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Optimizing artificial propagation of *Cyprinus carpio* in semi-intensive aquaculture: A case study from Pachora, Jalgaon

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Abstract

Study investigates the performance efficiency of artificial propagation of *Cyprinus carpio* (common carp) in a semi-intensive aquaculture system located at a 10-acre fish farm in Pachora, Jalgaon, Maharashtra. The primary objective was to assess the effectiveness of hapa-based breeding methods, combined with optimal water quality management and balanced feeding regimes, in enhancing growth, survival, and spawn production. Water quality parameters such as temperature (25-29°C), dissolved oxygen (5.5-6.5 mg/L), pH (7.3-8.2), ammonia (0.3-0.45 mg/L), and nitrite (0.05-0.09 mg/L) were monitored and maintained at optimum levels to ensure conducive breeding conditions. The use of hormonal induction with Ovaprim proved crucial in achieving high fertilization and early survival rates during artificial propagation. Over the course of the study, significant growth performance was observed, with an average specific growth rate (SGR) of 2.1% per day and an efficient feed conversion ratio (FCR) of 1.6:1. The survival rates of fry to fingerlings were notably high at 78%, while the overall survival to marketable size was 75%. The total spawn production reached 70 lakh (7 million) fry, showcasing the potential of semi-intensive systems for large-scale propagation. Research highlights the scalability and economic viability of common carp aquaculture in semi-arid regions, where water resources can be limited but managed effectively. The integration of proper feeding practices, disease control using Tata Aqua Medicine, and water quality management were key factors in achieving high productivity. The findings suggest that expanding *Cyprinus carpio* aquaculture in similar climatic zones can contribute to sustainable fish farming practices, offering economic benefits for farmers and supporting the growing demand for freshwater fish in India.

Keywords: Artificial propagation, hapa breeding, water quality, semi-intensive aquaculture, feed conversion ratio, survival rate, Jalgaon

Introduction

Aquaculture, the practice of breeding, rearing, and harvesting aquatic organisms, has become one of the most important avenues for ensuring food security and supporting the livelihoods of millions worldwide (Boyd et al., 2020) ^[3]. With the depletion of capture fisheries and increasing demand for fish as a source of protein, aquaculture has gained considerable importance. India, as one of the largest producers of freshwater fish globally, has seen significant advancements in aquaculture practices over the past few decades (Ghoshal et al., 2019) ^[10]. Sustainable aquaculture like multitrophic aquaculture and other semi-intensive aquaculture coming in big way (Sagar Vitthal Shinde et al., 2024; S. V. Shinde et al., 2024) ^[19-20]. The progress was particularly evident in the cultivation of carp species, which play a dominant role in the freshwater aquaculture sector. Carp culture, particularly of species such as *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, and *Cyprinus carpio* (common carp), were practised extensively due to their adaptability, rapid growth rates, and high market demand. These species form the basis of both polyculture and monoculture systems, providing an efficient and sustainable means of fish production (Muir, 2005) ^[14]. Among these, the common carp (*Cyprinus carpio*) has gained popularity due to its ability to thrive in a wide range of environmental conditions and its relatively easy breeding requirements (Paul, 2013) ^[16] makes it an ideal candidate for aquaculture, especially in regions like Jalgaon, where water resources are limited but conducive to aquaculture.

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Jalgaon, a district in the state of Maharashtra predominantly known for its agricultural practices, particularly banana cultivation. However, in recent years, the district has seen an increasing interest in fish farming as an alternative and supplementary source of income. Several factors have contributed to the rising interest in aquaculture in Jalgaon. Despite being located in a semiarid region, Jalgaon benefits from seasonal water bodies, irrigation canals, and small ponds, which are suitable for aquaculture. These water resources can be efficiently utilized for fish farming, particularly for species like common carp that can thrive in a variety of water conditions. Fish farming offers an additional source of income for farmers in Jalgaon, especially those with small landholdings. By integrating fish farming into existing agricultural practices, farmers can diversify their income streams and improve financial stability. Additionally, the growing demand for fish in local and regional markets provides a lucrative opportunity for fish farmers in Jalgaon. Various government schemes and programs aimed at promoting aquaculture have provided the necessary impetus for farmers in Jalgaon to take up fish farming. Subsidies for fish seed, feed, and pond construction, as well as training programs organized by organizations such as the Indian Council of Agricultural Research (ICAR) and state fisheries departments, have encouraged farmers to adopt aquaculture as a viable practice.

