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_ Survival and growth of stiped snakehead fish (Channa striata Bloch.) juvenile reared in acid sulfate water and rainwater medium 1,2Purnamawati, 3Daniel Djokosetiyanto, 3Kukuh Nirmala, 3Enang Harris, 4Ridwan Affandi 1 Study Program of Aquaculture, Graduate School, Bogor Agricultural University, Bogor, West Java, Indonesia; 2 Study Program of Aquaculture, Department of Marine Science and Fisheries, Pontianak State Polytechnic, Jalan Ahmad Yani, West Borneo, Indonesia; 3 Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor, West Java, Indonesia; 4 Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor, West Java, Indonesia. Corresponding author: Purnamawati, purnamawati_za@yahoo.com Abstract.

The aim of this study was to evaluate the effects of the use of the different mediums on the growth and survival of the striped snakehead fish (Channa striata). This experiment applied a completely randomized design with acid sulfate water medium and rainwater medium as the experimental treatments, each treatment had twelve replications. The C. striata juvenile with an average initial length of 2.4±0.2 cm and an average initial weight of 0.21±0.05 g reared in the aquariums sizing 30 x 25 x 35 cm (with a water volume of 25 L) with a stocking density of 2 individuals/L, for 40 days.

The specimens were fed commercial feed, twice a day (morning and afternoon) until to apparent satiation. The water replacement was performed every 2 days as much as 10% water of the total water volume in the aquarium. The results showed that rainwater significantly affected the biometric and physiological responses of the C. striata juvenile.

The rainwater medium gave better results shown by the higher value of survival (73.89%), growth rate (4.40% day-1), feed efficiency (59.1%), protein retention (24.31%), energy retention (41.34%), blood albumin content (3.75 g/100 mL) and blood glucose (26.45 mg/100 mL). Key Words: water quality, air-breathing fish, marginal lands, tidal area. Introduction.

Aquaculture sector in Indonesia is growing up with advances in other sectors that support the continuity of aquaculture practices. The development of aquaculture sector is not only conducted in freshwater area, but also in brackishwater or marine areas. Most of aquaculture practices have been applied in marginal lands, but in general the productivity has still relatively been low.

The low aquaculture productivity in these areas is due to various problems, especially poor water quality. The results of the laboratory analysis in 2014 showed that the water in the tidal area had a pH range of 2.53-3.39, sulfate range at 6.91-8.7 mg L-1, Fe range at 0.72- 2.83 mg L-1, dissolved oxygen level <5 mg L-1, and a large salinity shock, that can be problems for the stenohalin fish (Purnamawati 2017).

The entrance of seawater causes large salinity range in tidal area between the rainy season and the dry season reaching 0- 28 ppt. With this suboptimal medium, not all fisheries commodities can be cultured in the tidal water, especially in the water with acid sulfate soil. Acid sulfate soils are derived from marine and estuarine sediments which show a severe acidification because of the oxidation of sulfides that leads to the formation of sulfuric acid. The water with acid sulfate soil can be recognized by the very low pH values that are less than 4 in water.

This condition leads to several problems, including the insufficient growth of algae, the poor condition and slow growth of the fish, and the hazard of sudden fish mortality during heavy rains after a long dry period (Singh & Poernomo 1984). To determine fisheries commodities which can survive in acid sulfate water, it can be seen from several aspects, including the tolerance to the environment, survival and growth (El-Sayed et al 1996).

The striped snakehead fish (Channa striata) is an Indonesian freshwater native species which is widely distributed in Sumatra, Kalimantan and Java Islands. This species has wide range habitats found in rivers, swamps, ponds, canals, lakes, and land of rice fields (Song et al 2013). The local and international markets greatly demand on this fish due to its rapid growth, tolerance to high stocking density, and medicinal value in enhancing wound healing and reducing postoperative pain (Jais et al 1997; Qin et al 1997; Mollah et al 2009).

