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Environmental Manipulations to Increase Hatching Rate of Catfish Eggs (*Pangasius* sp.): A Review

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ABSTRACT: Catfish is the primary commodity of freshwater consumption fish that is widely cultivated with a high protein content of 68.6% and a high selling price. In addition, catfish meat is believed to be capable of preventing heart and cardiovascular disease because its unsaturated fats. Catfish skin can be used as a source of collagen in the culinary, cosmetic, and health fields. Catfish spawn all year round because of the abundance of food. The environment can help stimulate the synthesis of reproductive hormones in the reproductive activity of catfish. Environmental manipulations such as temperature, pH and salinity have different effects on the hatchability of catfish (Pangasius sp.) eggs. High temperatures can speed up the hatching time of the eggs but drop the hatching percentage and survival rate because high temperature activates the chorionase enzyme containing pseudokeratin which softens fish egg shells. In contrast to the pH treatment, a pH that is too acidic will deactivate the work of the chorionase enzyme so that the shells of fish eggs are difficult to break, resulting in a low percentage of hatching and survival rate with the longest hatching time. Salinity works by balancing the osmoregulatory pressure in the shell with the environment. A high salinity concentration can damage the egg by breaking into and swelling the eggshell, causing a low survival rate. On the other hand, eggs not treated with salinity were reported to have the lowest hatching percentage due to fungi attacking the eggs causing embryos to die. Salinity does not affect egg hatching time.

Keywords: temperature, pH, salinity, egg hatchability

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INTRODUCTION

The Marine and Fisheries Ministry (KKP, 2018) states that catfish consumption by international demand has increased rapidly. Catfish import demands from China have increased by 34,400 tons per year, followed by Thailand by 19,200 tons. The increasing demand for catfish globally became an opportunity for Indonesia to dominate the global catfish production market. Indonesia's total national catfish production was highly contributed by the island of Sumatra, around 68.07% with South Sumatra as the largest contributor, which is 47.23%. Directorate General of aquaculture of catfish production data (DJPB, 2018) shows an increase in production of around 6.52% from 2015 to 2018 and an increase in production of around 22.25% from 2017 to 2018 cultivated.

Catfish meat has a savory taste favored by the public with a relatively high selling price ranging from Rp. 25,000 to Rp. 38,000 (Caniago and Purba, 2020). According to Ghufran and Kordi (2010), catfish meat contains 68.6% high protein, 5.8% fat, 3.5% ash, and 59.3% water. According to Hardyanti (2014), catfish skin is one of the sources of collagen production with a content of 2.75 mg/kg fish skin or the equivalent of 85.3 mg/kg fish. Collagen has been used in culinary, cosmetic, biomedical,

and pharmaceutical industries (Chai *et al*., 2010). Catfish meat contains several suitable components for the human body, namely vitamins, minerals, and omega-3 fatty acids (Klemeyer *et al*., 2008). Triyanto (2020) added that consuming catfish meat could prevent heart and cardiovascular diseases because of the unsaturated fat content that can reduce cholesterol levels in the blood.

According to Tariningsih *et al*. (2015), the problem that often occurs in the management of catfish broodstock is the low hatchability of catfish eggs caused by the mismatch of water quality used in the cultivation process. Spawning in addition to being influenced by internal factors, spawning is also influenced by external factors such as the environmental conditions of fish, including physical factors (light, temperature, currents), chemical factors (pH, oxygen solubility, pheromones), and biological factors (presence of the opposite sex, and hormones).

Artificial stimulation given by environmental manipulation or hormone injections helps accelerate spawning. Hormonal manipulation by way of hormone injection is a technology to regulate the behavior of a living being by adding additional hormones into the body. Currently, hormonal manipulation has been widely used by breeders because: considered very effective in increasing seed production in quality and quantity.

However, Alonso *et al*. (2014) stated that using hormonal products in cultivation activities has a negative potential for environmental health and humans who consume them. Steroids are hormones produced from cholesterol and based on characteristic structures, can be divided into five groups, including androgens, estrogens, mineral corticoids, glucocorticoids, and progestogens. Consuming fish contaminated with steroids can cause endocrine disorders and then cause cancer (Bergman *et al*., 2013). Another drawback is that it is difficult to do because it requires trained human resources to inject the hormone properly.

The purpose of this review is to study environmental manipulation, a technique to regulate the behavior of living things by manipulating their environment.

