**Induced breeding in fishes: An overview**

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**Abstract:**

Fish provides a very nutritious food for human beings. In Current scenario, the fish population is declining very sharply because water resources are highly polluted, over consumption and reducing the number of water bodies because of natural disasters and human interference. Due to high demand for fish as food, fish culture is a technique used tofulfil the requirements by increasing productivity.Induced breeding is a technique where an organism is stimulated by a particular hormone or other synthetic hormone or by providing a condition, introduced to breed in intimate condition. The endocrine system performs as an executive relationship between the environmental incidents and maturation and liberation of gametes in vertebrates. The pituitary hormones control some activities like impression of secondary sexual features, breeding behaviour during courtship and timing of reproduction throughout the breeding season. Pituitary hormones such as luteinizing (LH) and follicle stimulating hormone (FSH) play an important role in spawning, induced breeding .

**Key Words:** Induced breeding, Pituitary gland, Major Carps, Hypophysation, Gonadotropin Releasing Hormones, FSH, LH, Synthetic hormones.

**Introduction**:

From ancient times fish played a very important role in the life of human civilization, history tells us that some form of fish culture existed around 300 B.C (Hora, S.L., 1953). From the ancient period of time fish were considered as a source of nutritious food. It also provides proteins, fats, vitamins, amino acids, fatty acids and omega-3 which are very important for health (Alp -Erbay and Yeşilsu, 2021, Allam, et al. 2020; Panda, S., 2016). India is second ranked globally in farmed fish production (Panigrahi, 2019).  The current fish production in India has reached 8.3 million tons, which is expected to reach 12.5 million tons by 2025 ( Dash et al. 2018). Major carps are the most important species from the perspective of their high food and nutritive values. The widely cultured Indian major carps in inland waters like mrigal (*Cirrhinus* mrigala), rohu *(Labeo rohita)*, calbasu (*Labeo calbasu)* and catla *(Catla catla)*,and Chinese carps, *black* carp *(Mylopharyngodon piceus),* big head *(Aristichthys nobilis),* silver carp *(Hypophthalmichthys molitrix), grass* carp *(Ctenopharyngodon  idella),* and mud carp *(Cirrhina molitirella),* normally do not breed  in circumscribed waters (Chaudhary et al. 1996). These culturable fishes do mature there but breed in the submerged shallow areas beside the course of the rivers during monsoon season which are their natural habitat (Alikunhi et al. 1965, Chakrabarti S. 2020). The first success in inducing the Indian major carps was achieved in 1957 (Chaudhuri and Alikunhi, 1957) and in silver carp and grass carp introduced in India in 1959, in the year 1962 (Alikunhi et al., 1963). Indian major carps are known to spawn in specialized environments like bundhs, in that area’s rainwater accumulation takes place during the monsoon season. These man-made or natural conditions mimic their original spawning habitats and allow for successful reproduction. In the past, fish culturists had to rely on collecting fish seeds from the river system. However, such collections often included not only the desired species, but also of uneconomic and unwanted species including predators and their separation sometimes became more difficult for farmers. The Asiatic carps are unable to breed in confined  stagnant waters, due to the lack of required ecological stimuli which affect the secretion of required quantities  of gonadotropic hormones (Jha and Neupane 2019, Alikunhi et al. 1964, Panigrahi, L. 2019) and so extraneous hormones such as pituitary extract or synthetic  hormones are injected to brood fish to induce them to breed in confined water and thereby ensure a  dependable source of quality seed to enhance the fish production and development of fishery (Panigrahi, L. 2019). Induced breeding in hatcheries has indeed revolutionized the production of high-quality carp seed. By controlling the breeding process in a controlled environment, hatcheries can ensure better genetics and higher survival rates of the fish. This method reduces the reliance on natural seed collection, which can be unpredictable and unsustainable (Alikunhi et al., 1960).

Induced breeding, also known as hypophysation, is a method used to breed economically important fish species that do not typically breed in captive environments. By stimulating the fish's gonads with hormones like pituitary hormones or synthetic alternatives, the process encourages the release of eggs and sperm, allowing controlled breeding to occur under captive conditions (Hossain et al. 2021, Ervilha et al. 2022, Kumar et al. 2022). This technique plays a crucial role in aquaculture and fisheries management. Induced spawning has opened the door of a new era in the production of fish throughout the world (Bhuiyan et al., 2013).

