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Spawning Technique of Tilapia (*Oreochromis niloticus*) at the Fish Fry Center in Cibiru, West Java

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Authors' contributions

This work was carried out in collaboration between both authors. Author YA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript, and managed the analyses of the study. Author RIP managed the literature searches and writing. Both authors read and approved the final manuscript.

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ABSTRACT

The demand for fish consumption continues to rise due to its high protein content, leading to an inadequate supply of fish stocks. To address this issue, the utilization of public water bodies for fish cultivation is seen as a potential solution. Cultivating fish in public waters can significantly boost fish production and maximize water utilization. One crucial stage in freshwater fish farming is freshwater fish hatchery development, aimed at meeting market demand for fish. Tilapia, a type of freshwater fish, holds great potential for cultivation due to its low production costs, high economic value, and adaptability to various aquatic conditions. The Cibiru Fish Fry Center in Bandung City plays a crucial role in tilapia fry production, with tilapia spawning being a significant endeavor. Tilapia is a freshwater fish species known for its elongated body shape, flattened sides, and blackish color. It exhibits a remarkable tolerance to different salinity levels and feeds on both animals and plants. Tilapia spawning at the Cibiru Fish Fry Center involves careful preparation of spawning ponds and

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the use of *kakaban* and water nets as substrates for egg attachment. Approximately 30,000 larvae are produced per spawning, with a hatching rate of 80%. Larvae management takes place in the same ponds as the spawning ponds and fertilizer application is used to promote the growth of natural food sources for the larvae. Feeding management is crucial for tilapia cultivation, with proper nutrition and feed quality influencing gonadal maturity and overall fish growth. The success of tilapia fry production at the center relies on various factors, including careful spawning preparation, optimal larval management, and effective feeding management.

Keywords: Aquaculture; fish fry; freshwater; spawning; tilapia.

1. INTRODUCTION

The demand for fish consumption has been steadily increasing due to its high animal protein content, both in seawater and freshwater fish. However, the growing consumer demand for fish is not being adequately met by the available fish stocks. In 2017, tilapia production reached 1.15 million tons, showing a 3.6% increase from the previous year's production of 1.14 million tons [1]. To address this issue, the utilization of public water bodies for fish cultivation is seen as a potential solution to enhance fishery production.

Cultivating fish in public waters can significantly boost fish production and maximize water utilization for increased productivity. Fish farming is a technological practice that encompasses various activities such as fish fry production, breeding, disease control, and ecosystem management. One crucial stage in freshwater fish farming is freshwater fish hatchery development, aimed at meeting the market demand for fish. The objective is to produce high-quality fish frys that fulfill the seven essential criteria: the right species, size, quality, quantity, timing, location, and price [2]. By adhering to these criteria, it is expected to meet the market's requirements and ensure sustainable fish production.

Tilapia, a type of freshwater fish, holds great potential for cultivation and is in high demand as a consumption commodity. Its popularity continues to rise due to its relatively low production costs and substantial economic value [3] (Arie, 2013). Tilapia is characterized by its elongated body shape, flattened sides, and blackish color. The name "Nile" was officially assigned by the Indonesian Government through the Director General of Fisheries [4]. In Indonesia, fish cultivators have been successfully cultivating two types of tilapias: common tilapia and red tilapia. Besides being affordable, tilapia is rich in nutrients, exhibits rapid growth, displays resilience to environmental changes, has a high tolerance to various aquatic conditions, offers relatively large body sizes with good quality meat, is easy to breed, and boasts a high survival rate. Moreover, tilapia demonstrates adaptability to both freshwater and brackish water environments and shows resistance to diseases, as noted by [2].

The Cibiru Fish Fry Center, located in Bandung City, plays a crucial role as an agency focused on freshwater fish fry production and serves as a center for research and the application of fish farming technology. Among the various activities conducted at this center, tilapia (*Oreochromis niloticus*) spawning is a significant endeavor.

