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Comprehensive review on Indian major carps: An integrated approach to pond cultivation, nutrition, and health management for sustainable aquaculture

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Abstract
Indian major carps (IMCs) are of great importance in freshwater aquaculture across the Indian subcontinent. This review article presents a comprehensive approach to successfully cultivating IMCs in aquaculture ponds. It covers various aspects, including taxonomy, pond preparation, broodstock maintenance, nutritional requirements, health management, water management, and biosecurity. The overview section highlights the ecological significance, economic contributions, and distribution of IMCs in the region. A detailed taxonomic classification facilitates proper species identification and management. Pond preparation is critical for optimal growth and reproduction of IMCs, with considerations such as pond design, soil quality, water source, and liming outlined. Maintaining healthy brood stock is vital for consistent production and genetic integrity. The article covers broodstock selection, breeding techniques, and management practices. Nutritional requirements are thoroughly addressed, with essential nutrients, feed formulations, and feeding strategies discussed for different life stages. Effective health management practices are pivotal in mitigating diseases and promoting fish welfare, with preventive and therapeutic measures, vaccination, and disease surveillance protocols explored. Water management principles, including quality monitoring, oxygenation, and nutrient management, are discussed for a healthy environment. Lastly, biosecurity measures are emphasized to prevent disease introduction and spread, with protocols for quarantine, disinfection, and farm isolation presented. In conclusion, this comprehensive review provides valuable insights into an integrated approach for successful Indian major carp aquaculture, promoting sustainable practices for improved productivity and long-term viability.

Keywords: Indian Major Carps, Fish, Rohu, *Catla*, Mrigal

Introduction

Indian giant carps (IMCs), along with fish species such as *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*, are economically important freshwater fish species widely cultivated in the Indian subcontinent They are highly valued for their meat quality, fast growth rate, and adaptability to various environmental conditions. The cultivation of IMCs plays a crucial role in the aquaculture sector, contributing significantly to food security and livelihoods in the region. To ensure sustainable and profitable IMC aquaculture, it is essential to adopt an integrated approach that encompasses various aspects of pond cultivation, nutrition, and health management. This comprehensive review aims to provide a comprehensive understanding of these critical aspects, enabling aqua culturists to make informed decisions and implement effective strategies. The taxonomy section of this review presents a detailed classification of IMCs, highlighting the taxonomic characteristics and differences among various species. This knowledge is crucial for proper identification and management of the species, which ultimately influences the success of aquaculture operations [1].

Pond preparation is a fundamental step in creating a suitable environment for IMCs. It involves careful consideration of factors such as pond design, soil quality, water source, and liming. Proper pond preparation not only enhances the growth and survival of IMCs but also minimizes the risk of diseases and improves water quality [2]. Broodstock maintenance is crucial for consistent production and genetic integrity. Selecting healthy brood stock, implementing effective breeding techniques, and maintaining optimal conditions for their growth and reproduction are essential. This section explores key principles and practices for broodstock management in IMC aquaculture [3]. Meeting the nutritional requirements of IMCs is vital for their growth, development, and overall performance. This review article delves into the essential nutrients, feed formulations, and feeding strategies for different life stages of IMCs. It also discusses innovative approaches to enhance feed efficiency and reduce feed costs [4]. Ensuring the health and well-being of IMCs is crucial for sustainable aquaculture. Effective health management practices, including disease prevention, early detection, and appropriate treatment, are essential. The article provides insights into disease surveillance, vaccination, and management protocols to maintain healthy fish populations [5]. Water management is another critical aspect that significantly influences IMC cultivation. Proper water quality monitoring, oxygenation, and nutrient management are essential for maintaining a healthy and productive aquaculture environment. This section explores various water management strategies to optimize the growth and survival of IMCs [6]. Finally, biosecurity measures are crucial in preventing the introduction and spread of diseases in IMC farms. This review highlights the importance of implementing biosecurity protocols such as farm isolation, quarantine procedures, and disinfection practices. It emphasizes the significance of biosecurity awareness and adherence to prevent potential losses [7]. In conclusion, this comprehensive review aims to provide a holistic understanding of the integrated approach to pond cultivation, nutrition, and health management for sustainable IMC aquaculture. By incorporating the latest research findings and best practices, this review serves as a valuable resource for aqua culturists, researchers, and policymakers involved in IMC farming.

Taxonomy

The taxonomy of major Indian carp represents the Animalia Kingdom, Chordata Phylum, Actinopterygii Class, Cypriniformes Order, and Cyprinid Family (Table 1).

Table 1: Taxonomy of Major Indian Carps

S. No	Taxonomy	*Catla catla* (Catla)	*Labeo rohita* (Rohu)	*Cirrhinus mrigala* (Mrigal)	*Labeo calbasu* (Calbasu)
1	Kingdom	Animalia	Animalia	Animalia	Animalia
2	Phylum	Chordata	Chordata	Chordata	Chordata
3	Class	Actinopterygii	Actinopterygii	Actinopterygii	Actinopterygii
4	Order	Cypriniformes	Cypriniformes	Cypriniformes	Cypriniformes
5	Family	Cyprinidae	Cyprinidae	Cyprinidae	Cyprinidae
6	Genus	Catla	Labeo	Cirrhinus	Labeo
7	Species	*Catla catla*	*Labeo rohita*	*Cirrhinus mrigala*	*Labeo calbasu*