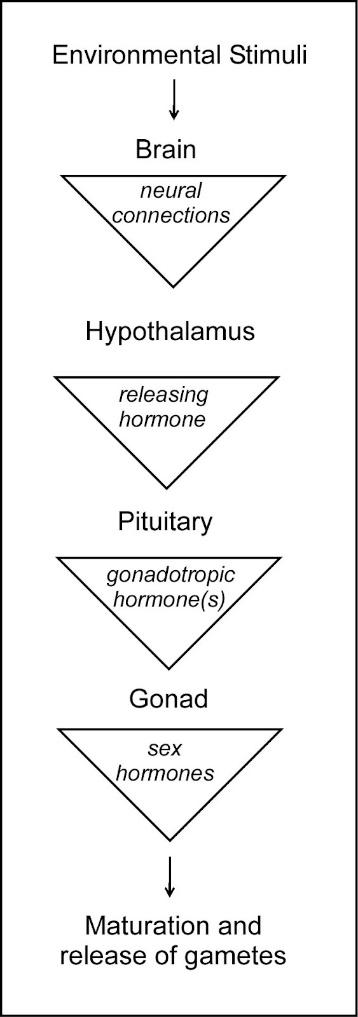
**History of Induced Breeding:**

The induced breeding technique was developed in Argentina by Houssay in 1930, which involved the use of pituitary extract to stimulate viviparous fish to give premature birth. This approach marked a significant advancement in understanding and manipulating fish reproductive processes for aquaculture purposes. In the year of 1934, Brazilians succeeded in induced breeding by pituitary extract. The technique of induced breeding quickly gained traction beyond Argentina. It was adopted in America by researchers like Merlin and Hubs, as well as in Russia by Gerebilisky. In India the firstly induced breeding in fishes was made by Khan in 1937 on *Cirrhinus mrigala*. Dr. Hiralal Choudhuri in 1955, also used this technique in the minor carps like *Esomus danricus* and *Pseudeotropius atherinoides*. Ramaswamy and Sunderaraj (1956) were first induced to breed *Clarias batrachus & Heteropneustes fossilis*. Dr. Hiralal Choudhuri's accomplishment in achieving the first successful induced breeding of major carps in 1957, involving *Cirrhinus mrigala*, *C. reba*, and *Labeo rohita*, marked a significant milestone in the advancement of aquaculture. It was observed in the Indian carp spawns induced by injection of pituitary hormones (Alikunhi et al. 1960). Additionally, Parameswaran and Alikuni's success in breeding exotic Chinese carps, *Hypophthalmichthys molitrix* and *Ctenopharyngodon idella*, in 1963 further demonstrated the potential of induced breeding techniques in diversifying fish production.

**Events of Natural Breeding:**

Many cultured farm fishes, including Indian major carps, often do not breed naturally in captive conditions. Indian major carps come under fishes which do not ordinarily spawn in confined water or stagnant water bodies such as ponds, lakes etc., but spawn usually in inundated terrains of rivers and streams during rainy season (Baruah, 2013). There are multiple reasons that played different role during breeding seasons as like environmental  parameters like photoperiods, rain, temperature, current of water influence the hormonal activity from  pituitary and release of its gonadotropin, and finally consider gonad maturation and spawning in both sexes (Alikunhi et al. 1965, Maulu, S. et al. 2021, Ibrahim et al. 1968, Siddique et al. 2022) The spawning site of Indian major carps benefits from fresh floods that eliminate terrestrial life and promote the growth of microflora and microfauna, providing a food source for the fry and fingerlings of these fish. This flood-driven cycle contributes to the survival and propagation of Indian major carps.(Padhi and Mandal, 1994).

Disturbances arise in any of these environmental conditions may cause the insufficient release of hormones in captive conditions and thus, the fish does not breed in captivity. The technique induced breeding is based on the principles of artificially manipulating hormonal or environmental factors (Kumar et al. 2021) for stimulation of reproduction in fishes (Figure 1, Harvey and Carolsfeld 1993).



**Figure 1:** Flowchart displays environmental and hormonal events of natural breeding.

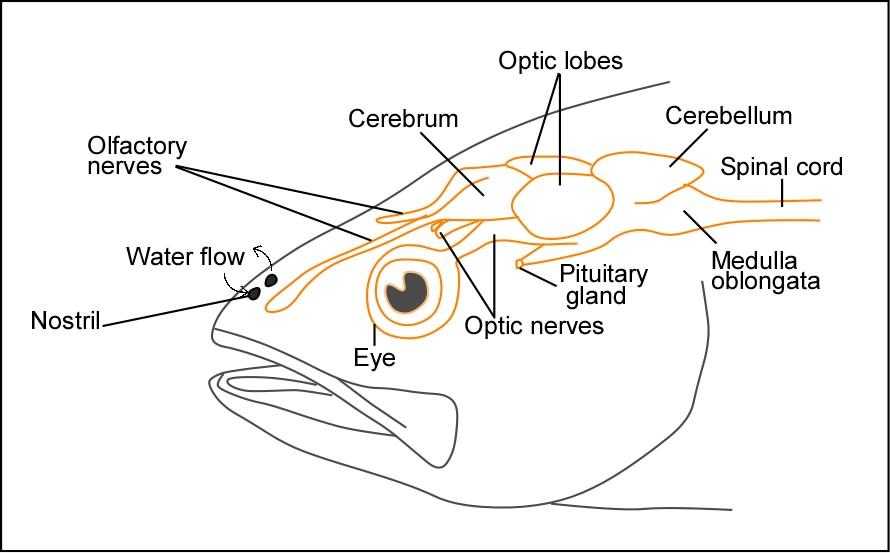
**Need of induced breeding:**

Due to the increase in demand of fish for food, recreation and ornamental fishes used in aquariums, the natural fish populations are gradually declined during the past several decades, because of environmental degradation like photoperiod, rain, temperature, currents of water and overfishing, chemical composition of water and many more factors (Pankhurst and Mundey 2011, Jha and Neupane 2019, Sudha, C. 2012). This raised trouble in the development of ways for hatchery products of fish. Traditional aquaculture species such as trout, catfish, common carp, golden shiner and goldfish reach sexual maturity and spawn in hatcheries or ponds, when conditions are appropriate. Indeed, some valuable fish species have proven challenging to reproduce in captivity despite their economic importance for aquaculture. Many of these fish spawning takes place in natural environments that are nearly impossible to stimulate in hatchery, hormone induced spawning is the only reliable method to induce reproduction in these fishes (Panigrahi, L. 2019, De et al. 2020). The reproductive processes of fish in captivity are a crucial step towards domestication and the development of a sustainable aquaculture industry (Mylonas et al., 2010, Saraiva et al. 2018).

