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Freshwater Lobster (*Cherax quadricarinatus*) Cultivation in Cangkuang District, Bandung Regency, West Java, Indonesia: A Case Study

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Authors' contributions

This work was carried out in collaboration among all authors. Author YA designed the study, wrote the protocol, and wrote the first draft of the manuscript, and managed the analyses of the study. Authors RIP and PWH managed the literature searches and writing. All authors read and approved the final manuscript.

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ABSTRACT

The fisheries sector presents significant economic opportunities for enhancing income and contributing to regional development. Bandung Regency, known for its abundant fishery resources, has emerged as a key player in this sector. Among the various fishery commodities, freshwater crayfish has gained popularity due to its market advantages and ease of cultivation. The development of crayfish cultivation in Bandung Regency offers an excellent opportunity for local farmers and investors, leveraging the region's abundant resources. Initially favoured as a

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consumable commodity, crayfish has now gained traction as an ornamental fish. Its higher profitability, shorter maintenance time, lower risks, and increased profits have contributed to its attractiveness as an ornamental fish commodity. This paper presents a case study on the development of freshwater crayfish cultivation in Cangkuang District, Bandung Regency, West Java, Indonesia, aiming to enhance the income of ornamental fish cultivators by maximizing cultivation productivity. Furthermore, Bandung Regency stands out as a promising area for aquaculture development, boasting vast public waters and a thriving fishery sector. Ornamental fish cultivation plays a significant role, with local farmers producing various species, including koi, comet goldfish, flowerhorn, and crayfish. To optimize crayfish cultivation, this study provides insights into culture techniques, including site selection, cultivation containers (such as ponds and aquariums), water quality management, feeding practices, parent selection, brood care, spawning processes, larvae rearing, and market analysis. By implementing these techniques, the cultivation of freshwater crayfish can flourish in Bandung Regency, contributing to the economic growth and income generation in the region.

Keywords: Aquaculture; crayfish; culture techniques; ornamental fish; Bandung Regency.

1. INTRODUCTION

The fisheries sector holds promising development opportunities to enhance people's income, making it an important economic activity. Bandung Regency boasts abundant fishery resources with the potential for professional development, positioning it as a significant contributor to the regional income.

Freshwater crayfish, a popular fishery commodity, offers market advantages and ease of cultivation, attracting widespread interest among the public. Several studies report that based on their habitat, lobsters can be divided into two groups, namely sea lobsters and freshwater lobsters. The most popular freshwater crayfish are from the genus Cherax. The genus Cherax was first discovered in Indonesia by a New Guinea Botanical Expedition team in 1920-1922 [1].

Originating from northern Australia, particularly Queensland, this species has spread to various regions worldwide, including Madagascar, Tasmania, New Zealand, and Papua. In Indonesia, there are 14 types of crayfish belonging to the Cherax genus, with species such as *Cherax monticola, C. lorentzi, C. communis, C. papuana,* and *C. wasselli* gaining significant attention for cultivation [2]. The development of crayfish cultivation in Bandung Regency presents an excellent opportunity for local farmers and investors due to the abundant resources available in the region. According to several research, factors supporting crayfish agriculture in Indonesia include a favourable climate and geography, current and developing growing techniques, a viable consuming market, and an appealing diversity of processed forms [3].

Initially, freshwater crayfish gained popularity as a consumable fishery commodity. Freshwater crayfish have a promising future in the fishing industry. Aside from being easy to raise, these animals are disease resistant, omnivorous, grow quickly, and have a high egg producing capacity. Freshwater crayfish are feasible widely developed in the community in terms of technical aspects of cultivation and market potential, so that it may bring economic benefits and maintain its sustainability. The success of hatchery procedures has a significant impact on the success of freshwater crayfish [4].

However, the prospects for its development as an ornamental fish commodity have significantly increased. As an ornamental fish commodity, crayfish offer greater profitability compared to consumption fish. The shorter maintenance time, lower risks, and higher profits associated with crayfish cultivation contribute to its attractiveness as an ornamental fish commodity [5],

This paper serves as a case study on the development of freshwater crayfish cultivation specifically in Cangkuang District, Bandung Regency, West Java, Indonesia. Conducting a thorough investigation is crucial to maximize the desired outcomes and enhance the income of ornamental fish cultivators in Bandung Regency through efforts aimed at increasing cultivation productivity.