REVIEW METHOD

The method used in writing this scientific article is a literature review. A literature review is a scientific paper written to provide the latest information on the advantages and disadvantages of a research method that has been reviewed. This paper can educate readers and researchers to try to use other methods that are more effective than previous studies (Banister and Wee, 2015).

According to Hart (2018), there are two types of literature review, namely interventionist (systematic) and scholastic (traditional) with different target readers. In a systematic review, the author collects and uses all information under the facts related to the topic of discussion to answer an existing problem. The target readers are those who need to make decisions on practical issues such as science, law enforcement and others.

While the traditional review aims to analyze arguments, find, and solve problems and provide challenges through conceptual analysis. The target readers are those who need to analyze the review writing to understand the writer's thinking and analysis skills, such as a dissertation supervisor. Then, there is a combination of the two types, namely writing a review of several libraries which must be based on rational research methods for the problems to be discussed. The author must understand the theoretical basis plus the facts of the research results as the main basis for conducting a literature review (Hart, 2018).

Habitat and Distribution

The distribution of catfish is quite broad, almost all over Indonesia. Catfish live in both flowing and calm waters and can be found in major rivers such as the Musi, Batanghari, Indragiri, Berantas and Bengawan rivers. Generally, these fish live in deep waters (Pramudias, 2014). According to Gupta (2016), catfish are widely distributed in Bangladesh, India, Indonesia, Pakistan, Myanmar, Vietnam, and Thailand. Catfish can be found living in various types of freshwaters, both flowing waters and calm waters. Generally, catfish live in large rivers, swamps, irrigation canals and lakes, especially during the monsoon period.

In Indonesia, precisely in the area of South Kalimantan, there is the Mahakam River, the original habitat of one species of catfish. The Mahakam River is the second largest in Kalimantan, with a length of 920 km and an area of 77,700 km2. This murky river has swift currents. The adult catfish are found swimming on the Mahakam River's surface, while the juvenile swims at the bottom (Pouyaud *et al*., 2002).

Reproductive Cycle Gonad

Gonad development is influenced by food, weather, season, and temperature, while food, hormones, and temperature influence gonad maturity. The advantages of environmental manipulation techniques compared to hormonal manipulation techniques are that they are cheap and easy to do.

Several studies have been conducted to determine the relationship between environmental factors and the hatchability of fish eggs. At a temperature of 32°C, the highest hatchability of catfish eggs was 90.18% (Putri *et al*., 2013; Masrizal *et al*., 2001). Research by Putra *et al*. (2020) stated that the pH treatment had a good effect on the hatchability of catfish eggs by 80.33% at pH 7 and the fastest hatching time at pH 8. In addition, a salinity of 4 ppt increases the hatchability of catfish eggs by 95.99% (Isriansyah, 2011).

In general, catfish are included in the catfish group because they do not have scales and the body shape of this fish resembles a catfish with two pairs of short whiskers around the mouth at the bottom of the head. Jambal catfish usually have a smaller head, long and wide towards the stage, with silver body color on the belly and bluish on the back. The growth of catfish can reach a body length of 120 cm (Oktavianti, 2014).

Naturally, catfish spawn when entering the rainy season or during high rainfall conditions. Generally, spawning occurs for 2-3 months but can occur for a full six months, depending on where the catfish live. Catfish are also actively spawning when floods and overflowing rivers inundate living waters. Without current flow, catfish tend to be passive because they are in a dormant phase, where the development of their gonads stops and does not ovulate (Wulandari, 2008). Fish are stimulated to spawn during the rainy season because of the distinctive aroma of falling rainwater on dry soil called petrichor (Betsy and Kumar, 2020).

The spawning conditions of fish are directly related to various internal and external factors. Egg maturity and breeding season (spawning) are regulated by hormones, female nutrition and external (ecological) factors. In addition, physiological factors such as the endocrine (hormonal) system, fish stress, water quality, and ecological and environmental factors such as temperature, photoperiod, periodicity, water currents (tidal), latitude, water depth, type of substrate, hormonal influences and rainfall can also affect influence timing and reproductive behavior (Tesfahun, 2019; Pankhurst and Munday, 2011).

Each species releases eggs in some period. In the spawning period, there is a

specific time when the fish will actively lay eggs and when the fish are not. However, oocytes can still receive hormonal signals for maturation in females or the release of spermatozoa in males, a phase ready to lay eggs (Rey, 2016). The reproductive cycle is closely related to the gonad development of female fish, especially the gonad maturity of female fish and the factors that influence it. The period between the reproductive cycle to the next reproductive cycle depends on the level of gonadal maturity that has been achieved. Some take a short time, but some take a long time to years. External factors are essential, especially feed availability in the environment (Yuniar, 2017).