A key challenge in aquaculture is the consistent and reliable availability of fish seed (juveniles or fingerlings) (Mustafa et al., 2021) [15]. In traditional capture-based aquaculture, farmers rely on natural breeding in ponds and rivers, which often unpredictable and leads to an inconsistent supply of seed. To overcome challenge, artificial propagation or induced breeding has emerged as a critical technique for ensuring the steady supply of high-quality fish seed, particularly for species like *Cyprinus carpio*. Artificial propagation involves the controlled breeding of fish in hatcheries through the administration of hormones to induce spawning. The process allows for the mass production of eggs and larvae, which are then reared in controlled environments to produce fingerlings (Das and Mandal, 2022) [7]. These fingerlings can be stocked in ponds and other water bodies for grow out, ensuring a continuous supply of fish for market purposes. Controlled Breeding: By controlling the breeding process, farmers can select broodstock with desirable traits such as fast growth, disease resistance, and adaptability to local environmental conditions (Bunting, 2013) [4]. This enhances the overall productivity of aquaculture systems. Higher Survival Rates: In natural breeding, the survival rates of fish larvae are often low due to predation, competition for food, and environmental factors. Artificial propagation, however, provides a more controlled and protected environment for the larvae, significantly increasing survival rates. Reduction in Inbreeding: Artificial propagation allows for better broodstock management, reducing the risks of inbreeding and maintaining genetic diversity within fish populations.

Among the various carp species, *Cyprinus carpio* is one of the most widely cultivated species in both India and around the world. Native to Asia and Europe, the common carp has become a major species in freshwater aquaculture due to its ability to adapt to diverse environmental conditions, including varying water temperatures, salinities, and dissolved oxygen levels (Rahman, 2015) [17]. These characteristics make it particularly suitable for semiarid regions like Jalgaon, where water resources may be limited or fluctuate seasonally. Additionally, common carp are known for their omnivorous feeding habits, which allow them to thrive on a wide range of feed types, including natural

plankton, detritus, and supplementary feeds like rice bran and oil cakes, makes them an ideal candidate for polyculture systems, where they can be cocultured with other species such as Indian major carp (IMCs) without significant competition for resources (Flajšhans and Hulata, 2007) [9].

The common carp's reproductive biology also lends itself well to artificial propagation. With proper broodstock management, hormonal induction can lead to predictable and successful spawning, allowing farmers to produce large quantities of fingerlings for stocking. It is particularly advantageous for Jalgaon, where access to high-quality seed can be a limiting factor for aquaculture expansion.

The objective of study to evaluate the performance efficiency of artificial propagation of *Cyprinus carpio* in Jalgaon, with a focus on understanding the key factors that influence successful breeding, seed production, and grow-out phases. The study also aims to assess the economic viability of common carp aquaculture in the region and to identify best practices that can be adopted by local farmers to enhance productivity and profitability. By focusing on site-specific conditions in Jalgaon, research seeks to contribute to the broader goal of promoting sustainable aquaculture practices in semiarid regions. It will also provide insights into how artificial propagation techniques can be optimized to improve the availability of fish seed, thereby supporting the expansion of aquaculture in the district.

2. Materials and Methods

2.1. Study Location

The study was conducted on a 10-acre fish farm located in Pachora, Jalgaon district, Maharashtra. The region experiences a semiarid climate with an average annual rainfall of 700-800 mm, mainly during the monsoon season (June to September). The farm consists of multiple ponds, each designed specifically for the culture of *Cyprinus carpio* (common carp). The primary aim of the farm is to evaluate the efficiency of hapa based breeding, feeding practices, and overall fish health management.

2.2. Species Selection and Hapa Breeding

The candidate species for this study was *Cyprinus carpio* (common carp), chosen for its adaptability to varying environmental conditions and high market demand. Hapabased breeding was utilized for artificial propagation. Hapas are rectangular enclosures made of fine mesh that are submerged in water and used for breeding, hatching, and early rearing of fish. The broodstock was carefully selected based on their size (weighing 1.5 to 2 kg) and health, ensuring they had no visible deformities or diseases. Each hapa measured approximately 3 m x 2 m x 1 m and was installed in ponds with water depths ranging from 1.5 to 2 meters.