2. METHODOLOGY

The research was conducted using a survey method, by conducting interviews with lobster cultivators who are members of the group. Data were analyzed descriptively.

3. THE POTENTIAL OF ORNAMENTAL FISH CULTIVATION IN BANDUNG DISTRICT

Bandung Regency stands out as a highly promising area for the development of aquaculture. It boasts an extensive expanse of public waters, covering 10,851.37 hectares, with a notable production of 771,8085 tons. Additionally, the region records 1,314.3 hectares of still water ponds, contributing to a production output of 4395.68 tons. The fishery activity in Bandung Regency thrives with a large number of individuals and groups actively involved in various fishing businesses. As of 2006, the fishery sector accommodated 56 groups and individuals, engaging in fish hatchery, consumption fish rearing, and ornamental fish cultivation.

The cultivation of ornamental fish in Bandung Regency yields significant value within the overall fisheries sector. The local ornamental fish farmers produce an impressive range of species, with quantities ranging from 1000 to 11,500 fish per month. The cultivated ornamental fish species include koi, comet goldfish, goldfish, flowerhorn, black molly, betta, guppy, cichlid, and crayfish. For a comprehensive overview, Table 1 presents the various ornamental fish cultivators in Bandung Regency.

Table 1. Ornamental fish farmers in Bandung Regency

Name	Address	Commodity	Marketing Destination	Production/month
H. Adjin	Lampegan Village RT 02/04	Koi, comet goldfish, goldfish, crayfish	Bandung Regency/City	4500 fish
Adad	Babakan Kopo, Lampegan village	Black molly, Flowerhorn	Bandung Regency/City	5200 fish
Udi Riswandi	Lampegan Village Rt 01/04	Flowerhorn, Koi	Bandung Regency/City	5000 fish
Yayan	Babakan Kopo, Lampegan village	Flowerhorn, Koi	Bandung Regency/City	2700 fish
Idil	Cikonyal	Koi, Comet, goldfish	Bandung Regency/City	2400 fish
Sopyan	Cikonyal	Flowerhorn, Koi, goldfish	Bandung Regency/City	6000 fish
Dadan	Awilega	Koi	Bandung Regency/City	10,000 fish
Husen	Lampegan village	Koi	Bandung Regency/City	3000 fish
Undang Mahyar	Lampegan village	Flowerhorn, Koi	Bandung Regency/City	2000 fish
Atep	Lampegan village	Koi, Comet, crayfish	Bandung Regency/City	11500 fish
Ayi Wiratman	Jl. Sukamenak No. 57, etc. Sukamenak	Koi (parent)	Bandung Regency/City	1000 fish
H. Hasyim	Kiangroke	Betta, Zebra, Comet, crayfish	Bandung Regency/City	6000 fish
Erni	Taman Kopo Indah II No. 9	Black molly, frontosa, guppy, cichlid	Bandung Regency/City	2100 fish

(Source : Primary data research)

4. CULTURE TECHNIQUES

4.1 Site Selection

The selection of cultivation sites is crucial and should be based on the suitability with the original habitat of the cultivated organisms [6]. Cherax, a freshwater crayfish species originating from the tropical region of Northern Australia (Queensland), readily adapts to tropical climates in Indonesia.

The location for lobster cultivation can be established on a small to medium scale, even in limited land areas. However, it is essential that the chosen location is supported by adequate facilities, infrastructure, and water quality. Having easy access to feed sources, medications, necessary equipment, and marketing locations is beneficial as it reduces transportation costs.

Fig. 1. Freshwater lobster

4.2 Cultivation Containers

Lobsters can be successfully cultivated in cement ponds or aquariums. The selection of the cultivation container depends on the available land area and capital. Crayfish ponds are typically rectangular in shape, measuring approximately 2 x 3 x 0.5 meters. The pond walls are constructed to be slippery to prevent lobsters from escaping. Additionally, the bottom of the pond is sloped towards one corner with a 4-inch diameter drain pipe installed. Ponds are used for maintaining parent lobsters and for their growth.