**Fish pituitary gland:**

The fish pituitary is a major endocrine gland which plays a decisive role in the neuroendocrine system including growth, development and the functioning of other endocrine glands. It is present in all vertebrates from agnathans (jawless fishes) to mammals and as in others it also consists of two main elements, the adeno-hypophysis derived from the Rathke's pouch and the neurohypophysis derived from the diencephalon (Harvey and Carolsfeld 1993, Shanthanagouda et al. 2018).

The pituitary gland of fish is a small (pea-sized) body situated as the ventral aspect of the brain in a concavity called as sella turcica and is connected to the brain by means of a stalk (Figure 2). Like higher vertebrates, fish pituitary glands also control a wide variety of physiological processes by secreting a number of hormones. The most important are gonad stimulating hormones, follicle stimulating hormone (FSH) in stimulating the development and maturity of the sexual organs and induce spawning in fishes



**Figure 2.** Schematic diagram of fish head showing location of pituitary gland ventral to the brain.

**Procedure of induced breeding technique:**

The most common method of induced breeding is hormone injection in which pituitary extract or any other synthetic hormone is injected in the body of ripe breeders which may be male or female. The mechanism of induced breeding is completed in several steps.

1. **Collection of Pituitary Gland:**

Pituitary gland is collected from a mature fish, which is called a donor fish. Most widely used donor fish is the common carp *(Cyprinus carpio)* as it breeds throughout the year and therefore mature individuals are available around the year (Islam, 2016).

The pituitary gland can be collected by any one of the following two methods-

a) Collection of glands through the foramen magnum.

b) Collection of glands by dissecting head.

**a)  Collection of glands through foramen magnum –** The foramen magnum is first exposed by removing vertebral parts adhering to the skull. Fat is removed first by means of forceps and then cotton pieces.  A couple of forceps then fitted into foramen magnum dorsally to the brain and anterior part of the brain now detached and remaining is precisely lifted out through the foramen magnum. The gland is then identified and removed.

**b) Collection of glands by dissecting heads –** This technique is not used commercially because the heads are damaged by this process. The method of head removal is less time consuming and economical as the heads are used for human consumption later. At first the head is dissected using a sharp butcher’s knife, a portion of the scalp is chopped off in a clean cut with one stroke. Fat encompassing the brain is removed with the support of cotton. Olfactory and optic nerves are now severed, and then the brain is lifted up and removed. Then identify and locate the pituitary gland (Figure 3). After the dissection gland may come up along with the brain or may remain behind on the floor of the brain cavity often covered with membrane (Das and Khan, 1962). In any case the gland is carefully removed after separating it from the membrane or the brain proper. The gland must not be broken or tattered.

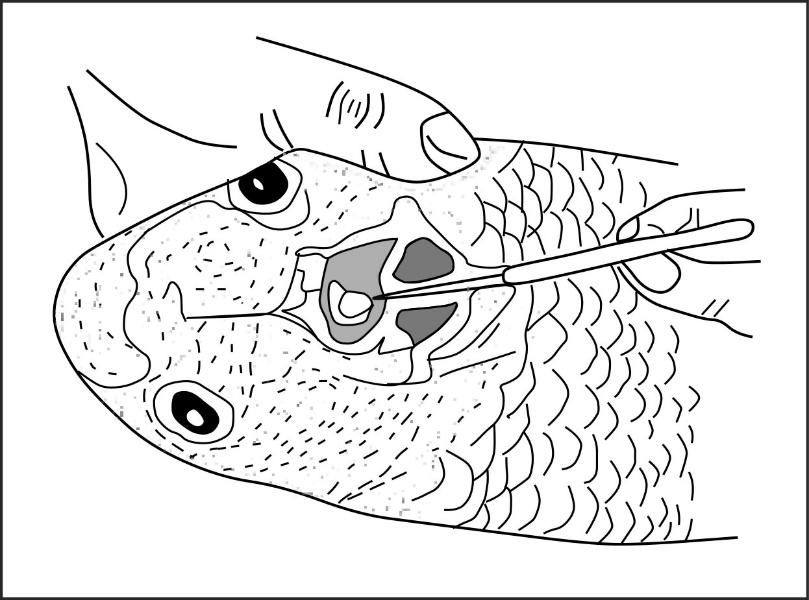


Figure 3.  The pituitary gland is completely exposed following removal of cranial bone and brain from the carp head.

**2. Preservation of Gland**

The collected gland can be preserved for a period of a week or so. After removal, the pituitary glands are immediately kept in absolute alcohol in sterile vials and other bottles for preservation. The absolute alcohol method is widely followed in India while acetone dried method is widely used in the USSR and USA. Freezing method is also used for storage of glands.

* Pituitary glands can be preserved in 100% ethyl alcohol.
* Acetone can be also used for preservation of glands in other temperate countries.
* Glycerine can also be used in the preservation of pituitary glands.

**3. Preparation of Gland Extract:**

The pituitary glands obtained from donor fishes are macerated to form an extract which is injected into the ripe breeders and force them to spawn.