2.3. Artificial Propagation Process

Hormonal induction was used to trigger spawning in broodstock. The brooders were injected with Ovaprim, a synthetic hormone widely used in fish breeding, at a dosage of 0.5 ml/kg for females and 0.3 ml/kg for males. Postinjection, the brooders were placed into the hapas for natural spawning to occur. Fertilized eggs were collected and transferred to separate incubation units. The hapa system was continuously monitored for egg deposition.

2.4. Water Quality Management

Water quality is a critical factor for the success of breeding, incubation, and grow out stages in aquaculture. (APHA, 1990) [2] The following water parameters were regularly monitored and

maintained to ensure optimum conditions for the growth and development of *Cyprinus carpio*.

- **Temperature:** Fish breeding and growth are highly sensitive to water temperature. The ideal temperature for common carp breeding ranges between 24 °C and 30 °C. Temperature was measured twice daily using digital thermometers.
- **Dissolved Oxygen (DO):** The DO levels were maintained at 57 mg/L, essential for both broodstock and juvenile survival. Aeration devices, including paddlewheel aerators, were used in ponds to maintain sufficient oxygen levels.
- **pH:** The pH of the water was kept between 7.0 and 8.5, which is ideal for common carp. pH levels were measured weekly using a portable pH meter.
- **Ammonia (NH₃) and Nitrite (NO₂⁻):** Regular water testing was performed to check for toxic levels of ammonia and nitrites. Safe levels of ammonia were maintained below 0.5 mg/L, while nitrites were kept below 0.1 mg/L to prevent fish stress and mortality.
- **Turbidity and Transparency:** Water turbidity was controlled by using organic manures (cattle manure) and Tata Aqua Medicine products. Transparency was maintained between 3040 cm using a Secchi disc.

2.5. Feed and Nutrition

Feed management plays a crucial role in the growth and health of fish. The farm adopted a combination of natural and supplementary feeding strategies:

- **Natural Feed:** The ponds were fertilized with organic cattle manure at a rate of 2 tons/ha, which helped promote the growth of plankton, the natural food source for the fish.
- **Supplementary Feed:** A mix of rice bran and mustard oil cake in a 1:1 ratio was used as supplementary feed. Feed was provided twice daily, with an average daily ratio of 35% of the fish body weight. Cattle feed was also introduced to ensure adequate nutrition.
- **Feed Conversion Ratio (FCR):** The FCR, which measures the efficiency of feed utilization by the fish, was calculated weekly. The ideal FCR target was 1.5:1.

2.6. Health Management and Use of Tata Aqua Medicines

Fish health was regularly monitored through visual observation and laboratory testing for parasites, bacterial infections, and other diseases. Tata Aqua Medicine, a reputable supplier, provided necessary medicines for disease control. Specific treatments included:

- **Antibiotics:** Administered in the case of bacterial infections, typically through medicated feed.
- **Antifungals:** Used to control fungal infections during the egg incubation phase.
- **Water Conditioners:** Tata Aqua water conditioners were used to maintain water quality, especially to reduce ammonia and nitrite levels during critical periods of fish growth. Preventive health measures, including vaccination and regular pond sanitation, were also practiced to avoid disease outbreaks.

2.7. Growth Parameters

Specific growth rate (SGR), feed conversion efficiency (FCR) were analysed as suggested by AOAC (2005) ^[1]; Panase and

Mengumphan (2015); Effendie, (1979).

The growth performance of *Cyprinus carpio* was monitored throughout the study period. Key parameters included:

- **Stocking Density:** The stocking density was maintained at 10,000 fingerlings per hectare, which aligns with semi-intensive aquaculture practices.
- **Growth Rate:** The growth rate of the fish was calculated biweekly by sampling 5% of the population. The length and weight of the sampled fish were recorded to estimate the average growth.
- **Specific Growth Rate (SGR):** SGR was calculated using the following formula:

$$SGR = (T \ln W_2 - \ln W_1) \times 100$$

Where: W1 and W2 are the initial and final weights, respectively T 1 the time in days between measurements

- **Survival Rate:** The survival rate was calculated at the end of the study period by comparing the number of fish stocked with the number of fish harvested.

2.8. Data Collection and Statistical Analysis

Data on water quality, fish growth, feed consumption, and survival rates were collected throughout the study. Statistical analysis was conducted using ANOVA to determine significant differences in growth performance and survival rates under varying water quality conditions and feeding regimes.

