From hormone to hatchling: A hands-on journey through carp breeding at hatchery

Md Faisal Ahmed

Aquatic Animal Health Group, Department of Fisheries, Faculty of Biological Sciences, University of Dhaka, Dhaka 1000, Bangladesh. Correspondence: Md Faisal Ahmed; Email: faisalahmed.fsh@gmail.com

Catla broodstock (Labeo catla).

Breeding life beneath the water

Bangladesh is a predominantly agricultural country, and the sector's contribution to its economy is significant. The abundance of fisheries resources also contributes strongly to socio-economic development. Natural fisheries distributed across the country help to underpin the industry. Bangladesh is currently one of the world's top fish producers, with total production of about 4.915 million tonnes in 2022-2023, up from 4.34 million tonnes in 2018-2019. This growth underscores ongoing commitments to enhance the fisheries sector, which plays a crucial role in national food security, employment and economic development.

According to the Food and Agriculture Organization of the United Nations (FAO, 2020), over the last 10 years Bangladesh ranked third worldwide for inland open-water fish production, and over the last six years it ranked second for freshwater fish production. For crustaceans and marine finfish, the country ranked 8th and 12th, respectively. The fishing industry makes a substantial contribution to socio-economic progress and poverty reduction. Fisheries account for 2.41% of gross domestic product (GDP) (DoF, 2023) and contribute about 25% of total agricultural income. Fish provide about 60% of daily animal protein intake. Against an average daily requirement of 60 g per person, national per-capita consumption is about 62.58 g.

Over the past decade, the fisheries sector has experienced steady GDP growth; over the last five years its contribution to GDP growth was 6.28%. Production trends over the last 36 years, disaggregated by sector, indicate that the contribution of closed reservoirs has more than tripled, reaching 57.39% (DoF, 2023).

Induced breeding

Without artificial reproduction, fish farming is limited. Induced breeding is a process in which an organism is encouraged to reproduce in captivity by administering a specific hormone (or other synthetic hormone) or by providing appropriate breeding conditions. The stimulation prompts the gonads to ripen and for the fish to engage in spawning. Hypophysation is the method of inducing reproduction by removing the pituitary gland and injecting an extract prepared from it into male and female broodstock.

History of induced breeding

After Houssay's production of pituitary extract in 1930, induced breeding was first developed in Argentina. In 1934, Brazil became the first nation to establish a method for hypophysation. Hamid Khan made the first attempt to induce breeding in mrigal *Cirrhinus mrigala* in India in 1937. Ali (1967) was the first to successfully induce spawning in carps in Bangladesh; the procedure was later codified (Islam & Chowdhury, 1976; Ahmed, 1983). About 98% of the country's fry are generated by hatcheries, which are a primary source of seed for fish culture (Amin, 2002).

General information on hatcheries in Bangladesh

The Government of Bangladesh has developed many public-sector hatcheries in various regions of the country following the success of fish-seed production using artificial breeding techniques. Over time, a substantial number of private hatcheries have also been established. Currently, there are 1,078 fish hatcheries in Bangladesh, of which 143 are public and 935 are private (Department of Fisheries, DoF, 2020). The country now produces sufficient carp seed domestically, albeit on a small scale and with high-quality seed. Of the Tk 50 billion incentive to address losses in the agriculture sector during the COVID period, the government offered Tk 1.04 billion (loans at 4% interest) to the fisheries sector.

Understanding carp breeding: A brief overview

Carp breeding is a foundation of freshwater aquaculture, playing a vital role in ensuring a stable supply of seed for fish farming worldwide, especially in countries such as Bangladesh, India and China. As the need for protein-rich food increases, the importance of efficient, large-scale carp seed production has grown rapidly. To understand how we progress from hormone-induced brood fish to free-swimming hatchlings, it is important to grasp the basic principles behind carp breeding.