Factors affecting the hatchability of catfish eggs

Bobe (2015) stated that one of the factors that affect the quality of fish eggs is environmental factors. Some fish species have fish reproductive cycles and the growth or maturity of fish gonads is influenced by the environment, one of which is temperature. Fish reproduction occurs due to environmental stimulation, which then becomes a signal to produce gonadotropin hormones. These stimuli include temperature, pH, salinity, season and current speed.

One of the reasons for the high and low hatchability of fish eggs is environmental factors that are not suitable for the media for hatching catfish eggs. The unsuitable environmental factors inhibit embryo development in the egg, thereby inhibiting the secretion of the enzyme chorionase that helps hatch catfish eggs. The inhibition of the secretion of the chorionase enzyme is due to the low stimulation of environmental signals such as temperature, pH, salinity, and others (Isriansyah, 2011).

Temperature

Temperature is the degree of hot or cold waters that significantly affect the survival of fish. Temperature changes result in changes in eating behavior, reproduction and even death due to stress. Temperature is influenced by seasons, photoperiod, and weather. Measurement of temperature using a Hg thermometer.

Comparison of Research Results

Several research results that have been conducted to determine the effect of temperature, pH, and salinity treatment on the hatchability of catfish (Pangasius sp.) eggs are presented in table 1 as follows.

Table 2. Comparison of Environmental Manipulation Treatment on Hatchability of Catfish Eggs (*Pangasius* sp.)

Variables	Treatment	Hatching time (hours)	Hatching Percentage (%)	Survival Rate (%)	Source
Temperature (^{o}C)	29	28,19	84,33	84,84	Anggraini *et al.*, 2019
	31	27,47	63,67	62,50	
pH	7	23,54	80,33	99,44	Putra *et al.*, 2020
	5	27,52	51,67	68,89	
Salinity (ppt)	3,6-4,0	21,46	72,78	88,86	Heltonika, 2014
	0	21,57	61,77	79,56	

Research by Anggraini *et al*. (2019) got the highest hatching percentage at 29°C at 84.33%, while the lowest hatching percentage at 31°C was 63.67%. Temperatures that are

too high will interfere with the work of the chorionase enzyme, which contains pseudokeratin that helps reduce chorion in the shell. The shell becomes harder, making it difficult for the embryo to come out, resulting in death. Research by Caniago and Purba (2020) stated that a temperature of 29-31°C increased the hatchability of catfish (Pangasius sp.) eggs by 87.5%. The fastest hatching time was at a temperature of 31°C with a hatching time of 27.47 hours, while the longest hatching time was at a temperature of 27 for 30.16 hours. Temperature affects the hatchability of fish eggs, where high temperatures will accelerate hatching time and vice versa. Temperature also affects increasing the metabolic rate of the embryo. When the water temperature is too hot, the metabolic work of the embryo increases so that the egg yolk as a food reserve for the embryo runs out and forces the embryo out of the shell using the pharynx. As a result, the embryo is born prematurely.

The survival of catfish larvae with a temperature of 29°C showed the best value of 84.94% while the temperature of 31°C showed the lowest result of 62.50%. Catfish larvae cannot survive at temperatures too high because the embryos are born prematurely, and their body resistance is meager. Research supporting parameters Anggraini *et al*. (2019) shows that DO temperature is 5.0-5.8 ppm and pH is 6.2-7.5.

pH

pH is the degree of acid or alkalinity of water that describes the high and low organic matter content in these waters. The cause of alkaline or acidic waters is caused by the residue of organic matter and metabolic waste that settles in the waters. Measurement of pH using a pH meter or pH paper.

Putra *et al*. (2020) obtained the highest hatching percentage at pH 7 of 80.33%, while the lowest hatching percentage value was at pH 5 of 51.67%. The acidic pH can deactivate the chorionase enzyme and interfere with the egg's metabolism, making it difficult for the embryo to come out of the shell and cause death, causing the hatching percentage to be different.

The fastest hatching time was at pH 8 with a hatching time of 21.59 hours, while the longest hatching time was at pH 5 22.31 hours. The pH 5 treatment became the treatment with the longest hatching time due to the too-acidic pH inhibiting the development of catfish egg embryos, so the work of the chorionase enzyme was not optimal. The survival of catfish larvae with pH 7 showed the best value of 99.44% while pH 5 showed the result of 68.89%. Catfish larvae are thought to be unable to survive at a pH that is too acidic because the acidic pH affects the gills and oxygen consumption level.