2.9. Harvesting

Harvesting was carried out after 8 months, when the fish reached marketable size (500800 g). A portion of the fish was sold locally, while the rest was retained as broodstock for future breeding cycles.

2.10. Economic Evaluation

An economic analysis was conducted to assess the profitability of the hapa based breeding system. Key indicators included:

- **Cost of Inputs:** Including the cost of seed, feed, medicines, and labour.
- **Revenue:** Based on the market price of common carp at the time of harvest.
- **Profitability Index:** Calculated as the ratio of net profit to total input cost.

3. Results

The study aimed to evaluate the performance efficiency of *Cyprinus carpio* (common carp) artificial propagation through hapa breeding, focusing on growth, water quality management, and total production. Key results in terms of water quality, growth performance, survival rates, and overall production of fish spawn are presented below.

3.1. Water Quality Parameters

Throughout the study, water quality parameters were regularly monitored to ensure they remained within the optimal range required for successful breeding and growth of *Cyprinus carpio*. The maintenance of water quality was crucial in achieving high survival and growth rates.

Table 1: The water quality data of various parameters

Parameter	Mean Range Observed	Optimum Range	Remarks
Temperature (°C)	25-29 °C	24 – 30 °C	Well maintained throughout the study
Dissolved Oxygen (mg/L)	5.5 - 6.5 mg/L	5 - 7 mg/L	Kept within optimal limits using aeration
pH	7.3 - 8.2	7.0 - 8.5	Stable and favorable for carp growth
Ammonia (NH ₃ , mg/L)	0.3 - 0.45 mg/L	<0.5 mg/L	Controlled with regular water exchange and treatment
Nitrite (NO ₂ ⁻ , mg/L)	0.05- 0.09 mg/L	<0.1 mg/L	Safe levels maintained
Transparency (cm)	35 - 40 cm	30 - 40 cm	Suitable for fish visibility and feeding behaviour

Table 2: Growth performance of common carp

Parameters	
Feed Conversion Ratio	1.6:1
Specific Growth Rate (SGR %)	2.1% per day
Survival Rate %	75%
Mortality Rate %	25%

The water quality parameters were maintained within the optimum range as outlined in the materials and methods, resulting in a conducive environment for the successful breeding and growth of *Cyprinus carpio*.

3.2. Growth Performance

The growth performance of *Cyprinus carpio* was evaluated throughout the study by monitoring average weight gain, specific growth rate (SGR), and survival rates. Key results are presented below:

- **Initial Stocking Weight (Broodstock):** 1.5 to 2 kg per fish
- **Final Average Weight of Spawn:** The fish reached an average marketable size of 600-700 grams by the end of the 8month culture period.
- **Specific Growth Rate (SGR):** The SGR was calculated to be 2.1% per day, reflecting consistent weight gain throughout the culture period.
- **Feed Conversion Ratio (FCR):** The FCR was calculated to be 1.6:1, indicating efficient feed utilization and low feed wastage.

2.3. Survival Rate

Survival rates of the fish during the different phases of the study (hatchling, fry, fingerlings, and grow-out stages) were monitored closely. The key findings are as follows:

Egg to Hatchling Survival Rate: 85%

Hatchling to Fry Survival Rate: 80%

Fry to Fingerling Survival Rate: 78%

Overall Survival Rate to Marketable Size: 75%

The survival rates were relatively high, particularly in the early larval stages, which often a critical period in fish propagation. The high survival rates can be attributed to the well-maintained water quality and effective health management protocols followed on the farm.

3.4. Total Spawn Production

One of the key objectives of study was to assess the total production of *Cyprinus carpio* spawn through artificial propagation methods. The total production during the study period was:

Total Spawn Production: 70 lakh (7 million) fry

The production of 70 lakh fry exceeded initial expectations, indicating the efficiency of the hapa breeding system used on the farm. The success of the breeding can be attributed to optimal

broodstock selection, proper hormonal induction for spawning, and careful monitoring of the incubation process.

3.5. Economic Performance

An economic analysis was performed based on input costs (feed, medicine, labour, etc.) and revenues from the sale of spawn and marketized fish. The profitability index showed a positive trend, making common carp aquaculture in Jalgaon economically viable.

Revenue Generated: The market price of *Cyprinus carpio* fry was ₹0.080 per fry, resulting in a total revenue of ₹ 5.6 lakh from spawn production alone. Further profits were generated from the sale of marketized fish.

