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Effects of temperature on the growth, survival, and feed intake of *Leiopotherapon plumbeus*

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ABSTRACT

Leiopotherapon plumbeus, locally known as ayungin, is a small, edible fish with an average size of 15.9 cm that greatly contributes to the rich biological diversity of freshwater bodies in the Philippines. However, its population has continuously decreased due to various anthropogenic (overfishing and predation of invasive species) and environmental factors (land and water pollution). One way to conserve the decreasing population is through aquaculture. This study investigated the effect of temperature on the growth, mortality, and food intake of *L. plumbeus* under laboratory conditions for 21 days. Two hundred twenty-five *L. plumbeus* fingerlings were reared in triplicate aquariums with varying temperatures of 20°C, 25°C, 28°C (control), 30°C, and 35°C. The volume of feeds given to the fingerlings was based on the 5% of their body weight. There were no significant differences in percent growth by weight and length which signified that the temperatures were suitable for aquaculture of *L. plumbeus*. Greater food consumption was observed at higher temperatures. The tolerance of the fingerlings to these temperatures could be used as information on designing or improving aquaculture protocol and/or practices. Also, the fish could be a model species on studying effects of climate change to their physiology.

Keywords: aquaculture, feed intake, freshwater fish, growth, mortality, temperature

1. Introduction

Leiopotherapon plumbeus, locally known as ayungin, is one of the many endemic fishes found in the Philippines that grows into a maximum length of 15.9 cm [1]. The fish was originally from Laguna de Bay but was transplanted to Sampaloc Lake in the 1950s and to Taal Lake in the 1970s [2]. Until 1991, *L. plumbeus* was the most abundant fish in Laguna de Bay, comprising almost 70% of the fish fauna. However, in 2002, the fish was ranked third in abundance due to the declining population. Environmental and anthropogenic factors such as overfishing, predation of invasive species and pollution that leads to the deterioration of lake water quality contributed to the further decline of the fish population [3].

These continuous threats on *L. plumbeus'* population brought about different conservation programs conducted by agencies such as the Bureau of Fisheries and Aquatic Resources. One way of conserving *L. plumbeus* is through aquaculture. However, fish production in culture systems has been restricted by several factors such as limited information on aquaculture set-up and inadequate information on water quality requirements of fishes [4]. Some studies successfully reared ayungin in outdoor tanks, but most of them focused on other physiology of the fish. In the study of [5], the researchers identified the developmental stages of the fish. There were five identified growth or developmental stages of *L. plumbeus* such as yolk sac larva, preflexion, notochord flexion, post flexion larva, and early juvenile which were differentiated by length. Moreover, the diet composition of *L. plumbeus* larva is dominated by zooplankton. Cladocerans, ciliates, and copepod nauplii are favoured by the small fish larvae of *L. plumbeus* and insect larvae and smaller fishes are the diet composition of the mature *L. plumbeus* [6]

Temperature is one of the physicochemical parameters of water that has a large impact on the biology of aquatic organisms. Just like other fishes, *L. plumbeus*, is also affected by temperature. Every species has an optimal temperature range at which they can grow, metabolize, and reproduce [7]. Therefore, knowing the optimal temperature range for *L. plumbeus* may support more aquaculture studies, provide information for creating or improving aquaculture practices and may help in developing and planning of different conservation programs.

The study intended to determine the effect of temperature on the growth, survival, and feed intake of *Leiopotherapon plumbeus.*

2. Materials and methods

2.1. Fish rearing and experimental set-up

A total of 500 fingerlings of *L. plumbeus* were obtained from the Bureau of Fisheries and Aquatic Resources - National Inland Fisheries Technology Center (BFAR-NIFTC) in Manila East Road, Suyoc, Tanay, Rizal. Prior to the experiment, the fingerlings were acclimated in an aquarium under ambient temperature of 28˚C (based from the room temperature without the intervention of air conditioner reared in the laboratory in BFAR-NIFTC) for two weeks. After acclimation, based from experimental fish allocation by [8],

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225 out of 500 fingerlings were randomly distributed into aquariums with five different temperature treatments of 20°C, 25°C, 28°C (control or ambient temperature), 30°C, and 35° C. Each temperature treatment had three (3) aquariums as replicates. To carry out all temperature treatments, each aquarium was equipped with individual filter pump (WP-3880F Aquarium Top Filter, SOBO, Guangdong Province, China), thermostatically controlled water heater (AT-700 50W, XiLONG, Guangdong Province, China) and PVC pipe which serve as the hiding place of the fishes (Figure 1a). To ensure uniform temperature distribution, the water heater was placed beside the filter pump to help circulate the heated water. Moreover, each aquarium was covered with a rectangular glass plate to maintain the temperature inside the aquarium. A total of fifteen (15) aquariums (20x10x12 in) with 5-gal of fresh water were utilized and randomly distributed in the laboratory table (Figure 1b). In each aquarium, 15 *L. plumbeus* fingerlings were reared considering the dimension of aquarium and to avoid the possible effect on the growth and survival rate caused by cannibalism [9] (Figure 1c).

