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NATURAL SPAWNING TECHNIQUE OF KOI FISH (*Cyprinus carpio*) IN THE CIPARANJE INLAND FISHERIES AREA, SUMEDANG, INDONESIA

ABSTRACT

The Ciparanje inland aquaculture area has emerged as a hub for breeding ornamental fish, with koi fish being a prominent species. The increasing demand for koi fish has led to a surge in koi aquaculture businesses. What sets koi fish apart from some other fish species is their ability to breed throughout the year, unaffected by specific seasons. However, in their natural habitat, koi fish typically spawn at the onset of the rainy season, triggered by the enticing aroma of the soil. The growth of koi fish is influenced by various factors, including fish species, genetic characteristics, feeding efficiency, disease resistance, and environmental conditions such as water and feed quality, as well as stocking density. To ensure the production of top-quality koi fish fry, it is crucial to employ the appropriate spawning techniques. In this study, a participative approach was employed to investigate and report on the natural spawning procedures of koi fish in the Ciparanje inland aquaculture area, managed by Padjadjaran University. The natural spawning method implemented in this area encompasses several crucial processes, including the preparation of spawning ponds, selection of breeding stock, egg hatching, and larvae rearing. A total of 90,175 eggs were collected from the examined koi broodstock during the spawning activities, and an impressive 80% of these eggs successfully hatched. The calculated Hatching Rate (HR) reached 96.5%, indicating a high level of achievement in the hatching of koi fish larvae.

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Keywords: aquaculture, Ciparanje, koi fish, spawning method

1. INTRODUCTION

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The Ciparanje Inland Fisheries Area has a land area of ±5 hectares. Land area is used for various facilities including office buildings, hatcheries, green houses, mess houses, feed manufacturing houses, and roads. While the rest is used for water storage, fish ponds, and rice fields. The Ciparanje Inland Fisheries Area is situated within Padjadjaran University in Jatinangor, specifically in Cileles Village, Sumedang Regency. It is categorized as a category III open laboratory that focuses on various activities related to freshwater biota, including hatchery operations, maintenance, and technology development in an open system. As part of the development, the Ciparanje experimental pond was constructed, along with the establishment of a wet laboratory dedicated to hatchery activities. The area is involved in the cultivation of different types of commodities, namely consumption fish, ornamental fish, and local fish. The consumption fish category comprises tilapia, Pangasiidae catfish, grass carp (*Ctenopharyngodon idella*), and Clariidae catfish. Ornamental fish include koi fish, comet goldfish, koki goldfish (*Carassius auratus*), and tengadak fish (*Barbonymus schwanenfeldii*).

32 Additionally, the local fish commodities being developed in the area consist of Nile fish
33 (*Osteochilus vittatus*), beureum panon fish (*Puntius orphoides*), tawes fish (*Barbonymus*
34 *gonionotus*), betutu fish (*Oxyeleotris marmorata*), and baung catfish (*Mystus*).

35 Koi fish is one of the ornamental fish developed in this area. Koi fish (*Cyprinus carpio*)
36 belong to the carp family and are highly valued ornamental fish. They possess vibrant body
37 colors with various patterns, making them visually appealing [1]. According to [2], the
38 characteristics of a good koi fish include an ideal body shape, a straight spine, vivid and
39 contrasting colors, calm yet agile movements, and overall health. The attractive body colors
40 of koi fish contribute to their promising market potential [3]. In fact, data from the Ministry of
41 Marine Affairs and Fisheries (2010) reveals that the export value of koi fish reached US\$10
42 million in 2009 and increased to US\$12 million in 2010. The high demand for koi fish has led
43 to an increase in koi fish farming ventures [4].

44 The life cycle of koi fish begins with the development of eggs and sperm in their gonads,
45 followed by the spawning process, resulting in the hatching of larvae that eventually grow
46 into mature individuals. Unlike some other fish species, koi fish can spawn throughout the
47 year without being influenced by specific seasons. However, in their natural habitat, koi fish
48 tend to spawn during the onset of the rainy season, as the scent of the soil acts as a
49 stimulus for spawning. Typically, koi fish prefer to spawn during the nighttime hours, with
50 spawning activity continuing until the approach of sunrise. During the spawning process, koi
51 fish actively seek out sheltered areas with ample vegetation, such as aquatic plants or grass
52 that covers the water's surface. These substrates serve as attachment points for the eggs
53 and aid in stimulating the spawning behavior [5].