This fish also has a high tolerance to adverse environments due to its hardiness to survive in water with high ammonia content and a low dissolved oxygen level caused by its air-breathing capability assisted by a suprabranchial chamber (Ng & Lim 1990; Qin et al 1997; Chandra & Banerjee 2004; Mollah et al 2009). The growth of the fish is strongly influenced by environmental factors, including nutrients in the rearing medium and water quality parameters such as the optimum salinity, pH, and oxygen level. To get the proper medium for the fish life, it would require a study about the response of the C. striata juvenile reared in the different mediums, e.g. acid sulfate water and rainwater. This is because each medium has different nutrient compositions between one medium to other mediums for the cultured fish. The aim of this study was to analyze the effects of different rearing mediums on growth and survival of C. striata. Material and Method.

This study was conducted on June-September 2014. The rearing of specimens (C. striata juveniles) was conducted at Wet Laboratory, Study Program of Aquaculture, Department of Marine Science and Fisheries, Pontianak State Polytechnic, Pontianak, Indonesia.

The measurement of blood albumin levels, the proximate analysis of the fish feed and the proximate analysis of the experimental fish were conducted at Fish Nutrition Laboratory, Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor, Indonesia. The measurement of plasma glucose levels was conducted at Environmental and Food Technology Laboratory, Tanjungpura University, Pontianak, Indonesia.

Experimental design. This study was conducted in laboratory through a completely randomized design (CRD). The treatments applied in this study consisted of two treatments, acid sulfate water medium and rainwater medium. Each treatment applied 12 replicates. Experimental fish. The experimental fish used in this study were C. striata juveniles with an average initial length of 2.4±0.2 cm and an average initial weight of 0.21±0.05 g. The fish were reared in mediums equipped with aeration equipment. Experimental tanks and mediums. The tanks used were 24 units of glass aquarium sizing 30 x 25 x 35 cm. The aquariums were filled with acid sulfate water obtained from tidal land of Kubu Raya District West Borneo and rainwater which had been prepared in a fiber tank.

The tops of aquariums were covered with nets to avoid the fish jumping out of the aquariums. Experimental procedures. Adaptation or acclimatization was performed prior that the experimental fish to be used for the experiment. The objective of this step was to adapt or acclimatize the fish to the new environmental conditions. This step was performed in 4 units of aquarium sizing 30 x 25 x 35 cm for 7 days. C. striata which had been acclimatized, were reared in the aquariums with a stocking density of

2 individuals/L (Vivekanandan 1977; Hidayatullah et al 2015). The study was conducted for 40 days.

The fish in all treatment groups were fed with commercial feed with chemical composition based on the result of the proximate analysis presented in Table 1, twice a day until to apparent satiation. Every two days, a water replacement was performed by replacing 10% water of the total water volume in the medium with new water.

Table 1 The result of the proximate analysis of commercial feed used in the present study Chemical composition _Content (% dry weight) _ _Protein _34.86 _ _Fat _3.92 _ _Carbohydrate _42.49 _ _Nitrogen free extract _39.30 _ _Crude fiber _3.19 _ _Ash _8.60 _ _Moisture _11.08 _ _ The fish mortality observation was conducted every day to get the survival data of the experimental fish at the end of the study, while measurements of the length and the weight of the fish were done every 10 days to get the growth data. To record the feed intake was done by summing the daily feed consumed during the study.

Observations and measurements of temperature, pH and dissolved oxygen level were carried out every day, while the measurements of sulfate (SO42-) and ammonia were performed at the beginning and the end of the study. Experimental parameters. The measurement of water quality parameters were performed following the procedures described by APHA (1989).