2. MATERIALS AND METHODS

The data collection method employed in this study encompasses both primary and secondary data. Primary data is obtained through recording observations, conducting informant interviews, and active participation. On the other hand, secondary data is gathered from books, reports, and other archival sources. The data analysis conducted for this study adopts a descriptive comparative approach, involving a comparison of field conditions with relevant literature. The parameters under observation include the spawning process, calculation of larval density in tilapia hatcheries, hatching rate (HR), survival rate (SR), and fecundity (F).

Hatching rate (HR) refers to the extent to which fish eggs successfully hatch. According to [5], determining the hatching rate of fish eggs can be accomplished using the following formula:

$$HR\ (\%) = \frac{P_t}{P_o} \times 100\%$$

Description:

HR: Degree of hatching of eggs
P_t: The number of eggs that hatched
P_o: The number of fertilized eggs

The survival rate (SR) represents the extent of fish survival from the initial stocking until the harvest stage. [5] suggests the following formula for calculating the fish survival rate:

$$SR\ (\%) = \frac{N_t}{N_o} \times 100\%$$

Information:

SR: Survival Rate of fish
Nt: Number of live fish (frys harvested)
No: Number of fish stocked (larvae)

Fecundity refers to the number of mature eggs released by the fish. According to [6], fecundity can be calculated using the following formula:

$$(F) = \frac{W}{w} \times n$$

Description:

F: Total number of eggs
W: Total egg weight (g)
w: Egg sample weight (g)
n: Total number of eggs counted during sampling (items)

3. RESULTS AND DISCUSSION

3.1 Biology and Morphology of Tilapia

Tilapia is a freshwater fish species commonly found in various aquatic environments, including rivers, lakes, reservoirs, swamps, rice fields, and irrigation canals. It exhibits a remarkable tolerance to different salinity levels. With an average weight ranging from 200 to 400 grams, tilapia is considered a large fish species. As an omnivorous fish, it feeds on both animals and plants, as noted by [7]. In its natural habitat, tilapia utilizes a diverse range of food sources, including phytoplankton, zooplankton, larvae, microorganisms present on the water bottom (molasses), aquatic plants like hydrilla, leftover food, as well as fruits and leaves that enter the water [2].

Fig. 1. Nile tilapia

According to [8] tilapia (*Oreochromis niloticus*) can be classified as follows:

Phylum: Chordata
Subphylum: Vertebrata
Class: Osteichthyes
Subclass: Acanthopterygii
Order: Percomorphi
Suborder: Percoidea
Family: Cichlidae
Genus: Oreochromis
Species: *Oreochromis niloticus*

Tilapia possesses an elongated and slender body shape with large, rough, and neatly arranged scales of the ctenoid type. The body color of tilapia is predominantly black with slight whitish hues. It features a distinctive lateral line that extends from the gill cover to the back of the dorsal fin. The eyes are prominent, large, and edged with white. There are five types of fins in tilapia: the dorsal fin, pectoral fin, ventral fin, anal fin, and caudal fin. The dorsal, pelvic, and anal fins are equipped with hard, sharp spines. The dorsal fin is characterized by its black coloration. Tilapia possess a pair of small pectoral and pelvic fins, a single dorsal fin, a lone anal fin, and a relatively elongated body shape. The caudal fin, on the other hand, is round and consists of a single lobe [7].

Tilapia is known for its euryhaline nature, enabling it to thrive in a wide range of salinity levels. It can tolerate water pH conditions ranging from 5 to 11; however, the ideal pH range for breeding and growth is 7 to 8 [8]. Tilapia can inhabit various freshwater habitats, including shallow waterways, ponds, rivers, and lakes. While tilapia can become problematic as an invasive species in warm water environments, it faces challenges in temperate climates due to its inability to survive in cold waters, typically below 21°C. Male tilapia generally exhibit higher salinity tolerance compared to females. Additionally, small tilapia tend to adapt more quickly to increased salinity levels compared to larger individuals [7].