54 The growth of koi fish is influenced by various factors, including fish species, genetic
55 traits, feeding efficiency, disease resistance, and environmental conditions such as water
56 quality, feed quality, and stocking density [6]. Low survival rates and slow growth rates are
57 common challenges in koi fish farming. To address these issues, it is crucial to provide
58 proper feeding, considering the size, quantity, and nutritional content of the feed [7]. The
59 feeding process directly impacts the metabolism, survival, and growth rate of koi fish seeds
60 (*Cyprinus carpio*). Additionally, selecting superior parent fish is essential to obtain healthy
61 and high-quality seeds.

62 Koi fish inhabit freshwater environments, including both public and controlled bodies of
63 water. They are highly sensitive to changes in the quality of their environment, emphasizing
64 the importance of maintaining suitable conditions for their well-being. Koi fish thrive within
65 altitudes ranging from 150 to 600 meters above sea level (asl), while temperatures of 25-
66 30°C are conducive to their optimal development. As omnivores, koi fish belong to the
67 category of fish that consume both plant and animal matter. They primarily feed on
68 vegetation and organisms found along the water's edges and at the bottom of their habitat
69 [5].

70 Therefore, employing the correct spawning technique is vital to obtain the best koi fish fry.
71 Given the increasing demand for ornamental fish seeds as a hobby and business
72 opportunity, the process of spawning koi fish holds significant importance. Koi fish farming
73 can be a profitable venture for farmers both domestically and internationally. The objective of
74 this study was to make a systematic, actual and accurate descriptive of the technical
75 implementation of natural spawning of koi fish conducted in the Ciparanje inland fisheries
76 area, which is under the purview of Universitas Padjadjaran.

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78 2. MATERIAL AND METHODS

79 The research was conducted in the Ciparanje Inland Fisheries Area, located in Cileles
80 Village, Jatinangor District, Sumedang Regency. Geographically, the area of Ciparanje
81 Inland Fisheries spans from 107°76'83.9" E to 107°76'90.7" E longitude and from
82 06°91'21.9" S to 06°91'31.4" S latitude. It is situated at the foot of Mount Manglayang,
83 approximately 700 meters above sea level. The soil type in this area is classified as
84 inceptisol, as described by [8].

85 The participatory method was employed in this activity at the Ciparanje Inland Fishing
86 Area at Universitas Padjadjaran. According to [9], the participatory method involves direct
87 and active involvement in field activities. By actively participating in these activities, valuable
88 data and information on natural koi fish (*Cyprinus carpio*) spawning techniques can be
89 obtained.

90 The data collection process involves two main approaches: primary data collection and
91 secondary data collection. Primary data refers to information obtained through direct
92 observation, interviews, and active participation. On the other hand, secondary data refers to
93 data or information collected and reported by individuals for specific purposes or scientific
94 studies.

95 Primary data is collected directly from the source and recorded for the first time [10]. It is
96 unprocessed data obtained firsthand. Various methods can be used to collect primary data,
97 including observation, interviews, active participation, and the use of specific measurement
98 instruments tailored to the research objectives.

99 During this project, observations were conducted to document the activities and record
100 relevant information pertaining to koi fish spawning activities in the Ciparanje Inland Fishery
101 Area. Additionally, interviews were conducted with the staff involved in order to gather
102 insights into the background of koi spawning technical activities, the organizational structure,
103 the workforce, the types of activities, and the common challenges encountered during koi
104 spawning activities in the Ciparanje Inland Fisheries Area. Secondary data was also
105 collected and utilized in this activity. As stated by [11], secondary data refers to primary data
106 that has undergone additional processing, such as presenting it in the form of graphs, tables,
107 diagrams, images, and other formats, making it more informative for various stakeholders
108 and researchers for further analysis. Secondary data can be obtained from libraries or from
109 reports and publication published by previous researchers. All data were analyzed
110 descriptively.

112 3. RESULTS AND DISCUSSION

113 3.1 Preparation of the Spawning Pond

114 According to [12], natural spawning refers to the process of spawning that occurs without
115 any hormonal stimulation or other artificial treatments. In the Ciparanje Inland Fisheries
116 Area, the breeding koi fish undergo natural spawning activities, which involve various steps
117 such as preparing spawning containers, selecting brood fish, carrying out the spawning
118 process, hatching the eggs, and rearing the larvae.