Aquariums are suitable containers for lobster cultivation, especially in cases where land availability is limited. Utilizing aquariums offers several advantages, including space efficiency and ease of monitoring and controlling the lobsters. The recommended size for the aquarium is 0.5 x 1 x 0.5 meters, constructed from 0.5 cm thick glass. The water level in the aquarium should be maintained at approximately 10-15 cm, and an aerator is used to supply oxygen. To maximize land utilization, the aquariums can be arranged in a tiered system. Aquariums are primarily utilized for hatching eggs and rearing larvae.

Fig. 2. Freshwater lobster cultivation pond unit

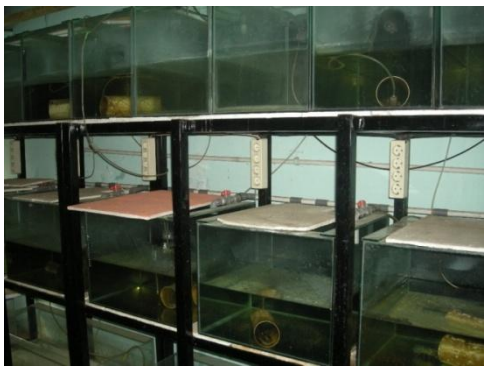

Fig. 3. Multilevel system aquarium

One critical factor influencing the survival of lobsters in aquaculture containers is the availability of shelters. Lobsters naturally inhabit the bottom of the waters and seek shelter, especially during moulting. The moulting phase is a vulnerable period for lobsters since their bodies are not protected by shells, making them easy prey for cannibalism [7]. Therefore, it is recommended to provide suitable materials as shelters in lobster cultivation ponds, such as PVC pipes, coral, bricks or mesh, roster, raffia rope, etc. This creates a habitat in the cultivation containers that resembles their natural environment.

4.3 Water Quality

Water quality plays a crucial role in the success of lobster cultivation. It directly impacts the

survival and growth of lobsters in aquaculture systems. Several water quality parameters, including temperature, dissolved oxygen (DO), carbon dioxide (CO_2), pH level, alkalinity, hardness, and ammonia (NH_3) content, are vital for crayfish farming. Table 2 below provides the ideal range of water quality values that support the life of crayfish.

Fig. 4. Placement of Parallon as shelter in cultivation container

4.4 Feed

Freshwater lobsters are omnivorous, which makes it easier for farmers to provide them with a varied diet. Lobsters consume plants, animals, and detritus. In a lobster culture system, they can be fed various foods such as tubers, silk worms, and artificial pellets. Adult crayfish are nocturnal, while juvenile crayfish are diurnal. Lobsters, like other crustaceans, eat slowly and continuously, requiring pellets with high stability in water.

The amount of daily feeding is determined based on a percentage of the lobster's body weight. During the juvenile stage, feeding is around 10-20% of their body weight per day, gradually decreasing to 15%, 10%, and, at maturity, only 3% of their body weight per day.

Table 2. Ideal water quality values for crayfish

Parameters	Optimal Value Range
Temperature	24-29^{o}C
Dissolved oxygen(DO)	≥ 5 mg/L
Carbon dioxide (CO2)	< 10 ppm
Degree of acidity (pH)	6.5 – 9
Alkalinity	30-500 mg/L $CaCO_3$
Hardness	< 120 mg/L
Ammonia (NH_3)	<0.1 mg/L

Source: [8,9]

4.5 Parent Selection

Broodstock selection is carried out using the selective breeding system method and to prevent the presence of parents from inbreeding, where good parents are parents that are not obtained from inbreeding, because inbreeding will produce bisexual or ordinary crayfish. called intersex and results in slower growth.

The selection and preparation of parents for spawning aim to obtain good-quality offspring. Parent selection involves recognizing their characteristics and morphology [10]. Broodstoock selection is carried out in plain view by looking at the outside (morphology) of the brood, that is, in male broodstock there are generally red markings on the outside of the two tips of the pincers and male genitalia at both bases of the fifth leg in the form of a bump and female genitalia are on both legs of the third leg , shaped like a bump but shorter than the male genitalia

To prepare the parents for spawning, the following steps should be followed:

1. Prospective brood stock must be healthy and free from diseases and parasites.
2. They should exhibit faster growth compared to others.
3. Actively feed on provided food.
4. Agile movement.
5. Complete limbs.