The natural vs induced breeding dilemma

In natural waterbodies, carp species such as rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) spawn during the monsoon season in rivers and floodplains. Their spawning is triggered by environmental cues such as water flow, temperature and rainfall. However, these ideal conditions are not easily replicated in artificial ponds or hatcheries. To overcome this, fish breeders use induced breeding, which mimics the natural reproductive cycle of carps through controlled hormone administration and environmental manipulation. Induced breeding enables hatcheries to produce large volumes of quality seed even outside the monsoon season, ensuring year-round availability of fry for aquaculture.

Key components of carp breeding

Carp breeding typically involves the following steps.

Selection of broodstock

Healthy, mature male and female fish (broodstock) are selected based on size, age and health. Proper broodstock management - including regular feeding and disease control - is essential for successful spawning. Six carp species are used as broodstock here: catla, bighead carp, silver carp, grass carp, Hungarian mirror carp and common carp. This account refers to a commercial hatchery, Sonali Fish Hatchery (23.147401, 89.202167), situated at Chanhra, Jashore Sadar, Jashore.

Hatchery system

Fish fingerlings suitable for stocking in grow-out ponds are produced in hatcheries. A typical farm includes: (i) ponds for stocking brood fish for spawning, serving as donors of pituitary glands and holding spent females and males; (ii) a hatchery proper - often an indoor facility - for spawning, egg incubation, hatching and rearing hatchlings to the post-larval stage; (iii) nursery ponds for feeding post-larvae to the fry stage; and (iv) rearing ponds for raising fingerlings from fry. According to Jhingran et al. (1988), the hatchery is the most essential part of a modern fish farm.

The essential components of a modern hatchery proper are ante-tanks or storage tanks, breeding tanks or ward tanks, incubators or hatching jars, and larval-rearing tanks. Ante-tanks are used to hold selected ripe breeders before injection. The smallest hatchery should have at least two ante-tanks - one for each sex of a species. Sometimes ante-tanks are used for both breeding and larval rearing. Both circular and rectangular breeding tanks are used to facilitate partially natural breeding and fertilisation. In the hatchery described, there was one circular breeding tank. Carp eggs were incubated in funnel-shaped incubators; four incubators were available. The larval-rearing tank functions similarly to an ante-tank, and circular breeding tanks are occasionally also used for larval rearing.

Preparation of induced breeding

Brood fish pond preparation

The use of healthy brood fish is essential for good seed production. The hatchery had six rectangular, drainable brood-fish ponds. The average size of each pond was 1 hectare, with an average width of 25 m, and average water depth of 1.2 m. The ponds were treated with lime and sun-dried before brood fish were released, after which freshwater from the municipal supply was added. Pond water temperature ranged from 25-28 °C and was free of chlorine, pesticides, and undesirable substances. The pond bottom was clay-loam, capable of retaining water. The ponds were fitted to restrict the entry of undesirable fish. These characteristics facilitated brood-fish rearing, netting and feeding.

Incubator.

Ante tank / storage tank.

Feeding of brood fish

Supplemental diets provided essential nutrients such as protein, carbohydrates, vitamins and minerals. The supplemental feed comprised fish meal, mustard oil cake, rice bran and wheat bran, with a total protein content of about 30%. The proximate composition was mainly crude protein (30-40%), crude lipid (10-12%) and carbohydrates (20-30%). During autumn and winter, brood fish were fed at 2-3% of body weight; later, feeding increased to 5% of body weight. Feed should be offered twice daily at fixed times and locations. Diets could be ready-made or farm-made. Supplemental feed such as oilcake, rice bran, molasses, wheat bran, wheat flour, fish meal and vitamins was provided at 2-4% of total body weight per day, morning and evening, to improve seed production (Harvey et al., 1993).