The measurement of blood albumin levels followed the method described by Infusino & Panteghini (2013), while the proximate analysis of the fish feed and the experimental fish were carried out according to the procedure by Takeuchi (1988). The measurement of plasma glucose levels was performed using a liquicolor Glucose commercial kit GOD-PAP with calorimetric method and the results of the measurement were read with a spectrophotometer at a wavelength of 500 nm following the procedure by Wedemeyer & Yasutake (1977). Survival rate was calculated using a formula according to Kang'ombe & Brown (2008): SR = (Nt x N0-1) x 100 Where: SR - survival (%); Nt - the number of the fish at the end of the study (individuals); No - the number of the fish at the beginning of the study (individuals). Specific growth rate, was calculated using a formula stated by Weatherley & Gill (1989). SGR = [(ln W2–ln W1)/(t2 – t1)] x 100 Where: SGR - specific growth rate (% day-1); W1 - the average weight of the fish at the beginning of the study (g); W2 - the average weight of the fish at time t2 (g); t2 – t1 - experimental duration. The feed efficiency of the C. striata juvenile was calculated using a formula constructed by Kang'ombe & Brown (2008).

e = [((Wt + D) – Wo) / F] x 100

Where: e - feed efficiency; Wo - the weight of the fish at the beginning of the study (g); Wt - the weight of the fish at the end of the study (g); D - the weight of dead fish during the study (g); F - the weight of total feed given during the study (g dry weight). Statistical analysis. The data of survival, specific growth rate, blood albumin level, feed efficiency, protein retention, energy retention, and blood glucose level were analyze through t test to see the differences among treatments. Results and Discussion.

The data obtained from the measurement of physical-chemical parameters of the water are presented in Table 2, while the data obtained from the measurement of biometric parameters (survival, growth, blood albumin level and feed efficiency) and physiological parameter (blood glucose level) of the C. striata juvenile reared in acid sulfate water and rainwater mediums are presented in Table 2.

Based on the data presented in Table 2, it was indicated that the values of water quality parameters of acid sulfate water medium used as a treatment for the C. striata juvenile were not appropriate for the species physiological requirements. From all parameters observed, only ammonia, oxygen level and temperature of the water were in the optimum range, while the other parameters were not in the optimum range. However, these average ranges of physical-chemical parameters were still quite good for the survival of C. striata juveniles, because these ranges were still on the tolerance ranges. On the other hand, the values of water quality parameters of the rainwater medium used as a treatment for C. striata specimens within the optimum ranges. Table 2 The values of physical-chemical parameters of the water in each treatment during the study Parameters _Treatments Acid sulfate water Rainwater _Tolerance range* and optimum range** pH 3.7–5.45 6.58–8.30 4.25–9.4*1) Sulfate (SO42-) (mg L-1) 81–143 13–19 5–100*2) Ammonia (mg L-1) 0.02–0.05 0.001–0.01 <1.57*3) Dissolved oxygen (mg L-1) 5.53–6.10 5.68–6.25 >5**1) Temperature (oC) 28.42–30.02 28.96–30.07 26–32*1) 1)Courtenay & Williams (2004), 2)Boyd (1988), 3)Jianguang et al (1997), *)tolerance range, **)optimum range. Table 3 show that the highest survival (73.89%), growth rate (4.40 % day-1), albumin content (3.75 g/100 mL), feed efficiency (59.1%), protein retention (24.31%) and energy retention (41.34%) were found on the rainwater medium. The lowest glucose level (26.45 mg/100 mL) was obtained in the rainwater medium.
Table 3 Survival (SR), specific growth rate (SGR), blood albumin level, feed efficiency (FE), protein retention (PR), energy retention (ER), and blood glucose level (BG) of Channa striata reared in the different mediums during the study Parameters _ Treatments Acid sulfate water Rainwater SR (%) 54.44±6.21a 73.89±6.12b SGR (% day-1) 2.93±0.40a 4.40±0.96b Blood albumin (g/100 mL) 3.63±0.65a 3.75±0.66a FE (%) 28.2±5.41a 59.1±18.76b PR (%) 5.81±2.16a 24.31±11.12b ER (%) 10.60±2.95a 41.34±18.28b BG (mg/100 mL) 29.99±0.58a 26.45±1.13b Different superscript letters in the same row indicate significant statistical differences (P<0.05).