These results indicate that the combination of optimal water quality management, hapa breeding, and artificial propagation techniques contributed to the successful production of *Cyprinus carpio* in semi-arid conditions like those in Jalgaon.

4. Discussion

The study on the performance efficiency of *Cyprinus carpio* (common carp) artificial propagation in Pachora, Jalgaon, Maharashtra, demonstrated promising results in terms of water quality management, growth performance, survival rates, and spawn production. The outcomes highlight the effectiveness of a semi-intensive aquaculture system, particularly the hapa-based breeding method, in producing substantial quantities of common carp spawn while ensuring economic viability.

4.1. Water Quality Parameters and Their Impact

Water quality management is critical for the success of fish farming, especially in intensive or semi-intensive systems. In study, all essential water parameters were maintained within the optimum range, as outlined in the Materials and Methods section, contributing to high survival and growth rates. The maintenance of temperature, dissolved oxygen (DO), pH, ammonia, nitrite levels, and turbidity was instrumental in achieving these outcomes.

- **Temperature:** The recorded temperature range of 25-29°C falls well within the ideal breeding range of 24-30°C for common carp. Temperature influences various physiological processes in fish, including metabolism, reproduction, and immune function. The stable temperature maintained throughout the study created favourable conditions for breeding and growth, especially during the crucial early stages of development. This is consistent with findings from other aquaculture studies, where slight deviations in temperature can lead to significant reductions in hatchability and growth (Tripathi et al., 2000)^[22].
- **Dissolved Oxygen:** The DO levels were successfully maintained between 5.5 and 6.5 mg/L. Adequate oxygenation is essential for aerobic respiration and metabolic activity in fish, and in the context of intensive or semi-intensive aquaculture, lower DO levels can lead to stress, reduced growth, and increased mortality. The use of aeration devices like paddlewheel aerators in this study

ensured that oxygen levels remained optimal even during peak feeding times. The relationship between higher oxygen levels and improved growth and survival is well documented, particularly in semi-intensive systems (CIFA, 2004) ^[5].

- **pH:** The water pH remained within the neutral to slightly alkaline range (7.38.2), which is ideal for common carp. A stable pH is crucial for osmoregulation, enzyme activity, and overall fish health. Sudden fluctuations in pH could have adversely affected growth and survival rates, but the consistent pH values observed in this study support the notion that well-managed aquaculture systems can minimize environmental stress on the fish.
- **Ammonia and Nitrite Levels:** The low levels of ammonia (0.3-0.45 mg/L) and nitrite (0.050.09 mg/L) were within safe limits. Toxic levels of these nitrogenous compounds can cause fish stress, gill damage, and even mortality. The regular monitoring and use of water conditioners from Tata Aqua Medicine helped maintain these levels, demonstrating the importance of proactive water management in minimizing toxic buildup, particularly in semi-intensive systems that rely on higher stocking densities.
- Maintaining optimal water quality played a crucial role in the overall success of the hapabased breeding system. This aligns with previous studies that have shown how balanced water quality can enhance growth rates and reduce mortality in carp farming (Kumar, 2016) ^[13].

4.2. Growth Performance

The growth performance of *Cyprinus carpio* in the study was consistent with the expected results from semi-intensive systems. The average weight gain observed, reaching a marketable size of 600700 grams, is indicative of efficient feed utilization and favorable rearing conditions.

- **Specific Growth Rate (SGR):** The SGR of 2.1% per day was within the typical range for common carp in semi-intensive systems. This reflects both the high-quality feed used and the optimal environmental conditions provided throughout the study. SGR is a critical metric for assessing the efficiency of growth in aquaculture, and the results here suggest that the combination of natural feed (plankton) and supplementary feed (rice bran and mustard oil cake) was effective in promoting rapid growth. Previous research supports the conclusion that balanced feeding regimes, combined with good water quality, lead to optimal growth rates in carp culture (FAO, 2017) ^[8].
- **Feed Conversion Ratio (FCR):** The FCR of 1.6:1 observed in this study indicates that the fish were able to efficiently convert feed into biomass. FCR is a key indicator of the cost-effectiveness of aquaculture operations, and lower values (closer to 1:1) are generally more desirable. The results obtained are comparable to FCR values reported in other studies on semi-intensive carp culture, where FCRs typically range between 1.5:1 and 2.0:1 depending on the feed quality and feeding practices (Jayasankar & Giri, 2013) ^[12]. This suggests that the feed provided in this study was both appropriate and effective, contributing to overall production efficiency.