Fig. 5. Selected lobster parent (brood stock)

To select and prepare prospective broodstock for spawning, consider the following:

1. Minimum length of 15 cm and a weight of at least 25 grams. It is preferable to use larger parents, both male and female, who have previously spawned two or three

times. Such parents can produce up to 1,000 eggs per individual.
2. Complete limbs.
3. Prospective broodstock must be healthy and free of parasites.
4. Male and female parents should be similar in size, as differences in size can complicate the spawning process.

According to several studies, good brooders have a perfect morphological shape, male and female parents have separate genitalia, and male parent weight ranges from 60.1 to 80 grams and females from 62.27 to 82.82 grams. The male parent's pincers are larger and red in color, but the female parent's pincers are not red [11].The body length of the prospective lobster parent should be between 5-6 cm, indicating readiness for spawning. Mature gonads, both male and female, can be identified by the opening of the genital pore and the presence of white spots on the left and right sides of the carapace. During the preparation of spawning grounds, male and female parents are kept separately for seven days and provided with natural food, such as earthworms, to stimulate gonad maturity and expedite the spawning process. Obtaining high-quality lobster broodstock can be achieved through various methods, including using cultivated broodstock or collecting broodstock from natural sources.

4.6 Brood Care before Spawning

The success of spawning is highly dependent on the preparation and care of the prospective broodstock. Once the male and female parents are ready to spawn, they are placed in an aquarium. As an example, an aquarium measuring 100 cm x 40 cm x 40 cm can accommodate the prospective male and female parents in a ratio of 1:2 or 1:1. If a spawning tank is used, the number of broodstock should be adjusted according to the tank's capacity. Some studies report that the ratio of suitable broodstock in spawning activities is 1:3 (one male to three females).

Prospective broodstock can be fed small cubes of sweet potato and provided with earthworms as a protein source. Feed should be given twice a day, considering the nocturnal nature of lobsters, preferably in the late afternoon or late at night. In addition to natural food, artificial pellets can also be provided [12]. Feeding chopped meat should be avoided to prevent cannibalism among lobsters.

Fig. 6. Lobster parents to be spawned

Maintaining water quality in tanks or aquariums housing prospective broodstock is essential. Temperature control is particularly important to stimulate spawning. The water temperature can be gradually raised to reach 19-21°C, which can help induce spawning behaviour.

4.7 Spawning Process

High-quality brooders are selected through a rigorous individual selection process from the maintained prospective broodstock. Freshwater lobsters should only be spawned after they reach one year of age and have a body length of over 20 cm. There is a direct relationship between the size of the lobster and the number of eggs it produces. Larger individuals tend to produce more eggs. According to various studies, freshwater lobsters themselves take 4-6 weeks to hatch eggs. The difference in this time span is influenced by internal and external factors. Internal factors are hormones and egg volume, while external factors are salinity, temperature, pH, dissolved oxygen, and light intensity.

The spawning process typically occurs at night or early in the morning when the environment is calm and undisturbed, aligning with the lobsters' nocturnal behaviour. It starts with the release of oil-like fluid, followed by the female approaching the male parent aggressively. During this time, a copulation process resembling the letter "Y" takes place, involving the transfer of sperm. Once copulation is complete, the male parent disengages, while the female parent remains supine, releasing the eggs into the brood chamber.

After depositing all the eggs into the brood chamber, the female's tail bends to protect the eggs. The female then returns to her normal

position, keeping her tail bent to safeguard the eggs. Once the eggs are secured in the brood chamber, the female parent focuses on protecting them from disturbances. Stress can cause movements that may result in the accidental shedding of the incubated eggs. During this phase, feed in the form of small pieces of sweet potatoes or earthworms is provided to the parents four times a day. The feeding frequency decreases when the eggs are being incubated.

The relationship between broodstock weight and juvenile production is thought to be closely related to the cross-sectional area of the abdomen. With the increasing weight of the parent, the cross-sectional area of the abdomen is also getting bigger, this can be seen by the increasing body circumference of the parent. The area of the abdomen affects the capacity of eggs and juveniles, because from egg stage to juvenile lobsters are still attached to the peleopods in the broodstock abdomen [13].

4.8 Egg Hatching

Before hatching, lobster eggs undergo an incubation process facilitated by the female parent. Approximately 70-80% of incubated lobster eggs hatch successfully. In some cases, lobsters that have spawned multiple times can achieve a full hatching success rate. Egg development phase, 0 – 7 days of color Yellow, 8-14 days Greenish yellow, 15-21 days dark brown, 22-28 days orange, 29-32 days Orange black spots, 33-39 days Hatch. and 40-47 days to become larvae.