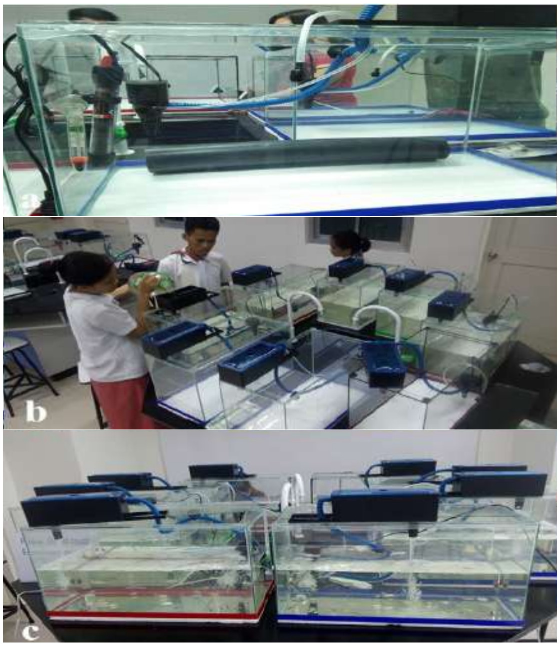

Figure 1. Photograph of (a) an aquarium setup with individual filter pump, thermostatically controlled water heater, and PVC pipe, (b) preparation of 15 aquarium setups, (c) aquarium setup with *L. plumbeus* fingerlings.

To avoid thermal shock, temperatures were adjusted at 1.0℃ with 2 to 3 days intervals so that all treatments reached the final treatment temperature on the same day. Temperature adjustments took 7 days to complete. After the temperature adjustment, fingerlings were held at constant treatment temperatures until the end of the experiment.

All fingerlings in each treatment were given the same amount of feed. To ensure a sufficient amount of feed for the fish, the feeds were offered at 5% of the fish' body weight, based on their feeding rate. Fingerlings in each treatment were fed with commercial feeds (Tateh Feeds: PO2 Prawn Feeds, Santeh Feeds Corporation, Quezon City, Philippines) containing 27% of crude protein, twice daily at 5:30 am and 5:30 pm.

2.2. Initial measurement

Fingerlings were measured for the initial weight (g) and length (cm) before subjecting to the experiment. Fingerlings were starved for 24 hours before measuring to ensure that the feeds will not affect the weight [10]. To avoid stress, fingerlings were taken out of the aquarium using fishnet. Moreover, all the equipment that was in contact with fingerlings must be wet first to avoid cuticle damage during the measurement. To avoid longer time exposure of the fish to air, length was measured by taking their photograph using digital camera (Canon EOS M6, New York, USA) in a petri dish filled with source water and calibration (cm) as reference for length measurement via image processing using ImageJ (Figure 2). On the other hand, for the measurement of initial weight (g), fingerlings were measured inside a Petri dish using top-loading balance (ME403TE/00 Precision Balance, Mettler Toledo, Ohio, USA).

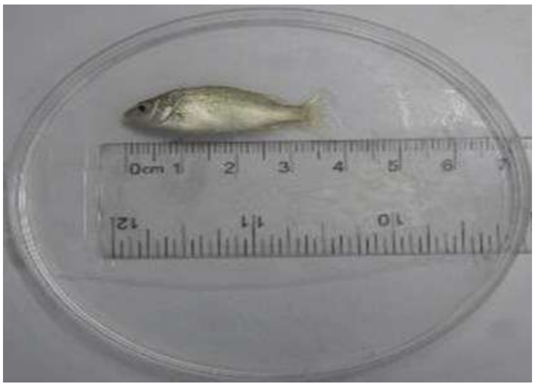

Figure 2. *L. plumbeus* in a Petri dish with calibration (cm) as reference for length measurement via image processing

2.3. Maintenance of aquarium set-up

Due to water evaporation especially at 30 and 35°C, permanent sticker marks were used to indicate the initial water level of 5 gallons in each aquarium. When the water level went down beyond the mark, water was added to the aquarium until the water level reached the permanent mark. In addition, faeces were removed by manual suctioning via siphon pump to control the level of debris and toxins in the aquarium due to the wastes produced by the fingerlings.