The high survival and the growth of specimens reared in the rainwater medium related to the water quality conditions of the medium. Water quality parameters (dissolved oxygen, temperature, ammonia, sulfate and pH) of this medium were in the optimum ranges and the tolerance ranges (Table 2). The water temperature in the acid sulfate water medium ranged from 28.42 to 30.02°C, while that in the rainwater medium ranged from 28.96 to 30.07°C, those values did not show any difference to the temperature range required by the species.

Muslim (2007) stated that the temperature range that could be tolerated by the C. striata were 25.5-32.7°C. C. striata is tolerant to poor water quality conditions. Oxygen is an important factor that determines the life of aquatic organisms. In this study, the dissolved oxygen level in the acid sulfate water medium ranged from 5.53 to 6.10 mg L-1, while that of the rainwater medium ranged from 5.68 to 6.25 mg L-1. According to Courtenay & Williams (2004), C. striata can survive in the low dissolved oxygen level that is less than 5 mg L-1.

The dissolved oxygen levels in the treatment mediums during the study were on the optimum range for C. striata. This fish is categorized as a fish which has an ability to take oxygen directly from the air. Ammonia (NH3) is generated from the reform process of proteins (amino acids) contained in the feed eaten by the fish and converting them into energy.

The metabolic waste is disposed in the form of ammonia (NH3) through the gills. In the treatment using acid sulfate water medium, the range of NH3 contained in the medium was 0.02-0.05 mg L-1, while that in the rainwater medium ranged from 0.001 to 0.01 mg L-1. These ranges were low and could be tolerated by specimens. At an ammonia concentration of 1.57 mg L-1, C. striata juvenile can still grow (Jianguang et al 1997). The ranges of sulfate content in the acid sulfate water medium and the rainwater medium were 81-143 mg L-1 and 13-19 mg L-1, respectively. Although the sulfate content in acid sulfate water medium was relatively high, but it was still within the tolerance range for the species (Boyd 1988).

The range of pH during the study in the rainwater medium (6.58-8.30) was still within the tolerance range to promote the growth of C. striata juvenile, because this range created an optimum environmental condition to support the physiological activity of the fish. According to Courtenay & Williams (2004), the tolerance range of pH for the life of C. striata is at a range of 4.25-9.4.

At this range, the gills ability to bind oxygen becomes more optimal. On the other hand, the acid sulfate water medium showed a pH range below the tolerance range (3.7-5.45), so that the growth of specimens in this medium did not excelled. Although

C. striata is sensitive to changes in pH, this species can survive on acidic and alkaline water (Pillay 1995), but the growth will not ensure a maximum level. The low pH and high aluminum concentration in the acid sulfate water may kill the fish or weaken them, so that they become easy to be attacked by diseases and parasites (Singh & Poernomo 1984).

The result of t test presented in Table 3 demonstrated that the survival of C. striata juveniles reared in the rainwater medium with a value of 73.89% was significantly different ($P<0.05$) from those reared in the acid sulfate water medium. It was higher than that on the acid sulfate water medium treatment (54.44%), and it also was higher than the survival of the catfish reared in the freshwater medium as reported in the study of Hollerman & Boyd (1980).

This was caused by the optimum water quality in the rainwater medium that supported the life of C. striata compared to acid sulfate water medium, indicated by the ideal water ecosystem both on the feed absorption efficiency and the availability of an optimum amount of dissolved oxygen.

The low survival found in the treatment of acid sulfate water medium was caused by the high energy required by the fish to adapt to environmental stress caused by the low pH. The high energy requirement to survive will stimulate the glucose mobilization to the blood (Costas et al 2008). This was indicated by the high blood glucose level in the treatment of acid sulfate water medium (29.99 mg/100 mL).