Breeding tank preparation

The hatchery had two circular breeding (ward) tanks, each about 1 m deep. Before receiving brood fish, tanks were cleaned and sterilised with a potassium permanganate solution. Water was supplied from an overhead tank. pH was approximately neutral, and temperature ranged from 20-23 °C. The water was free of contamination, and oxygenated water flowed continuously through the tanks. The water level could be maintained via an outlet. Breeders were held in these tanks for natural spawning and fertilisation.

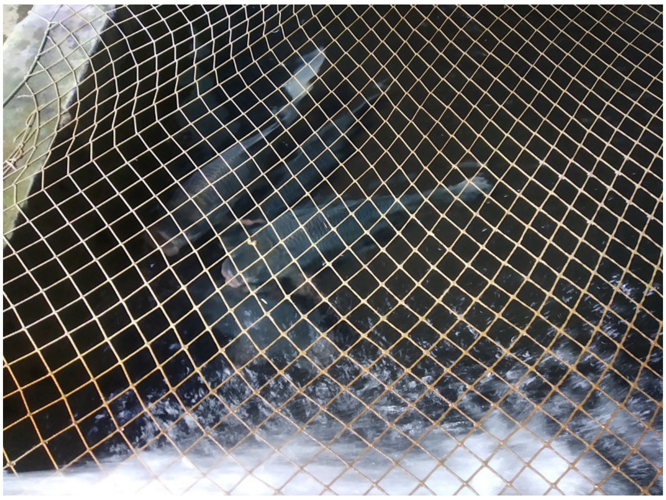
Netting

Seine nets were typically used for netting operations. For larger ponds, two nets were employed to improve efficiency. Netting was done early in the morning, when conditions are relatively cool and fish are active. Care was taken during netting to minimise stress and injury.

Selection of broodstock: choosing the right parents

To obtain high-quality sperm and eggs, broodfish were harvested during the peak of spawning. Age and weight of the broodfish are significant factors in breeding. The simplest method of selection is based on external characteristics, which farmers can manage with ease due to their experience. Unnecessary fish should be released into the pond immediately.

The proper age and weight of carp broodfish play a vital role in the success of induced breeding. Under standard hatchery practices, some carp species reach appropriate maturity for breeding at around two years of age. For example, both *Hypophthalmichthys nobilis* (bighead carp) and *H. molitrix* (silver carp) should be at least 2 years old and weigh over 2 kg. *Ctenopharyngodon idella* (grass carp) requires a somewhat higher body weight, with a minimum of 3 kg at the same age. Likewise, *Cyprinus carpio carpio* (European common carp) and *Cyprinus carpio* (common carp) should be at least 2 years old, with minimum weights of 2 kg and 1.5 kg, respectively. For *Labeo catla* (catla), a key Indian major carp species, broodfish should also be at least 2 years old and weigh over 2 kg. Ensuring broodfish meet these age and weight thresholds is important for optimal spawning performance and high-quality seed production in carp hatcheries.



Conditioning of brood fish.

Sex determination of breeders

Sex determination is a crucial step for successful reproduction because male and female hormone requirements differ. For induced breeding, males and females were identified and separated. Several physical characteristics help differentiate mature females and males during the breeding period. Female broodfish generally have a conspicuously bulging abdomen that extends beyond the pelvic region to the genital aperture, and the abdomen feels soft to the touch. The genital aperture appears swollen, protruding and turgid, with a pinkish margin. Pectoral fins in females are relatively small and weak, with a smooth inner surface. When gentle pressure is applied to the abdomen, eggs may be released through the genital pore. Females also tend to have a stouter body than males of the same age.

In contrast, male broodfish usually have a less pronounced abdominal bulge and a firmer abdomen. The vent is not protruding and appears pit-like. Males possess relatively long and prominent pectoral fins with a rough inner surface that can be felt by touch. Upon gentle abdominal pressure, whitish milt is released through the genital pore, and the overall body shape is thinner and more linear compared with females of the same age group.