2.4. Measurement of growth rate, survival and feed intake

Individual fingerlings were weighed at the beginning and at the end of experiment only to avoid stress to fingerlings. Percent growth rate (% d^{-1}) was measured as follows:

$$PGR\ (\%d^{-1}) = \frac{\frac{Final\ Weight}{Initial\ Weight}}{\frac{1}{Number\ of\ Days}} \times 100$$

$$PGR\ (\%d^{-1}) = \frac{\frac{Final\ Length}{Initial\ Length}}{\frac{1}{Number\ of\ Days}} \times 100$$

Fish mortalities were recorded twice a day before every feeding. Survival rate (%) was calculated as:

$$Survival\ (\%) = \frac{No. of\ fingerlings\ that\ survived}{Initial\ Total\ Population}$$

Feed intake (FI) was determined for each treatment. The fingerlings were fed for 15 minutes. After 15 minutes, the uneaten feed was collected. The collected unconsumed food was oven-dried at 60°C [11] until constant weight for about two to three days. Feed intake was calculated by difference:

$$FI = Feed\ Given\ (g)\ - Feed\ consumed\ (g)$$

2.5. Statistical analysis

For the statistical analysis, one-way analysis of variance (ANOVA) was performed and Tukey's HSD as post hoc analysis after normality test using R software. Statistical significance was determined at $p<0.05$.

3. Results and discussion

3.1. The growth rate of *L. plumbeus*

The percent growth rate of *L. plumbeus* in terms of weight and length at different temperatures did not differ significantly (Figure 3 and 4). Although not significantly different, *L. plumbeus* showed positive growth rate in all of the temperature treatments. This might suggest that *L. plumbeus* can grow in weight and length at a wide range of temperatures. The growth rate of *L. plumbeus* in terms of weight was shown at Figure 3. The highest percent growth rate in weight of 3.79% day^{-1} was recorded at 20℃. This result is almost similar with Japanese flounder fish larvae that exhibits maximum growth rate between low temperatures of 18℃ and 21℃ [12].

In the present study, 3.77% day^{-1}, the second highest percent growth rate was noted at 30℃. In a study on *Cichlasoma urophthalmus*, the fish reaches it maximum growth rate at 33.3℃ [13]. Another species, *Labeo rajasthanicus*, shows highest growth rate at 30℃ [14]. The present study resulted into a high growth rate in weight at temperature treatments of 20℃ and 30℃. It may suggest that experimental temperature of 20℃ and 30℃ could be either the upper or lower limit of the tolerance range of *L. plumbeus* in terms of growth in weight.

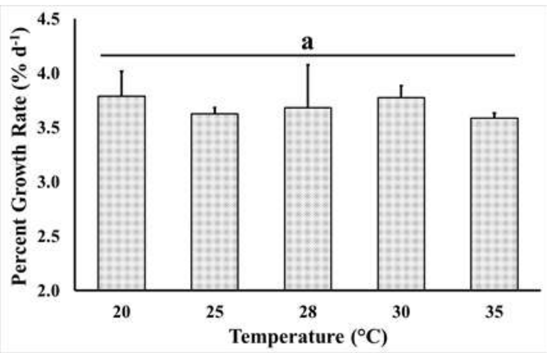

Figure 3. The percent growth rate in weight of *L. plumbeus* reared at different temperature treatments. Vertical bars with the same letter are not significantly different ($p<0.05$).

The percent growth rate (in terms of length) was shown in Figure 4. The highest recorded percent growth rate in terms of length are at temperature of 20℃ and 35℃. Similar with *L. plumbeus*, *Xyrauchentexanus*, *Catostomus latipinnis*, *Gilacypha* and *Ptychocheiluslucius* showed high growth rate in terms of length at 20℃ [15]. In addition, similar percent growth rate of 0.84% day^{-1} was observed at 30℃ which suggests that experimental temperature of 20℃ and 35℃ could either the upper or lower limit of the tolerance range of *L. plumbeus* in terms of growth in length.