The statistical analysis result showed that the treatment of rainwater medium significantly affected ($P<0.05$) the specific growth rate of C. striata juvenile. The specific growth rate data showed that the highest growth of C. striata juvenile after 40-day experiment was obtained in the treatment of rainwater medium (4.40%), while the lowest growth was obtained in the treatment of acid sulfate water medium (2.93%).

This showed that the rearing mediums gave a significant effect on the fish growth. The specimens reared in the rainwater medium were better in utilizing energy obtained from the feed, so the nutrients contained in the feed could be metabolized efficiently. A better growth of specimens reared in the rainwater medium was reflected by a high protein retention value (24.31%).

Ballestrazzi et al (1994) stated that the protein retention was a parameter to indicate the contribution of protein consumed from the diet on the body protein accretion. Protein retention needs to be specifically noted to see the contribution of protein consumed from the diet to the increase of the fish weight or height (Watanabe 1988).

The protein retention value also shows the quality of protein contained in the diet, the higher the protein retention value, the better the feed quality (Halver 1989). It was clear that the rainwater medium contributed better to the feed energy utilization, as more proteins were stored and were decomposed only in a little amount or those were utilized as energy to maintain homeostasis.

Lipid is usually stored as energy reserves for long-term energy needs during the full activity period or during the period without food and energy. This phenomenon could be seen from the energy retention of C. striata juvenile. The fish reared in the rainwater medium had an energy retention value of 41.34%, while the result obtained in the treatment of acid sulfate water medium was 10.60%.

The low energy retention in the treatment of acid sulfate water medium possibly happened because the energy produced secreted more by the body for metabolism, reproductive activity, biosynthesis and it was also lost as heat. Moreover, Jobling et al (1991) stated that the high energy for the activity of the organism will reduce the energy budget for growth.

According to Nelson & Chabot (2011), the energy in the feed is physiologically used for the body treatment and metabolism, if there is a rest of it, it will be deposited as the body tissues in the process of growth and reproductive tissue synthesis. The results showed that the higher value of feed efficiency is on the treatment of the rainwater medium (59.1%) compared to the treatment of acid sulfate water medium (28.2%). The high feed efficiency in the treatment of rainwater medium indicated a better feed utilization.

The efficiency of feed utilization will run optimally, if the environmental conditions were in normal conditions. According to Brett (1971), the amount of feed consumed by the fish per day is one of the factors that influence the potential of the fish to grow maximally and the daily feed intake is closely related to the capacity and the emptying of the stomach.

The daily feeding rate, feeding frequency and type of feed used affect the digestibility of the fish, which plays an important role in lowering feed conversion ratio or increasing feed efficiency by efficient utilization of the feed (Chiu et al 1987; De Silva & Davy 1992). The results of the present study demonstrated that the blood albumin level of the fish reared in the rainwater medium did not show any difference with those reared in the acid sulfate water medium. C. striata is one of the species which has a high level of blood albumin (Mustafa et al 2012). Albumin is a kind of globular protein which soluble in water, salt and acid solvents (Masuelli 2013). The previous studies reported that fish physiological status, age, season and habitats influenced on serum protein properties, especially albumin (Kovyrshina & Rudneva 2012). Several researchers have shown that albumin concentration strongly depends on diet composition (Chukwuma et al 2010; MacQueen et al 2011). Moreover, fish physiological status that affect albumin concentration strong correlated with seasonal fluctuations depending on water temperature, oxygen level, food composition, anthropogenic impact and algae bloom (Kamal & Omar 2011). In this study, diet composition, water temperature, and oxygen level were in the same range, so that the blood albumin levels of C. striata specimens reared in the different mediums tested in this study did not show any differences. Conclusions. The use of the rainwater as a rearing medium for C. striata juveniles gave higher values concerning all indices monitored (SR, SGR, FE, PR, ER, BG), against acid sulfate water medium.

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