* The known amount of pituitary gland is taken by measuring the total quantity of fish which are bred.
* The pituitary gland is then dried in air by using blotting paper.
* After drying the gland is taken in a tissue homogenizer with a small quantity of distilled water.
* The grade of dilution is 0.2 ml/kg of body weight of the fish.
* The pituitary extract is then centrifuged and only the supernatant part of solution is used for injection in fishes.

**4. Brooders Selection:**

The selection of ripe brooders is a very important step in this technique because if brooders are not mature, healthy or fully ripe then this technique doesn't give appropriate results.

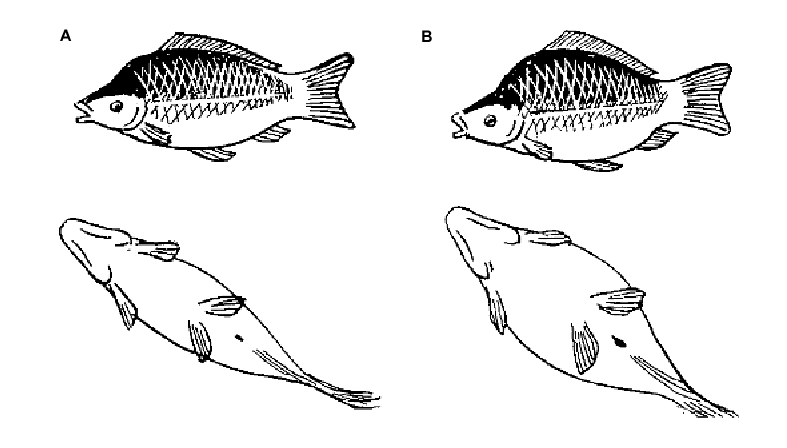
* The brooders must be healthy enough and ripe.
* 2 – 4-year-old fishes are generally selected.
* The body weight of fishes is preferably 1 – 5 kg.

**Characters for the identification of Male and Female mature Indian carps:**

Salient features of male and female carps are described below in table 1, as well as in figure 4.

**Table 1.** Comparison of characteristics of male and female carp.

| **MALE FISH** | **FEMALE FISH** |
| --- | --- |
| The inner surface of pectoral fin is rough | The inner side of pectoral fin is smooth |
| The abdomen is narrow | The abdomen is soft and bulging |
| The vent (genital region) is whitish in color and remains inwards | The vent is pinkish in color and remains protruded |
| When the abdomen is pressed gently milt oozes out | When the abdomen is pressed eggs are released |

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**Figure 4.** Common carp; Male (left) and Ripe female(right) (Costa Pierce et al., 1989)

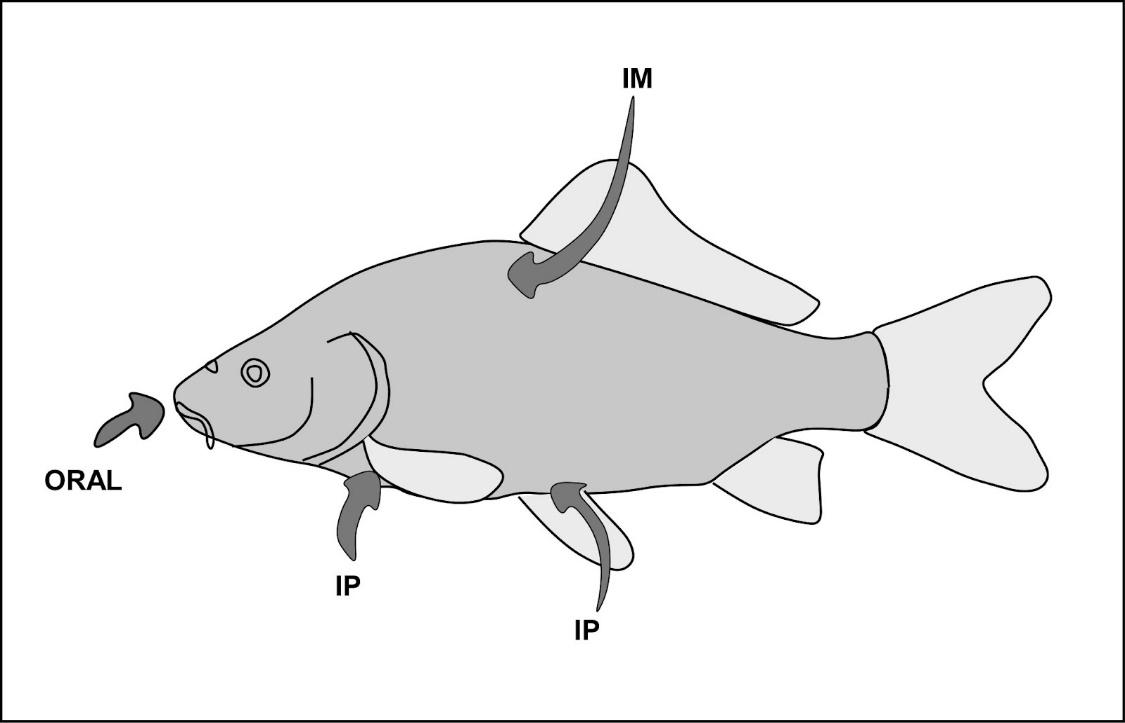
**5. Injection to the Brooders:**

**Types of injection:**

* **Homoplastic injection:** Injecting pituitary gland extract from one fish and used in closely related fish of the donor species. E.g., carp pituitary gland extract to carps.
* **Heteroplastic injection:** Injecting pituitary gland extract from one fish to another distantly related fish of the donor species. E.g., carp pituitary gland extract to catfish and vice versa.