3.2 Tilapia Spawning Activities

3.2.1 Preparation of spawning pools

The process of tilapia spawning at the Cibiru Fish Fry Center involves the careful preparation of spawning ponds, and rearing ponds within a single pool. Rectangular-shaped concrete pools measuring 30×30×70m^3 are utilized for this purpose, with two ponds designated specifically for tilapia. To ensure optimal conditions, the first

step is to clean the dry pond bottom, removing any snail shells and dried organisms. This meticulous cleaning process aims to eliminate potential sources of diseases. However, it is worth noting that cleaning the pond bottom is a practice rarely observed at the Cibiru Fish Fry Center.

Subsequently, the pool is filled with water by opening the inlet channel while closing the outlet channel. The water is then carefully filled to a height of 70 cm from the bottom of the pond. The next stage involves the installation of a water net and *kakaban*. The water net is secured with weights and firmly tied to poles situated at each end of the water net.

Fig. 2. Spawning pond

In the prepared water net, the next step involves submerging the *kakaban*. The *kakaban* serves as a tool for securing eggs during the spawning process. Various materials are used by cultivators to create *kakaban*, such as coconut fiber, palm fiber, *paranets*, or even water nets. At the Cibiru Fish Fry Center, rectangular palm fiber is used to construct the *kakaban*. It is clamped with two bamboo blades and weighted with stones. A total of 10 *kakabans* and 2 water nets are utilized. The *kakaban* and water net serve the crucial function of providing a suitable environment for tilapia eggs to attach and develop.

Fig. 3. Water Net instalation

Fig. 4. Substrate for egg *(kakaban)* instalation

3.2.2 Parent selection

At the Cibiru Fish Fry Center, meticulous parent selection takes place in the broodstock rearing pond. The selection process is primarily based on sex determination, which is achieved through the stripping method applied to the abdomen. When male tilapia are stripped, they release a thick milky white sperm, while female tilapia exhibit abdominal swelling towards the urogenital region and emit a yellow liquid when stripped.

Parent tilapia at the Cibiru Fish Fry Center is deemed ready for spawning when they reach two years of gonad maturity, ensuring that their reproductive organs are fully developed. The maturation process of the main gonads is influenced by both internal and external factors. Internal factors encompass the fish species and hormones, while external factors encompass temperature, food availability, stocking density, light intensity, and more.

Among the external factors, particular attention is given to the influence of feed and the environment on the maturation of parent gonads [9]. Reproduction in fish is intricately regulated by environmental factors that impact the function of the endocrine glands, which are responsible for producing reproductive hormones crucial for gonad development, gametogenesis, and the reproductive cycle [10]. The readiness of the parents for spawning is indicated by the release of white liquid (sperm) upon the gentle massage of the lower abdomen towards the anus [11]. This process is influenced by various environmental stimuli, including temperature, light, and weather, which are received by receptors and subsequently transmitted to the nervous system. The hypothalamus then releases hormones that stimulate the pituitary gland, thereby controlling the development and maturity of the gonads for successful spawning [11].

Fig. 5. Preparation of tilapia parent sorting

Characteristics of mature female tilapia include slow movements, an enlarged or distended abdomen towards the back, a soft texture when touched, a slight protrusion or swelling of the anal canal, and the release of a reddish-yellow liquid when gently massaged towards the anus. On the other hand, male parents exhibit agile movements, slim bands, and emit white sperm fluid when massaged toward the anus [12]. In terms of weight ratio, the broodstock used consists of 6 kg of males and 2 kg of females, maintaining a ratio of 3:1. This ratio is chosen to ensure maximum fertilization of the female's eggs by male tilapia sperm, thus optimizing the reproductive success of the breeding process.

3.2.3 Spawning

The reproductive activity of aquatic animals varies depending on environmental conditions [10]. According to [13], fish spawning techniques in fish farming can be categorized into three methods:

1) Natural fish spawning: This method involves fish spawning without human intervention, occurring naturally without hormone stimulation.
2) Semi-artificial spawning: In this method, hormone stimulation is provided to accelerate gonadal maturity, but the actual ovulation process occurs naturally in ponds.
3) Artificial fish spawning: This technique involves hormone stimulation to accelerate gonadal maturity, and the ovulation process is artificially induced through stripping or sequencing techniques.