119 The initial step in the natural spawning process of koi fish involves preparing the
120 container, which includes the pond, *hapa*, and *kakaban*. To begin with, the pond is dried for
121 two days to break the cycle of pests and diseases. Subsequently, the pond undergoes
122 liming, where lime is evenly spread at a dose of 50 g/m² and left for one day. After the liming
123 process, fertilization is conducted using chicken manure, applied at a dose of 200–500 g/m²,
124 and stored in sacks. Once the drying, liming, and fertilizing processes are complete, the
125 pond is filled with water to a height of 50–70 cm, followed by the installation of *hapa* and
126 *kakaban*.

127 The *kakaban* is constructed using palm fiber clamped to bamboo slats and securely
128 nailed. A well-made *kakaban* consists of long, flat fibers measuring 120 cm in length and 40
129 cm in width. The number of *kakaban* required depends on the size of the female parent,
130 typically ranging from 4 to 6 pieces per kilogram of the female parent. To ensure buoyancy,
131 the *kakaban* is arranged on an intact piece of bamboo, which is placed on top of the
132 *kakaban* group and tied together to prevent scattering during the spawning of the parent pair.

133 Before installation, the *kakaban* is thoroughly cleaned, washed, and rinsed to remove any
134 mud or debris. The *kakaban* is then installed after the pond has been filled with water.
135 Continuous water flow is maintained into the spawning pond to stimulate the koi pair to
136 engage in spawning activities [12].



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Fig. 1. Spawning pond for Koi fish in Ciparanje site

3.2 Parent Selection

Proper and accurate parent selection plays a vital role in enhancing fecundity and maximizing the number of produced seeds, as emphasized by [13]. Sex determination is a crucial step in parent selection, achieved through the stripping method on the abdomen. The optimal age for spawning koi fish ranges from 2 to 3 years, as suggested by [12]. Careful consideration must be given to selecting parents that exhibit mature sexual organs and physically mature bodies. Maturing sex organs indicate the male parent's ability to produce sperm and the female parent's capability to produce mature eggs. Furthermore, physically mature prospective parents are essential for ensuring their readiness to become productive breeders. It is important to note that stressed or unhealthy koi fish (*Cyprinus carpio*) may not engage in spawning behavior. Thus, selecting healthy and robust broodstock is crucial for successful koi fish (*Cyprinus carpio*) spawning.



Fig. 2. Parent selection process for Koi fish

When selecting parents, cultivators should be mindful of important factors to avoid mistaking males for females. To aid in distinguishing between male and female koi fish (*Cyprinus carpio*), a range of specific differences can be observed, as outlined in Table 1 [14]

Table 1. Specific Differences between Male and Female Koi Fish (*Cyprinus carpio*)

Characteristics	Male	Female
Body	Slim	Large
Stomach	Small	Enlarge
Anus	Protrudes	Concave inwards
Abdomen to anus	If pressed, will emit a milky	If pressed, will emit a clear

Swimming moves	discharge	yellowish liquid
Growth	Agile	Slow
	Faster	Slow

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3.3 Spawning Process

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As described by [15], broodstock with mature gonads is carefully selected and released into the prepared spawning ponds. The spawning process takes place within the *hapa* nets that have been meticulously set up. In the case of koi fish (*Cyprinus carpio*) spawning, it begins with the preparation of the *kakaban*. Initially, the female parent is introduced to the pond to allow for proper acclimatization, minimize stress, and ensure optimal egg production.

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Fish spawning occurs by pairing male and female koi fish in dedicated fish spawning ponds, typically maintaining a ratio of 3 males to 1 female. The actual mating of the koi fish takes place naturally and predominantly during nighttime hours, often around midnight, with a spawning interval ranging from 11 to 18 hours after pairing [16]. The male koi fish actively pursues the female fish, carrying her around the prepared substrate, and releasing sperm as the female fish deposits her eggs on the substrate. The eggs, once fertilized, adhere to the *kakaban*, which serves as a supportive medium for egg incubation

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Observable signs of male fish readiness to spawn include their energetic pursuit of female fish, their carrying of the female fish around the prepared substrate, and the subsequent release of sperm upon the female fish releasing eggs in proximity to the substrate [16]. Meanwhile, the female fish spawns by releasing eggs onto the provided substrate, ensuring that the eggs firmly adhere to their surface.