**Process of injection in fishes:**

* It is very important to determine the correct dosage of pituitary gland extract which are given to breeders.
* The dose of pituitary extract depends on size and state of maturity of recipient (breeders) and it also depend upon the state of maturity of donor fishes
* The pituitary extract is administered into the body of breeders by means of hypodermic syringe either intramuscular or intra peritoneal.
* The female fish are usually given two doses of injection whereas the male given only a single dose of injection.
* Generally, females are given a preliminary dose of 2-3 mg/kg of body weight. The preliminary dose is not given to the male. After an interval of time about 6 hrs a second dose of 5–8 mg is given per kg of body weight of the female fish.
* The male was then given the first dose of injection with female @ 2-3 mg/kg of body weight. The doses of hormones depend upon the maturity of fish, age, sex and also the environmental conditions.
* For intramuscular injection, the fish is laid on its side while held in a hand net and the needle is inserted either in the caudal peduncle or in the shoulder (Figure 5, and 6). For intraperitoneal the injections are given in the bases of paired pectoral fins. But it is avoided because less expert hands can puncture the heart of the fish (Figure 5).



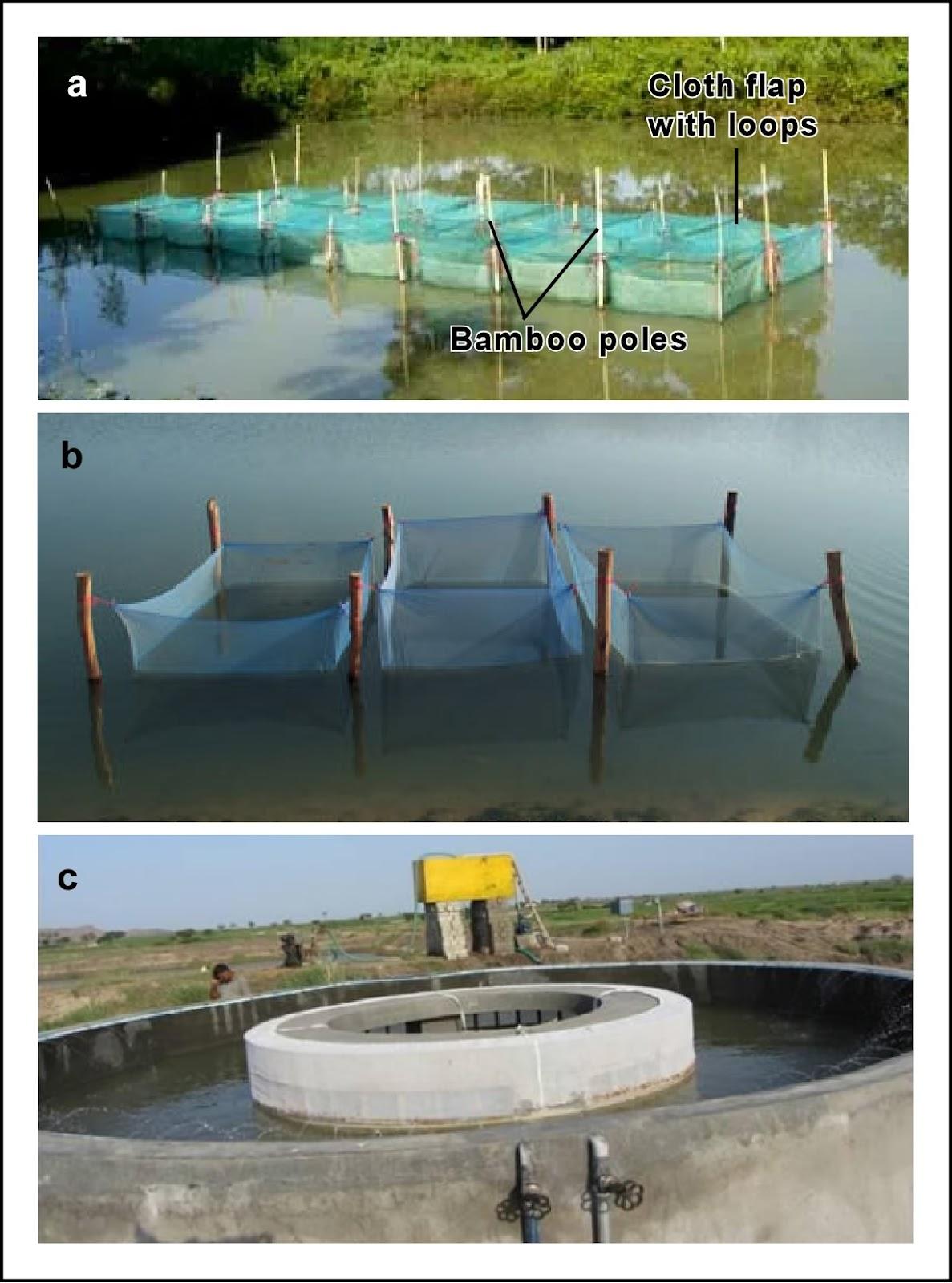
**Figure 5.** Three routes (Oral; Intramuscular, IM; and intraperitoneal, IP injection or slow release implant) for administering spawning hormones to fish.