The role of hormones in induced breeding

The choice of hormone depends on many factors, including species, cost, availability and egg incubation. Two main types of inducing agents were used:

- Pituitary gland (PG)
- Compound S-GnRHa (synthetic gonadotropin-releasing hormone analogue) “Ovaprim/Ovulin” fish-spawning hormone.

Pituitary gland is used for *Ctenopharyngodon idella* (grass carp), *Cyprinus carpio* (common carp), *Cyprinus carpio carpio* (mirror carp) and *Labeo catla* (catla). Compound S-GnRHa (Ovaprim/Ovulin) is used for *Hypophthalmichthys molitrix* (silver carp) and *Hypophthalmichthys nobilis* (bighead carp). PG used for induction was procured via marketing channels in

Bangladesh and India; it is favoured for ready availability and comparatively low price. The compound S-GnRHa (Ovaprim/ Ovulin) used was manufactured by Shijiazhuang ZDHF Stock-Raising Co., Ltd., China, and is selected for ease of acquisition, relatively low cost and long shelf life.

The dosage of hormones and breeding protocol differ among carp species according to their physiology and spawning characteristics. For common carp, mirror carp and catla, both males and females are typically injected with pituitary gland extract (PG). Females receive a total dose of 6 mg/kg body weight, split into two doses: an initial priming dose of 2 mg/ kg followed by a second dose of 4 mg/kg after an appropriate interval; males receive a single dose of 2 mg/kg at the time of the female's second dose. In grass carp, females receive a first dose of 1.5 mg/kg PG followed by 4 mg/kg after 6-8 h, and males receive a single dose of 2 mg/kg at the same time as the female's second dose. Silver carp and bighead carp may be induced using PG or a synthetic hormone such as S-GnRHa. For these species, females are administered a first dose of 230 IU S-GnRHa and a second dose of 7-8 mg PG (or equivalent) 9-12 h after the first. Males receive 2 mg PG at the time of the female's second injection, usually 6-9 h after the first dose. Timing and dosage must be managed carefully to ensure successful spawning and fertilisation.

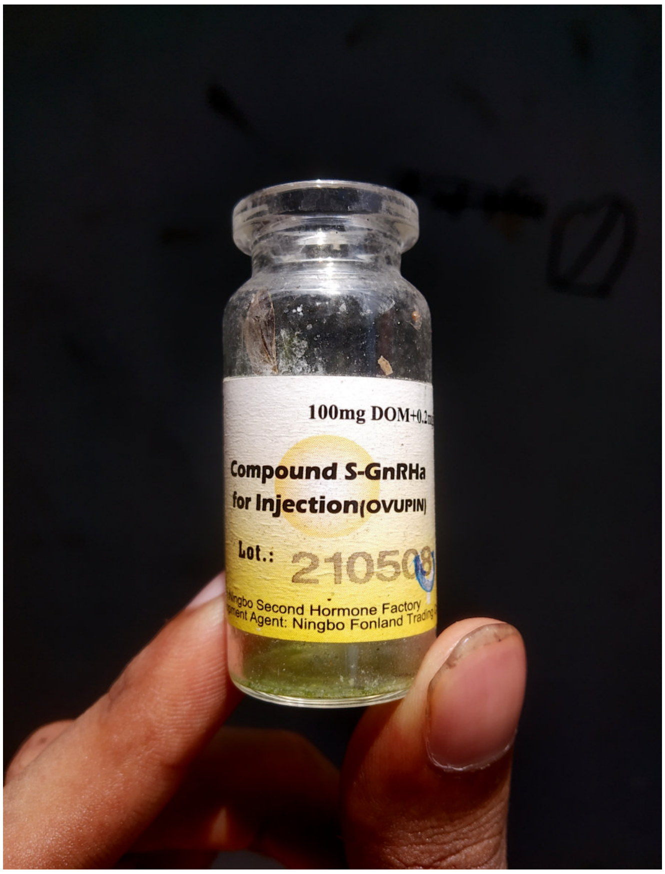
A high-quality inducing agent is essential for an effective induced-breeding programme. The required PG was taken from storage and dried for 2-3 min on filter paper (each PG weighing about 3 mg). Glands were placed in a tissue homogeniser with distilled water, mixed, and further distilled water added as needed (typically 0.5 mL per kg body weight). The extract was then loaded into a syringe for injection. Alternatively, glands were transferred to a mortar and pestle, crushed thoroughly and diluted with the required volume of distilled water. For S-GnRHa, the necessary dose was combined with distilled water (about 0.5 mL per kg body weight) and the solution injected.