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3.4 Hatching Eggs

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Following the spawning process, the fertilized eggs become attached to the prepared *kakaban*, and the male and female koi fish are returned to the main pool. To ensure the well-being of the eggs, dry leaves from *ketapang* trees (*Terminalia catappa*) and banana leaves are spread throughout the pond. This practice effectively prevents the growth of fungi that could harm the koi fish's (*Cyprinus carpio*) eggs. It is important to note that fertilized eggs are considered healthy if they exhibit a bright yellow color, indicating the presence of viable embryos. Conversely, eggs that appear pale white in color are damaged or unlikely to hatch successfully.

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The hatching process of koi fish (*Cyprinus carpio*) eggs in aquaculture ponds typically takes around 2–3 days. During this period, the developing embryos often undergo repositioning within the eggshell due to limited space. As a result of these movements, the softer parts of the eggshell start to break. Generally, the tail end of the embryo breaks free first, followed by the rest of the body. However, it is not uncommon for the heads of the embryos to break free first due to their larger size. Throughout the staging process of the eggs, some non-viable eggs may be observed.

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This occurrence highlights that not all fertilized eggs will successfully hatch into larvae. Unhatched eggs can be attributed to poor egg quality, which is often indicated by the presence of a water mixture during egg collection. Additionally, the eggs can stick together or overlap each other during distribution in the hatchery filter, resulting in disrupted oxygen circulation and subsequent oxygen deprivation, leading to the death of the affected eggs. Dead eggs are susceptible to fungal infection by *Saprolegnea* sp., and if infected eggs come into contact with fertile ones, fungal transmission can occur [17].

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The hatching of koi fish eggs typically takes around 30–36 hours or 2-3 days. The egg count was conducted through direct observation of the 11 utilized *kakabans*. The calculation revealed a total of 90,167 successfully fertilized koi fish eggs, with an estimated hatching rate of approximately 80%, considering the number of larvae observed swimming along the pond's edges. On the fourth day, the *kakabans*, which served as the attachment medium for the eggs, are removed, as it is anticipated that all the eggs have hatched completely by that time, reaching a 100% hatching rate.

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Fig. 3. Fertilized koi fish eggs

After the eggs have successfully hatched, the Hatching Rate (HR) or hatching degree is determined as a measure of the hatching success. The HR is calculated by conducting two separate samplings of the larvae from the total number of fertilized eggs using a petri dish. The number of hatched eggs is then divided by the number of fertilized eggs and multiplied by 100% to obtain the HR percentage. During the initial sampling, a HR of 97% was recorded, while the second sampling yielded a HR of 96%. Taking the average of these two sampling stages, the overall HR is calculated to be 96.5%.

3.5 Larvae Rearing

The survival of larvae, particularly in the early stages, is highly dependent on their feeding. Without an adequate food supply, larvae can experience high mortality rates in a short period of time. Providing optimal feeding conditions in terms of both quality and quantity is crucial for enhancing their survival [18].

The success of achieving a high survival rate for koi fish larvae is closely tied to the care they receive. During the critical period in the early stages of their life cycle, which occurs before and after they consume their yolk sac and transition to external feeding, the behavior and movement of the larvae in their search for food play a significant role in their overall success [17].

To promote the growth of microorganisms, which serve as natural food for koi larvae, four sacks of perforated husk fertilizer were introduced into the larval-rearing pond. This practice encourages the proliferation of microorganisms, creating a favorable environment for the larvae's nutritional needs.

4. CONCLUSION

The natural spawning method employed in the Ciparanje Inland Fishery Area encompasses several essential steps, including the preparation of spawning ponds, broodstock selection, egg hatching, and larvae rearing. Through the conducted spawning activities, a total of 90,175 eggs were obtained from the sampled koi broodstock, with 80% of the fertilized eggs successfully hatching. The calculated Hatching Rate (HR) averaged an impressive 96.5%, indicating a high level of success in the hatching of koi fish larvae. Moving forward, it would be beneficial to prioritize the implementation of enhanced biosecurity measures in the pond area to minimize the potential spread of pathogens during koi fish spawning activities.

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COMPETING INTERESTS

“Authors have declared that no competing interests exist.”.

AUTHORS' CONTRIBUTIONS

Author 1' 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 2' managed the literature searches and writing. All authors read and approved the final manuscript.”

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