**Figure 6.** Photograph displays intramuscular injection in carp fish.

**6. Spawning:**

After injecting hormones to the brooders (male and female) a set of brooders are immediately released into breeding hapa or circular breeding hapa for spawning. The one set of brooders usually consist of one female and two males. In hapa breeding the hapa is the box-shaped container, rectangular, fine netting and is fixed by four bamboo poles one at each corner in the pond (Figure 7a). The hapa is made up of fine meshed markin cloth or close meshed mosquito net. The thick markin cloth is not used as it restricts proper circulation of water which leads to suffocation. Closed mesh mosquito netting is preferred for that purpose, as it meshes will allow a good circulation of water and will also not let the laid eggs and milt escape through the meshes. The hapa measures the range of 3m × 1.5m × 1m for breeders weighing 3 to 5 kgs. The height of the hapa should remain about 20 cm above the level of water (Hossein et al.,2021). The hapa is closed on all sides but the roof can be open or closed as required (Figure 7a, b). Nowadays other than breeding hapa, Chinese hatcheries are in trend. These breeding tanks are circular in shape of about 2m in diameter and 1m deep (Figure 7c). After 2-3 hours of the second injection, the breeders start swimming actively, become excited and restless. Males start chasing the female, pushing her with the snout. The spawning takes place within 3-6 hours following the second dose. While injection may be given at any time in the day but cool, cloudy and injection in the evening give more appropriate results. Spawning occurs at midnight if the second injection was given in the evening. Successful induced breeding results in the spawn of fertilized eggs. Then fertilized eggs are transferred into the hatching hapas for hatching. In *Osteobarma belangeri,* it is found the success rate of spawning is depend on the rate of inducement and also type of inducing agent used (Das et al. 2016).



**Figure 7:** Different types of hapa **(a)** Breeding hapa **(b)** Hatching hapa **(c)** Operation of the Chinese hatchery

The fertilized eggs are crystalline, transparent and pearl like. They come to the upper side of the surface on slight movement of water, whereas unfertilized eggs are opaque or whitish in color as shown in figure 8 (Hossen et al. 2021).

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**Figure 8.** Photograph of fertilized and unfertilized eggs of *Mystus gulio*.

**Role of other natural and synthetic hormones in induced breeding:**

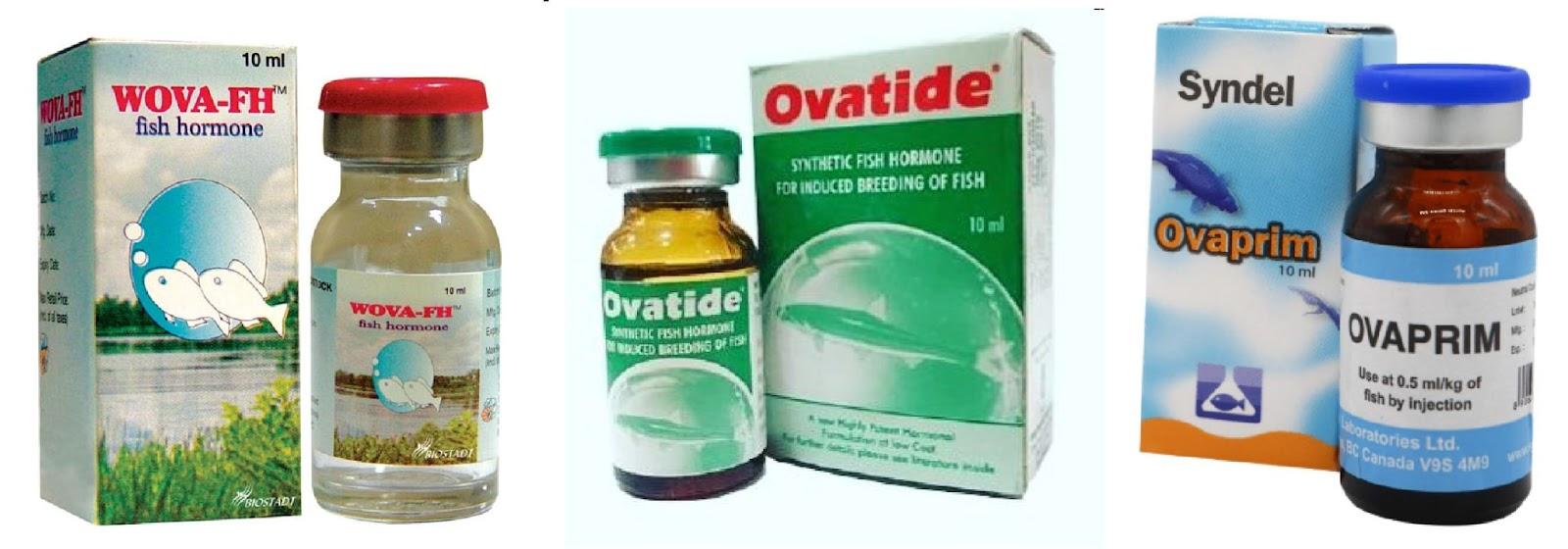
Hormones play a crucial role in inducing reproduction in fish. GnRH analogues (Gonadotropin-Releasing Hormone analogues) are often used in combination with dopamine antagonists to stimulate reproductive processes. Additionally, the injection of gonadotropins, such as HCG (Human Chorionic Gonadotropin), can also trigger spawning and oocyte maturation in fish (Park et al., 1992). These hormone-based techniques have been extensively employed to control and manipulate fish reproduction in aquaculture and research.