Each method offers distinct advantages and can be chosen based on specific breeding goals and environmental factors.

Fig. 6. Tilapia spawning ponds

Tilapia spawning at the Cibiru Fish Fry Center is conducted naturally, without human intervention or hormone stimulation. Male and female parents are placed together in a pond, utilizing *kakaban* and water net as substrates for the eggs to attach to. According to [14], the optimal time to release the broodstock is in the morning or evening, when the water temperature is relatively low. At the Cibiru Fish Fry Center, tilapia spawning takes place at night. The female parent releases eggs onto the *kakaban* and water net before midnight, followed by the male parent secreting white sperm. Fertilization calculations are carried out 6 hours after the spawning process. Based on observations, fertilized eggs appear transparent with clear contents, while unfertilized eggs appear pale, in line with [15] statement that fertilized eggs display a brown color, whereas unfertilized eggs appear opaque and pale.

After spawning, further observations are made in the spawning ponds, where tilapia eggs are observed adhering to the *kakaban* and water net. Hatched eggs develop into larvae, while unhatched eggs remain white, indicating their demise. Factors such as imperfect fertilization and eggs sticking together or overlapping in the nets, causing disrupted oxygen circulation, can contribute to egg mortality [16]. The success of hatching tilapia eggs is influenced by the maturity of brood fish gonads and water quality.

Spawning is conducted three times a year, resulting in approximately 30,000 larvae per spawning. Each female tilapia weighing 450 grams exhibits high fecundity, producing around 550 eggs per head. This is supported by [17], which states that tilapia broodstock weighing 500 grams has a fecundity of 200 eggs per 100 grams. Research conducted by Widyastuti et al. (2008) on selected and non-selected tilapia using artificial spawning revealed a fecundity range of

620–1,175 eggs per kilogram. Approximately 350 larvae successfully hatch, resulting in an 80% hatching rate (HR). According to [18], the normal hatching percentage for fish ranges from 50% to 80%.

After hatching, the water net and *kakaban* are removed and cleaned. After one month, the parent tilapia is transferred from the spawning pond to the brood-rearing pond. The advantage of the tilapia spawning technique at the Cibiru Fish Fry Center is the integration of spawning and larval rearing in a single pond, eliminating the need for the "*anco*" (life net) system used in other fish fry centers. This approach offers space efficiency by utilizing a limited hall area, optimizing time usage, and requiring fewer human resources.

3.2.4 Larvae management

Tilapia larvae handling takes place in the same ponds as the spawning ponds at the Cibiru Fish Fry Center. The hatching process of tilapia eggs typically lasts for approximately 48 hours. Hatched eggs develop into larvae, while unhatched eggs remain white, indicating that they did not survive, as mentioned by [12].

Fish larvae represent a critical phase in fish farming due to their vulnerability to environmental changes and limited resistance. Once hatched, tilapia larvae will attach themselves to the *kakaban*. Therefore, the *kakaban* is removed 2–3 days after the eggs have hatched.

At 2–3 days old, the larvae still possess food reserves in the form of egg yolk sacs, which can sustain them for around 3–4 days. Another essential aspect of larval management is the application of fertilizer. The Cibiru Fish Fry Center utilizes a combination of goat manure and rice husk as fertilizers. This mixture is prepared by creating small holes on each surface of the sacks containing eight sacks of fertilizer, each weighing 50 kg. The purpose of this fertilizer application is to promote the growth of natural food sources required by the larvae once they have depleted their yolk reserves.