Prepared inducing-agent solutions were administered to breeders at mL/kg body weight. Accordingly, the proper dose of inducing agents and the weight of breeders were measured.

The injection process: timing and technique

Two injection techniques were applied. The initial (stimulating) dose was followed by a second (resolving) dose 6-8 h after the first. Females received both doses; males received a single dose at the time of the females' second injection. There are two possible injection routes: intramuscular and intraperitoneal. When the fluid volume does not exceed 2 mL, the intramuscular route is suitable for smaller fish. The intraperitoneal route is preferred for larger volumes, as the peritoneal cavity provides more space. In this study, injections were given intraperitoneally because volumes exceeded 2 mL. The base of the pectoral fin was the target site. To avoid injury to the heart, a small syringe was used. Broodfish were collected from tanks and covered with cloth during the procedure, with the eyes also covered. Fish were placed on a foam block, and injections were administered at a 45° angle to minimise the risk of internal injury. Fish were returned to tanks immediately after injection.

Pituitary glands.



S-GnRHa hormone.

Injecting the breeders.

Spawning and fertilisation: Nature meets science

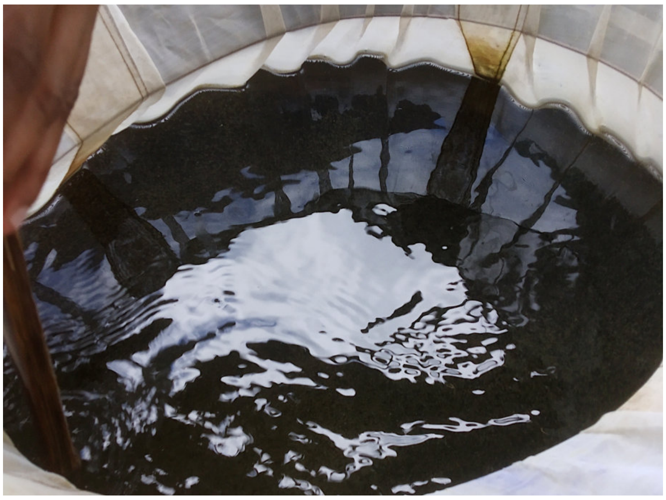
After injection, breeders were held in breeding tanks at a 2:1 male:female ratio. Signs of spawning were observed. Artificial breeding was conducted for silver carp, bighead carp, grass carp, common carp, mirror carp and catla. Stripping was performed at a set time after injection. A very soft abdomen in the female indicated readiness. Brood females were removed, wrapped in cloth and, with gentle pressure on the abdomen, loose eggs were released from the genital opening into a plastic dish. The female was then returned to the tank.

Milt was extracted from a male and added to the same dish as the eggs; two males were used per female. The males were then released back to the tanks. Eggs and milt were gently mixed with a feather to achieve fertilisation, then repeatedly washed with clean water. Fertilised eggs were transferred to incubators.

Egg stripping.

Milt stripping.

Mixing eggs and milt with a feather.



Eggs kept for incubation.

Hatching time: Monitoring the miracle

The incubation period is when the fish develops inside the egg. Fertilised eggs quickly swelled and turned slightly whitish. These were then transferred to incubators, where hatching occurred after 24-48 hours. In the hatching tanks, a hapa was placed around the fertilised eggs to prevent them from escaping with the draining water. The timing of hatching was affected by environmental temperature. No additional nourishment was provided during incubation. There were three main phases of egg development: the swelling phase, the cleavage and germ-development phase, and the embryonic development phase.