Fish pituitary was mainly used for induced breeding but due to difficulties in the preparation of injection and preservation of pituitaries, nowadays synthetic hormones like LHRH-a, HCG, WOVA-FH,Ovatide, Synahorin, Ovaprime, are used (Figure 9).

* **LHRH-a and Domperidone -** LHRH-a (Luteinizing Hormone-Releasing Hormone agonist) and domperidone is used to induce oocyte maturation and ovulation in bighead carp, *Aristichthys nobilis* (Richardson) (Armando C F, 1991).
* **HCG -** Human Chorionic Gonadotropin used to induce ovulation in fish. HCG offers three major advantages;
* HCG is more cost-effective.
* It has a longer shelf life due to better stability.
* It is available in a purified form.

HCG injected to *Labeo rohita* @ 460-2010 IU/kg body weight did not precipitate spawning.  However, it has been reported that *Labeo rohita* could be bred by injecting HCG @ 600 IU/kg body weight in a few cases. In the case of silver carp, successful spawning could be achieved by injecting HCG (Organon) alone @ 630-660 IU and also with HCG 240 IU + 12 mg carp pituitary per kg body weight.

**WOFA-FH** - WOVA-FH, a synthetic Gonadotropin Releasing Hormone analogue (SGnRH), has proven to be effective for induced breeding in Indian Major Carp, Exotic Carp and Catfish. SGnRHs are often used to manipulate reproductive processes in fish, and their success in inducing breeding are a valuable tool in aquaculture and fisheries management.



**Figure 9:** Few synthetic hormones, which are popularly used in induced breeding.

* **Ovatide -** Ovatide is an indigenous, cost-effective and hormonal formulation for induced breeding of fishes. It is also effective in breeding major carps. The doses for females are 0.20-0.40 ml/kg for rohu and mrigal, 0.40-0.50 ml/kg for catla, silver carp and grass carp. The dosages for males are 0.10-0.20 ml/kg for rohu, mrigal, 0.20-0.30 ml/ kg for catla and 0.20-0.25 ml/kg for silver carp and grass carp. It gives high fertilization and hatching percentage about (85- 95%).
* **Synahorin - S**ynahorin (a mixture of CG and mammalian pituitary extract) in combination with pituitary gave positive results when injected to rohu and silver carp, but failed to induce spawning when tried alone in rohu.
* **Ovaprim - I**t is the new inducing hormone for fish and an absolute substitute of pituitary extract though it’s costly. Ovaprim is far superior to carp pituitary in inducing spawning in several species of carps (Marte et al. 1987, Sharma and Singh 2012, Nandeesha et al. 1990).

1. The rates of fertilization and hatching were generally higher in Ovaprim treatment when compared to pituitary.

2. The size of eggs after water hardening was always considerably bigger in Ovaprim treated fish as compared to that of pituitary treatment. This probably indicates complete development of eggs.

3. The spawning response time was almost equal in both Ovaprim and pituitary treatments.

4. The hatchlings obtained from Ovaprim treatment appeared to be healthier than those produced with pituitary. However, this aspect is being confirmed.

5. Based on the observations of the present study, the dosage of Ovaprim required for female brood fish of various species is as follows:

• Catla 0.40 to 0.50 ml/kg

• Roku 0.30 to 0.40 ml/kg

• Mrigal 0.25 to 0.30 ml/kg

• Silver carp 0.50 to 0.70 ml/kg

• Grass carp 0.50 to 0.70 ml/kg

• Bighead carp 0.50 ml/kg

• Bata 0.50 ml/kg

• Fringe-lipped carp 0.50 ml/kg

6. Although the dosage required for males of various species could not be standardized, it appears that males of most species will respond to 0.10 to 0.20 ml/kg. On several occasions, males could be induced with dosages of 0.10 to 0.15 ml/kg.

7. The post-spawning mortality of Ovaprim treated fish was negligible due to relatively less handling in comparison to pituitary treatment.

8. Ovaprim does not require refrigerated storage and hence can be preserved at ambient temperature.

**Factors influencing induced breeding:**

Environmental factors and doses of hormones also influence the induced breeding. Favourable climatic conditions are crucial for successful induced breeding. Failures can result from various factors including incorrect selection of breeders, improper doses of pituitary extracts and unfavourable weather conditions. It's interesting to note that hot, salty or sunny days are not ideal for induced breeding. Environmental factors such as light, temperature, water condition etc. influence the release of pituitary gonadotropins, which in turn control fish reproduction.

Climatic factors have a more pronounced impact on fish physiology compared to terrestrial animals, and aquatic ecosystems are generally more sensitive to environmental changes. As a result, the aquaculture industry is particularly vulnerable to the adverse effects of climate change (Pankhurst and Porter, 2003). The dynamic nature of aquatic environments makes them more susceptible to shifts in temperature, precipitation, and other climate-related factors, which in turn affects fish production and the overall sustainability of aquaculture operations.

Rainfall is a vital factor for the acceleration of sensational responses and hormonal functions of fish (Servili et al., 2020). In recent years, studies have shown that extreme temperature and rainfall events are adversely affecting the production of fish fry in hatcheries (Lebel et al., 2016). Moreover, extreme climatic events are pushing production back by damaging hatchery infrastructure and brood stock.