4.9 Larvae Rearing

After an incubation period of 30-35 days, the eggs hatch, with the head appearing first, followed by the limbs and tail. After breaking free from the eggshell, the transparent larvae attach themselves to their mother's swimming legs for around 10 days. They detach once the food supply from the eggs is depleted or when they can swim and forage independently. At this point, the parents should be removed, leaving the larvae in the hatching tank.

The larval stage is crucial in the life cycle of lobsters. Adequate feeding is essential during this period. After 10 days of hatching, the larvae can be provided with diluted and filtered egg yolk as their feed. When they reach more than 10 days old, a filtered paste consisting of chicken eggs, squid meat, vitamins, wheat flour, or fish meal can be introduced.

Fig. 7. Fertilized freshwater crayfish eggs

Fig. 8. Parent crayfish hatching the eggs

Feeding should occur every four hours, adjusting the amount to the larvae's capacity. Improper feeding practices can lead to mortality rates of up to 50%. The critical period is considered passed when the larvae undergo their first molt, which typically occurs around 20 days after hatching [14]. After reaching 20-25 days of age, crushed pellets or silk worms (tubifex) and feed containing animal protein and fat sources. In addition, it is given legume flour which is a source of protein and carbohydrates derived from vegetable sources. can be added to their diet. Feeding frequency reduces to once a day, preferably in the late afternoon.

During the first molt, it is important to address the cannibalistic tendencies of lobsters. Molting lobsters emit a distinct aroma that stimulates

others to prey on them. To mitigate this behaviour, molting individuals should be relocated. For young lobsters, cannibalism can be managed by providing timely and appropriate feed quantities. As the lobster juveniles become satiated, cannibalistic tendencies diminish [15]. According to several studies the process of moulting is influenced by internal factors related to the production of ecdysteroid hormones and Moult Inhibiting Hormone (MIH) [16]. These genetic factors have implications for the molting process. It is suspected that the seeds produced by broodstock with larger weights have a higher average molting frequency compared to the seeds produced by broodstock with lower weights, a higher moulting frequency indicates faster growth of lobsters.

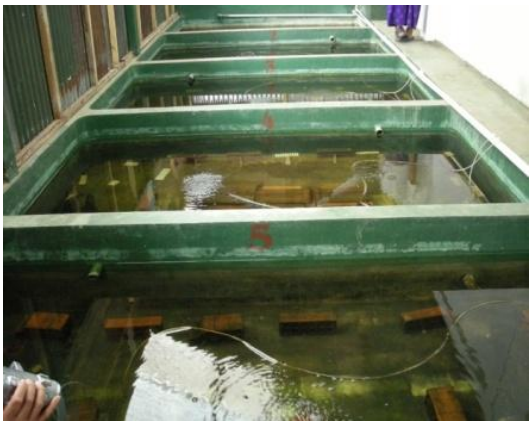

Fig. 9. Freshwater lobster rearing pond

5. MARKET ANALYSIS AND MAPPING

Freshwater lobster is a highly valued commodity in the freshwater aquaculture sector, catering to the middle to upper market segment [17]. Currently, the majority of crayfish sales are targeted for the export market, with only a small portion serving the local market. Consequently, the price of crayfish in the local market remains relatively higher compared to other freshwater fishery commodities.

The distribution of ornamental freshwater crayfish from Bandung Regency has predominantly focused on Bandung City, utilizing a sales system that caters to both collectors and end-users, who are primarily ornamental fish enthusiasts and hobbyists. The consumers of freshwater crayfish in Bandung can find them in various locations, including Jalan Karapitan, Buahbatu, and the Pagarsih Ornamental Fish Market.

Fig. 10. Freshwater lobster display at an ornamental fish shop

6. CONCLUSION

The cultivation of freshwater crayfish in Cangkuang District, Bandung Regency holds significant potential for development. However, there are obstacles that need to be addressed, such as limited capital and the need to improve technical and managerial capabilities. To facilitate a more successful implementation, government intervention is essential. This intervention should include providing capital and investment opportunities, as well as offering technical and managerial assistance to freshwater crayfish cultivators in Bandung Regency.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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