4.3. Survival Rates

The survival rates recorded during the different life stages of *Cyprinus carpio* were notably high, particularly during the hatchling fry (80%) and fry to fingerling (78%) phases. This indicates successful larval rearing, which can often be a challenging aspect of aquaculture due to the fragility of larvae

and fry.

- **Broodstock Health and Hormonal Induction:** The use of Ovaprim for hormonal induction played a pivotal role in achieving a high fertilization rate and early survival of hatchlings. The survival rate of 85% during the egg to hatchling phase is higher than average, which can be attributed to both the broodstock health and the precise environmental management within the hapas. The use of Ovaprim has been shown to improve spawning success in various studies (CIFA, 2004) ^[5], and the results here reaffirm its effectiveness in semi-intensive systems.
- **Juvenile Survival:** The overall survival rate to marketable size was 75%, which is within the expected range for common carp in controlled environments. Survival rates are often influenced by water quality, feed, and disease management. The use of Tata Aqua Medicine products to control potential pathogens likely played a role in reducing disease related mortalities, further supporting the importance of comprehensive health management practices in aquaculture.

4.4 Total Spawn Production

The total spawn production of 70 lakh (7 million) fry demonstrates the success of artificial propagation using the hapa breeding system. This level of production is significant, especially in a 10acre farm, and highlights the potential for scaling up operations in similar regions.

- **Efficiency of Hapabased Breeding:** The high spawn production can be attributed to the efficiency of the hapa system, which provides a controlled environment for breeding, egg incubation, and early larval development. This method reduces predation risks and allows for easier monitoring of water quality and broodstock health, thus improving the chances of successful reproduction.
- **Market Demand and Economic Viability:** The production of 70 lakh fry not only met local demand but also contributed to the economic sustainability of the farm. With a market price of ₹0.0801.00 per fry, the revenue generated from spawn production alone was substantial, ranging from ₹5.6 lakh to ₹6 lakh. This revenue, combined with the profits from the sale of marketized fish, indicates that common carp aquaculture in Jalgaon is economically viable. The profitability index calculated in the study suggests that aquaculture, even in semiarid regions, can provide significant returns when optimal water management and feed practices are followed.

4.5. Implications for Aquaculture in Semiarid Regions

The success of this study has important implications for aquaculture in semiarid regions like Jalgaon. The results demonstrate that with proper management, including maintaining optimal water quality, using efficient breeding techniques, and providing balanced nutrition, high production levels can be achieved even in areas with challenging environmental conditions.

The use of hapa based breeding systems, in particular, offers a scalable and cost-effective solution for artificial propagation. Given the increasing demand for freshwater fish in India, particularly in regions with limited agricultural potential, expanding carp culture could serve as a sustainable livelihood option for farmers.

5. Conclusion

Study on the performance efficiency of *Cyprinus carpio*

artificial propagation in Pachora, Jalgaon, demonstrated the potential of semi-intensive aquaculture systems to achieve high production levels under controlled conditions. Through the use of hapabased breeding, optimal water quality management, and a balanced feeding regime, the farm produced 70 lakh fry, highlighting the success of artificial propagation techniques. The results also indicated strong growth performance with an SGR of 2.1% per day and a survival rate of 75%, ensuring both ecological and economic viability. The efficient feed conversion ratio of 1.6:1 further reinforced the success of this aquaculture model, making it a sustainable practice for farmers in semiarid regions. Maintaining key water quality parameters such as temperature, dissolved oxygen, pH, and ammonia levels within the optimal range played a crucial role in ensuring the health and productivity of the broodstock and their offspring. The integration of hormonal induction using Ovaprim, regular water quality monitoring, and disease prevention measures from Tata Aqua Medicine helped achieve high survival rates, especially in the critical early stages of development. Study demonstrates that semi-intensive aquaculture, when carefully managed, can provide substantial production and economic returns, even in regions where environmental conditions may pose challenges. The success of highlights the potential for scaling up common carp aquaculture in regions like Jalgaon, where water resources are limited but manageable. The outcomes of research provide valuable insights into optimizing breeding, water management, and feeding strategies, ultimately contributing to the broader development of sustainable aquaculture practices in India.

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