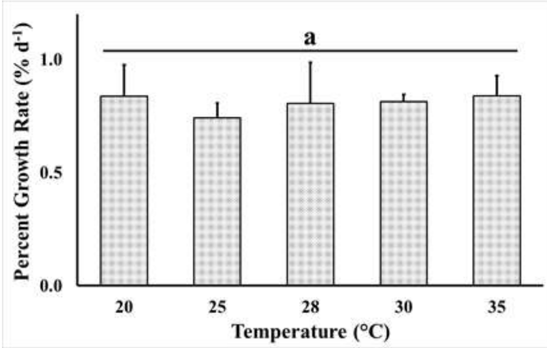

Figure 4. The percent growth rate in length of *L. plumbeus* reared at different temperature treatments. Vertical bars with the same letter are not significantly different ($p<0.05$).

3.2. The survival percentage of *L. plumbeus*

The percent survival of *L. plumbeus* showed no significant difference at different temperatures (Figure 5). This might imply that the tested temperature seems to be suitable for the survival of the fish. All fish reared at temperature 28 (control), 20, 25 and 35℃ survived except for one fingerling at 30℃ during 1st week of experimentation (Figure 5). Similarly, [16] recorded a 100% survival rate recorded for marine rabbitfish in temperature treatments of 17, 22, 27, and 32℃. In addition, a study also resulted in zero mortalities in sea bass when reared into 13, 16, 19, 22, 25 and 29°C [17].

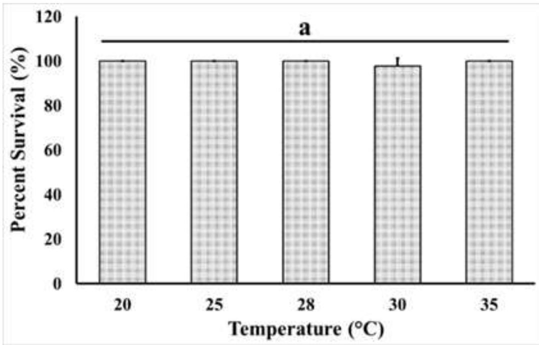

Figure 5. The percent survival of *L. plumbeus* reared at different temperature treatments. Vertical bars with the same letter are not significantly different ($p<0.05$).

3.3. Feed intake of *L. plumbeus* at different temperatures

The food intake of *L. plumbeus* did not differ significantly among tested temperatures (Figure 6). However, an increased food uptake at warm temperature was observed. This might be due to the fact that the fish subjected to high water temperatures increases their metabolic rates, resulting in an increased demand for food [18].

The feed intake of *L. plumbeus* at control, 20, 25, 30 and 35°Care 13.26 g, 13.01 g, 12.71 g, 13.15 g and 14.11 g, respectively (Figure 6). At 35°C, species show the highest consumption of feed with 14.11 grams. On the other hand, low feed consumption was seen at treatment 3 (25°C) with 12.71 grams feed consumption.

The highest feed intake of *L. plumbeus* was observed at the highest temperature treatments. Same result was observed in the study of [13] that showed high feed intake of *C. urophthalmus* at temperature treatments of 29.7, 33.1 and 36.3°C. On the other hand, *C. urophthalmus'* lowest feed intake was recorded at temperature of 22.5 and 25.7°C.

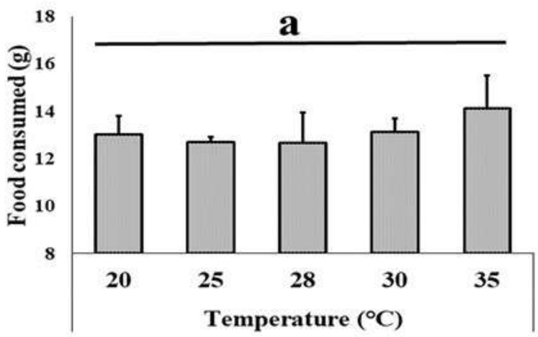

Figure 6. The amount of consumed feeds of *L. plumbeus* reared at different temperature treatments. Vertical bars with the same letter are not significantly different ($p<0.05$).

Further studies, using much lower time of experimentation and higher temperature may be conducted to test how much temperature ayungin (*Leiopotherapon plumbeus*) can tolerate, are recommended. Moreover, a study may also be conducted to investigate other physicochemical parameters that can also affect the growth, survival and feeding intake of *L. plumbeus*.

4. Conclusions

L. plumbeus showed no significant differences in their growth rate in terms of weight and length, survival, and feed intake within the temperature range of 20 to 35℃. This implies high tolerance of ayungin to the temperature range. Therefore, the temperature range of 20 to 35℃ is favourable for the growth, survival, and feed intake of *L. plumbeus*.

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