth, possible brain malfunctioning, and reduction in the oxygen-carrying capacity of the fish muscle depolarization, hyper excitability, convulsions and finally death. When ammonia is dissolved in water, it is partially ionized, depending on the pH and temperature of water. Ammonium which is the ionized ammonia is not toxic to the fish. Ogbonna and Chinomso (2010) stated that in low pH and low temperature, the ammonium level increases thus decreases the toxicity. Lower water temperatures slow down aerobic bacterial activity, thus slowing the nitrification process whereby ammonia is converted to harmless nitrate (Durborow et al., 1997). As stated by Durborow et al. (1997), fish should not be overfed, and the feeder should know that fish are consuming the feed offered since this important in both of practical and economic importance.
2.5 Effect of temperature on fish

Body temperature, growth rate, food consumption, feed conversion and other body functions of fish are greatly influenced by the temperature of surrounding water (Houlihan et al., 1993; Britz et al., 1997; Azevedo et al., 1998). According to National Research Council (1983), the optimum growing temperature for freshwater fish range is 25-30 °C at which they grow quickly. However, these may change with age, size and species of the fish, as many of the juveniles fish prefer warmer temperatures than adults fish (McCauley and Huggins, 1979; Pedersen and Jobling, 1989). The study of juvenile *Oreochromis niloticus* by Workagegn (2012) in different temperature at 24, 26, 28, 30, 32 and 34 °C revealed that growth performance, feed utilization efficiency and survival rate is highest at 32 °C while the lowest growth performance, feed utilization efficiency and survival rate is at 24 °C. The results also showed that the fish reared at 34 °C water temperature had reddish colour around the fines and the operculum while fish reared at others water temperature do not having the same problem. Therefore, it is conclude that the water temperature ranging from 28 °C to 32 °C is optimum for rearing of *Oreochromis niloticus* (Workagegn, 2012). Another study of juvenile *Seriola lalandi* by Abbink et al. (2011) in different temperature at 21, 23.5, 25, 26.5 and 29 °C showed that growth was optimised at 26.5 °C. The lowest growth performance and feed intake are 21 and 23.5 °C which did not differ from each other. The growth of juvenile *Seriola lalandi* was significantly reduced at the extreme temperature of 29 °C compared with the optimal temperature of 26.5 °C.
2.6 Effect of pH on fish

Good fish production is the result of many important factors including pH (Lopes and Silva, 2001). Different species have different pH tolerance; however, the generally accepted pH range for fish culture is 6.5-9.0 (Zweig et al., 1999). According to De Silva and Anderson (1995), fishes have a narrow tolerance of pH so many studies have been focusing on the pH limits at which fish grow and reproduce rapidly. In another study, Boyd (1982) concluded that fish will be dead at pH 4 and pH 11. However, if waters are more acidic than pH 6.5 or more alkaline than pH 9.0 for long periods, reproduction and growth of the fish will diminish. The study of juvenile *Seriola lalandi* by Abbink et al. (2011) in different pH at 6.58, 7.16 and 7.85 showed that the survival of juvenile *Seriola lalandi* was lower than pH 7.16 and 7.85 which both experienced 100% survival. The growth of fish at pH 6.58 was slower than at both pH values. Another study of *Cyprinus carpio* L. by Heydarnejad (2010) in different pH for 21 days at 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, and 9.0 resulted in greater weight, length, survival, and biomass were found for pH values of 7.5 and 8.0. *Cyprinus carpio* L. that were exposed to pH 9.0 did not survive and died at day 14 of the experiment. The results of this study showed that common carp grow and survive best when exposed to a water pH of 7.5-8.0. A study by El-Sherif and El-Feky (2009a) showed that the growth of Nile tilapia (*Oreochromis niloticus*) fingerlings performance was significantly decreased at pH 6 and 9, while the differences between pH 7 and 8 were not significant. They also reported that feed conversion ratio (FCR) increased at pH 6 and 9, since its value at the pH 6 was significantly higher than pH 9. Therefore, it was concluded that water pH 7-8 could be more suitable to tilapia culture for optimum growth performance and survival rate.
3.0 MATERIALS AND METHODS

3.1 Tank preparation

For experiment on pH (experiment 1 and 2), five fiberglass rectangular tanks of equal dimensions were used. The dimension of each tank is 2.10 m long x 1.30 m wide x 0.61 m deep. Thus, the total volume of each tank is 1.67 m$^3$ (Figure 1). In each tank, three rows of smaller compartments was placed perpendicular to the length of the tank. They were placed at equal distance from the edge of the tank and among each row. Each row was subdivided into three equal compartments made from polyvinyl chloride (PVC) and net with length of 0.49 m, width of 0.39 m x depth of 0.67 m. Therefore, the total volume of each compartment is 0.13 m$^3$.

![Figure 1: The dimension of fiberglass tank and set up of experimental design.](image)
For temperature experiment (experiment 3), five rectangular tanks of equal dimensions were used. The dimension of each tank is 1.73 m long x 1.19 m wide x 0.78 m deep. Thus, the total volume of each tank is 1.61 m³ (Figure 2). In each tank, three rows of smaller compartments was placed perpendicular to the length of the tank. They were placed at equal distance from the edge of the tank and among each row. Each row was subdivided into three equal compartments and net with length of 0.44 m, width of 0.41 m x depth of 0.85 m. Therefore, the total volume of each compartment is 0.15 m³.

Figure 2: The dimension of tank and set up of experimental design.
3.2 Tank water preparation and volume

For experiment on pH (experiment 1 and 2), every tank was filled with tap water to a depth of 0.42 m. Anti-chlorine solution (NIKA) was added to each tank at a volume of 0.2 ml per liter of water. The water was aerated and left for a period of 3 days before the start of experiment. The volume of the water in the tank is 1.15 m$^3$ and the volume of the water in each compartment is 0.07 m$^3$.

For experiment on temperature (experiment 3), every tank was filled with tap water to a depth of 0.59 m. Anti-chlorine solution (NIKA) was added to each tank at a volume of 0.2 ml per liter of water. The water was aerated and left for a period of 3 days before the start of experiment. The volume of the water in the tank is 1.21 m$^3$ and the volume of the water in each compartment is 0.11 m$^3$.

3.3 Acclimation of fry and juvenile

The fry and juveniles of *Barbonymus schwanenfeldii* and *Oreochromis niloticus* were obtained from the Department of Agriculture in Tarat, Serian and PM Aquaculture, Kota Sentosa respectively. Before placing these fry or juvenile into the tank in the laboratory, 25% of water volume from the tank was added to the plastic bag holding the fry or juveniles and left for 30 minutes. The fish were stocked into acclimatization aquaria 3 days before experiment start until the fish become active and no mortality occurred due to stress during transportation and handling.