Salinity

Salinity is the concentration of dissolved salt in the water. Salinity in fresh waters ranges from 0-6 ppt, brackish waters range from 7-22 ppt, and in salty waters > 22 ppt. The concentration of salinity in waters can be caused by evaporation from hot water temperatures. Salinity measurement using a salinometer.

Research by Heltonika (2014) obtained results in the average hatching value of catfish eggs with salinity treatment of 3.6-4.0 ppt showing the most significant value of 72.78%. The lowest average hatching value of catfish eggs was shown at 0 ppt salinity, 61.77%. According to the results of Heltonika's research (2014), eggs without salinity treatment cause the growth of fungus on catfish eggs which causes death.

The measurement results of the fastest hatching time in the treatment of 3.6-4.0 ppt with an average of 21.46 hours. Meanwhile, the longest hatching time was in the salinity treatment of 5.7-6.0 ppt for 22.21 hours. This is explained by Heltonika (2014), that the water

temperature in the salinity treatment of 3.6-4.0 ppt was hotter than the salinity treatment of 5.7-6.0 ppt where salinity did not affect the length of hatching time.

The measurement results of the highest survival rate in the salinity treatment of 5.7-6.0 ppt were 89.10%, while the lowest survival rate was in the 0 ppt salinity treatment at 79.56%. In the 0 ppt salinity treatment, Heltonika (2014) explained that catfish eggs not treated with salinity were more likely to be attacked by fungi. This fungus will attack unfertilized eggs and infect other eggs that have been fertile but are not healthy.

The supporting parameters of Heltonika's research (2014) were obtained as follows; in the salinity treatment of 3.6-4.0 ppt, the water temperature ranged from 28-30°C with DO range from 6.5 to 7.0 ppm and pH ranged from 6.74-6.96. In the salinity treatment of 5.7 to 6.0 ppt, the water temperature ranged from 29 to 31°C with DO range from 6.3 to 7.1 ppm and pH from 6.87 to 7.60. In the 0 ppt salinity treatment, the water temperature ranged from 29 to 31°C with a DO range from 6.6 to 7.4 ppm and a pH range from 6.65 to 7.13.

The hatchability of catfish (Pangasius sp.) eggs based on the results of research by Anggraini *et al*. (2019); Putra *et al*. (2020); Heltonika (2014) is determined based on several things, such as hatching percentage, survival rate and hatching time. Hatching percentage states how many eggs hatch, survival rate states how many seeds survive after hatching and hatching time states how long it takes for the eggs to hatch.

The hatchability of catfish eggs is influenced by several factors, one of which is external factors such as temperature, pH, salinity and others (Tang and Affandi, 2000). Temperature is the degree of hot or cold an object is. Water temperature significantly affects the survival of fish, from the egg to the juvenile stage. Water temperature that exceeds the optimal temperature of the catfish's living media has a negative impact in the form of stress which can cause eggs to fail to hatch until death (Muhajir, 2017).

Water quality parameters pH is influenced by temperature and dissolved oxygen content. The lower the dissolved oxygen content, the higher the pH or the water becomes alkaline. Conversely, when dissolved carbon dioxide increases, the lower the pH or the water becomes acidic. Salinity affects the osmoregulation process of catfish eggs. Salinity is affected by the dry season and temperature. The dry season and high temperatures will make the waters evaporate so that the salinity content in the water becomes concentrated.

Each environmental manipulation treatment has a different effect on the hatchability of catfish (Pangasius sp.) eggs. The temperature of 29°C greatly influences the hatching time with the highest hatching percentage. A pH of 7 caused the highest embryo survival rate, while the highest hatching time was seen in the salinity treatment of 3.6-4.0 ppt.

CONCLUSION

Based on the results of the review that has been obtained, it can be concluded that the hatchability of catfish eggs can be influenced by environmental factors such as temperature, pH, salinity, and others. Each of these water quality parameters influences the degree of hatching of eggs. Temperature 29°C gave the highest hatching percentage with a yield of 84.33%, pH 7 gave the highest larval survival rate with a yield of 99.44% and salinity 3.6-4.0 ppt gave the fastest hatching time with a yield of 21 hours 46 minutes. Temperatures that are too high and pH that is too acidic will deactivate the chorionase enzyme which contains pseudokeratin which helps soften egg shells. Eggs not treated with salinity cause fish eggs to be susceptible to

fungal attacks which then kill the embryos in the eggs.

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