After 15-20 minutes of stripping, the appearance of the "eye spot" and the enlargement of fertilised eggs allowed for separation from unfertilised ones. Fertilised eggs were transparent, while unfertilised eggs appeared white and opaque. The fertilisation rate was estimated using the following formula:

Fertilisation rate (%) = (Number of fertilised eggs in sample / total number of eggs in sample) × 100

For hatching, fertilised eggs were placed in funnel-type incubators with a continuous flow of water. After 42-48 hours of fertilisation, eggs began to hatch. Hatchlings were collected in a dish, counted visually under a magnifying glass, and recorded. The hatching rate was calculated as follows:

Hatching rate (%) = (Number of hatchlings in sample / total number of fertilised eggs in sample) × 100

After hatching, fry did not consume external food for 70-72 hours, relying instead on their yolk sac for nourishment. After 72 hours, fry were fed boiled egg yolk, ground in a homogeniser, four times daily. Samples were taken after 96 hours to count live fry, and survival rate was calculated as:

Survival rate (%) = (Number of surviving fry in sample / total number of fertilised eggs in sample) × 100

Post-hatch management: Caring for the fry

Hatchlings from hatching jars and incubators were transferred to larval-rearing tanks by siphoning and acclimatised before release. Continuous water flow and aeration were maintained after transfer. On the third day after hatching, samples of hatchlings were observed in a beaker or petri dish to determine readiness for exogenous feeding. Once the yolk sac was mostly absorbed, vertical movement shifted to horizontal swimming, signalling feeding readiness. Artificial feed was introduced at this stage, primarily boiled chicken egg yolk (one yolk per 2-3 kg of larvae). Overfeeding was avoided. Hatchlings were reared for 24-48 hours before being sold.

Delivery and transportation of fry

Fry were transported in double-layered polythene bags placed inside a third outer plastic bag. Fry were collected from the larval-rearing tank using polyester cloth and sold on a wet-weight basis, measured with a cup. The weighed fry were placed in bags pre-filled with clean groundwater (about 5 L per bag). For transporting 1 kg of fry, four such bags were used. After adding fry, the bag was filled with pure oxygen gas - one-third with water and two-thirds with oxygen. The top was twisted and tightly sealed with a leak-proof knot to prevent oxygen loss during transport.

Larvae.

Challenges in carp hatcheries: Practical insights

Hatchery owners are often unaware of the exact lineage of broodstock, leading to inbreeding depression. The focus tends to be on high output and profit. In the absence of skilled personnel, fish are sometimes handled inappropriately and age records are not maintained accurately. With limited research undertaken at hatcheries, fish-seed quality has not improved. Poor hormone quality, incorrect dosages, the use of immature breeders and rough physical handling all contribute to broodfish mortality - factors that remain poorly understood. Hormones are expensive, and dosing and administration are sometimes incorrect. Pond soil quality may decline over time with repeated use. Hatchery workers may also struggle to maintain hygiene due to insufficient sanitation training. In addition, water supply is frequently disrupted by power failures.

Endnote

The journey from hormone to hatchling encapsulates the delicate balance between scientific precision and hands-on hatchery practice in modern aquaculture. Through induced

Packing.

Filled bags.

Oxygenating bags for transport.

Loading bags onto a truck.

breeding, seasonal and environmental constraints on natural spawning can be overcome, ensuring a consistent and controlled supply of quality carp seed. By understanding each step - from broodstock selection and hormone administration to fertilisation, incubation and fry management - we gain not only technical knowledge but also a deeper appreciation of the vital role hatcheries play in sustaining fish production. This hands-on approach shows how innovation and traditional skill together shape the future of aquaculture, providing important lessons for aspiring professionals and contributing to food security and rural livelihoods.

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