1. **Light:** Light plays a crucial role in regulating the reproduction of fish. Extended photoperiods can lead to early maturation and spawning of fish. In India *Cirrhinus reba* is observed to attain early maturity in day time.
2. **Temperature:** The environmental temperature influences the sexual maturation and breeding of fishes. The presence of optimum temperature ranges and critical limits, beyond which fish won't reproduce, is a consistent finding. Warm temperatures play a central role in stimulating gonadal maturation and accelerating spermiation in many fish species. This suggests that temperature directly impacts gonads and indirectly affects their responsiveness to pituitary stimulation, consequently influencing the synthesis and release of gonadotropins. For Indian major carps, it's noted that their breeding occurs within a temperature range of 24°C to 37°C, with the best temperature being around 27°C (Chaudhary 1968). Breeding success diminishes significantly beyond 30°C.
3. **Water currents and rain:** The rheotactic response to water current, where fish are influenced by the flow of water, is well-established. Rainfall becomes a prerequisite for the spawning of major carps, even when they're given pituitary extract injections. It's observed that a stronger monsoon with increased rain leads to greater water current, which in turn stimulates maturation and gonadal activity. Successful spawning in many fish species is induced during cloudy and rainy days, particularly after heavy showers. This is significant as the cool and cloudy weather seems to attract the fishes, contributing to the overall success of the spawning process.
4. **pH:** The carps can breed within a wide pH range. However, alkaline pH levels are essential for successful breeding.

**Advantages of Induced breeding:**

There are many advantages of induced-breeding which are given as follows;

* It gives pure spawn of certain species of fishes under cultivation. Spawn collected from natural water is not pure because some undesirable wild species may come with them in culture ponds. Sorting of pure seed is quite impossible in those stages. In later stages it is possible, but time consuming.
* It assures timely availability of pure seed, whereas in nature the availability of desirable seed of specific fish species is quite uncertain.
* It can fulfill any quantity of demand at any time.
* It also cuts short the holding potential spawners over long periods in uncertain hope of their breeding in time. Many carps take their full maturity in confined water but do not breed.
* The technique is very simple and does not need too much technical assistance or knowledge. It can be easily learnt by a layman without much training.
* The cost of expenditure is very low than the natural collections of spawns.

**CONCLUSION:**

Induced breeding technique, primarily of Indian major carps (IMC) a great landmark in the aquaculture development in India and other countries and it also made blue revolution possible. Carp-like fish which are usually cultured in ponds, do not breed in captive conditions due to environmental or hormonal factors. The environmental factors like temperature, rain current of water directly affect the hormonal activity of the pituitary gland gonads. In captivity, these conditions are not fulfilled so there are no sufficient hormones released and fishes do not breed in captivity. Success in inducing major Indian carps to breed in confined waters by injection of fish pituitary gland hormones and other synthetic hormones is an important event in the history of fish farming industries.

The successful induction of breeding in major Indian carps through the use of fish pituitary gland hormones marked a significant advancement in the field of fish culture in India. This breakthrough not only transformed traditional fish rearing methods but also opened up extensive opportunities for the growth of pond fish culture, not just within India but also across other Asian countries with similar fish culture practices. This innovation has had a profound impact on aquaculture practices and fisheries management in the region.

Indeed, through continued refinement of breeding and hatching methods, along with the establishment of standardized hormone doses, there's potential to fulfil a substantial demand for high-quality fish seeds in India. The simplicity of the method means that private fish culturists can learn it with dedicated effort. To spread awareness of this technique, it's crucial to set up an ample number of demonstration centers across the country, involving fisheries experts in the process. This approach will play a key role in popularizing and disseminating the successful breeding technique.

The demand for artificial production of fish seed is anticipated to increase significantly in the coming years due to the potential scarcity of fish seed in natural habitats. Rapid industrialization in India has led to the establishment of numerous factories, resulting in the discharge of substantial amounts of waste into rivers nationwide. Unfortunately, these factory effluents have a detrimental impact on water quality, causing pollution and adversely affecting riverine fisheries in the process.

The important highlighted factors affecting riverine fisheries. The construction of dams has indeed hindered fish migration and altered natural spawning environments, leading to a decline in fish populations. Additionally, frequent floods during monsoon months and the construction of embankments have further impacted fish spawn collection and disrupted natural habitats. Given these challenges, there's a growing concern that riverine fisheries will continue to decline, making it increasingly difficult to obtain an adequate quantity of fish seed from these areas. This emphasizes the growing necessity for artificial fish breeding methods to meet the demand for fish seed in the face of these challenges.

This placing greater emphasis on the development and widespread adoption of induced breeding techniques for fish is a prudent step. Ensuring a consistent supply of high-quality fish seed is vital for successful intensive fish cultivation and the growth of inland fisheries. This method holds great potential for enabling economic estuarine fish varieties to breed successfully, thereby providing valuable seed for brackish water fish farming. By focusing on advancing this technique and promoting its usage, it's possible to address the challenges posed by changing riverine environments and industrialization, ensuring a sustainable future for fisheries.

The conducted experiments have yielded promising results and provided a solid foundation for ongoing research. There's a strong push to refine the techniques further, and the collective efforts being made are expected to contribute to increase the production of fish seed of preferred varieties on a commercial level. With dedicated endeavors and collaboration from all sectors, there's a belief that this progress will enable India to meet its demand for fish seed and further advance the field of fish culture.

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