3.3 Feeding Management

The quality and quantity of feed play a crucial role in hatchery processes, broodstock maintenance, and fish growth. Effective feeding management significantly impacts the growth and overall condition of fish, especially in achieving optimal gonadal maturity. One approach to ensuring proper nutrition is by estimating protein requirements and protein-energy ratios, as suggested by [19]. This aligns with the notion emphasized by [9], highlighting the significant influence of feed and environmental factors on broodstock gonadal maturity. Providing high-quality feed in sufficient quantities is essential for enhancing the quality of the broodstock. It is important to note that feed quality has a significant impact on both male and female gonadal maturity, making the selection of appropriate feed crucial to the process.

The availability of adequate feed in terms of quality and quantity greatly influences tilapia cultivation, as emphasized by [20]. Feed accounts for approximately 60 ± 70% of the production costs in tilapia aquaculture, underscoring the need for effective and efficient feed management. The good feed should fulfill the nutritional requirements of the fish. Enhanced tilapia growth can be achieved through improved utilization of feed protein, leading to greater deposition of body protein [21]. The absorbability of nutrients by the fish's body is influenced by factors such as feed composition and quantity [22].

At the Cibiru Fish Fry Center, artificial feed (pellets) is provided to the parent fish and tilapia larvae twice a day, in the morning at 08:30 AM and in the afternoon at 03:00 PM. [23] suggests that feeding tilapia broodstock should be carried out in the morning and evening, with a feeding rate (FR) of 3%. At the center, feeding is done along the edges of the pond, establishing a habit for the fish to gather near the edge, which facilitates harvesting later on.

For the maintenance of tilapia broodstock, sinking pellet-type artificial feed is used, specifically the "Cargill" brand. The feed provided to tilapia larvae is the "Feng-Li Standard" brand in powder form. The availability of feed at the Cibiru Fish Fry Center is determined by the Bandung Food and Agriculture Service. The "Feng-Li" feed has a refined protein content of 40%. Cargill fish feed contains a minimum of 26% crude protein, 5% fat, 4% maximum crude fiber, 10% maximum ash, 12% maximum moisture content, and 100 ppm vitamin C.

It is worth noting that the feed provided at the Cibiru Fish Fry Center is not specifically formulated for tilapia species. The catfish feed used is designed for sinking and tailored to catfish needs. On the other hand, the "Feng-Li Standard" feed is formulated for intensive tiger

prawn cultivation. The "Cargill" brand feed, with a protein content of 26%, does not fully meet the protein requirements of tilapia broodstock. The digestibility values, which indicate the percentage of nutrients absorbed by the fish's digestive tract, closely relate to feed conversion and efficiency.

Nutrient absorption by the fish's body is influenced by various factors, including feed quality and quantity consumed. Therefore, the suitability of the feed type can directly impact tilapia growth. The utilization of nutrients by tilapia affects the supply of protein and non-protein energy in the body. Increased energy availability enhances the fish's ability to convert and store energy in the form of protein and fat.

Feeding should be adjusted to the fish's needs, employing a gradual feeding system until the fish no longer consume the feed provided. This approach reduces the amount of unconsumed feed, minimizing contamination of the rearing environment. Nutrient intake from additional or artificial feed significantly improves fish growth due to the more complete and sufficient nutrients entering the fish's body.

Ad-libitum feeding was implemented, which involved providing feed in small increments until the fish exhibited signs of satiety and no longer responded to the feed. This feeding method aimed to minimize the accumulation of leftover feed at the bottom of the rearing tank, as such remnants can lead to the production of ammonia. Excessive ammonia levels can negatively impact water quality and often lead to fish mortality. For a visual representation of the feeding process at the Cibiru Fish Fry Center, please refer to Fig. 7.

Fig. 7. Feeding stage

4. CONCLUSION

Through a comprehensive analysis of observations, literature studies, and practical experience, it can be inferred that tilapia spawning at the Cibiru Fish Fry Center is conducted naturally, resulting in remarkable productivity. The spawning process occurs three times a year, yielding a substantial number of larvae in each cycle. Notably, the Cibiru Fish Fry Center stands out for its advantageous tilapia spawning technique, wherein both spawning and larval rearing take place within a single pond, ensuring heightened efficiency throughout the entire process.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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