***Catla* (*Catla catla*)**

Catla is a major carp in India and is cultured along with column and bottom-feeding fishes as a composite culture {Fig 1) [8]. They breed in fields that are flooded, and dry bunds by triggering riverine conditions in ponds and grow outs. During the southwest monsoon, they breed in natural habitats where the seeds are available from hatcheries and breeding grounds from May to August. The induced breeding of catla marks its success in stagnant waters of fish ponds [9]. The feeding regime of catla varies from fingerlings to adults where the fingerlings feed on zooplankton, supplementary feeding, and commercial feeds, on the other hand, adults feed on meroplankton, vegetable matters, supplementary feeding and commercial feeds available in the market [10]. The catla has a black color body with dusky grey fins, tails, and a silvery white belly. The body shape of a catla has a deep and laterally compressed body, which means it is broad from side to side and flattened from top to bottom [11]. The mouth of Catla is large and directed upward, indicating its surface-feeding behavior. It is well-adapted for capturing food from the water's surface and the head is relatively large compared to its body size [12]. The main characteristic feature of catla is that it has lower jaws that protrude slightly and it can reach a maximum size of up to 63 kg which is known for its fastest growth, However, its size may vary depending on the habitat and growth conditions [13, 14]. The greater demand for catla is that it can be cultured via polyculture systems and contributes to 60% of the total production [15, 16]. The distribution of catla reserves to India and its subcontinents however countries like Israel and Japan had their cultures way back in 1954 and 1960 respectively. In India, Catla is found in various river systems and water bodies throughout India. It occurs in the Ganges, Brahmaputra, Mahanadi, Godavari, Krishna, and Cauvery River basins, among others. It is also found in many lakes and reservoirs across the country [17]. Catla is present in the rivers and water bodies of Pakistan, particularly in the Indus River system, and is widely distributed in the rivers and water bodies of Bangladesh, making it an essential fish species for the country's fisheries and aquaculture industry [18]. Catla has been widely distributed to various countries like Sri Lanka, Laos, Malaysia, Thailand, Vietnam, Bhutan, and the Philippines for aquaculture and fisheries purposes.

Rohu (*Labeo rohita*)

Rohu (*Labeo rohita*) is a freshwater fish species belonging to the family Cyprinidae (Fig 1). The most important and extensively cultured carp species in South Asia. It is widely distributed in rivers in ponds and is considered a native of North India, Orissa, and Bengal as well as in the Indian subcontinents [19]. The fish is in great demand due to its delicious taste preferred by the people of India and other countries. The monsoon is considered the best for breeding for this fish in rivers and ponds. The *Labeo rohita* does not breed in stagnant waters and the significant feature of this fish is that it moves with the current of water before breeding and moves against the current of water during breeding in shallow watered ponds [20]. The induced methods have been widely practiced in India for breeding and the fish grows large but less when compared to the growth of catla. It takes 12 to 14 months for this fish to become sexually mature and the off spring range from 1.6 to 1.9 lakhs/gram body weight [21]. The feeding regime of rohu fingerlings and adults depends on daphnia, decomposed water material, vegetable matter, phytoplankton, and supplementary feeding along with commercial feeds available in the market. Rohu has an elongated and slightly laterally compressed body, which means it is slender and flattened from side to side. The dorsal profile of Rohu is more convex, giving it a slightly arched appearance. The body of Rohu is bluish above and silvery on the flanks. It possesses a reddish tinge at the dorsal, pelvic, anal, and caudal fins with reddish-colored eyes. Juvenile Rohu typically exhibits a dark band at the caudal peduncle, which may fade as they grow older. Rohu has fringed lips, and the maxillary barbells are prominent. Barbells are sensory organs located near the mouth, which help the fish locate food [8]. Rohu is extensively distributed in rivers, lakes, and other water bodies throughout India. It occurs in the Ganges, Yamuna, Brahmaputra, Mahanadi, Godavari, Krishna, and Cauvery River basins, among others. It is commonly found in North India, Orissa, Bengal, and other parts of the country. Rohu is also found in the rivers and water bodies of Pakistan, Bangladesh, Nepal, and Myanmar [13].

Mrigal (*Cirrhinus mrigala*)

Mrigal (*Cirrhinus mrigala*) is one of the major species of Indian carp, widely distributed in rivers, lakes and other fresh water bodies in India and neighboring countries (Fig. 1). Other species of mrigal such as *C. cirrhosa, C. latia, C. reba, C. fulungee* is also produced on a small scale [21]. The mrigal is an economically important fish in aquaculture, its culture has spread due to its suitable stimulated reproduction and rapid growth It is an important animal for polyculture systems in India and other parts of South Asia, and contributes significantly for fish production in the region. The mrigal averages about 40 cm in length. It is present but in favorable conditions can grow large, and is widely distributed in rivers, lakes and growing areas in India [8]. The mrigal generally breeds during the rainy months. It is well suited for induced breeding, and fingerlings spawn on natural soil from July to November. Both young rabbits and adult dogs eat primarily animal protein. Both male and female dogs reach sexual maturity at about two years of age. However, stimulated fish species are believed to mature within a year [13]. The fawn has a beautiful body, with a rounded belly and deep tail wings. The jaw is depressed, and the mouth is broad and rounded downward. The two sensory organs near his mouth are barbels. The body color of the cat is bronze, with white and golden flanks. The eyes are goldened. The shark is found chiefly in the rivers and lakes of northern India. It is also well established for aquaculture in South India. It is also known to inhabit the waters of Pakistan, Bangladesh and Burma.

Fig 1: Indian Major Carps

Maintenance of the Broodstock

The proper selection and management of brood fish are indeed crucial for successful breeding and growth outcomes in aquaculture. When choosing brood fish, it is essential to focus on characteristics such as good health, robustness, and desirable genetic traits. Rather than solely relying on fast growth and size, consider other factors like disease resistance, reproductive performance, and overall vigor [22]. Inbreeding can lead to reduced genetic diversity, lower growth rates, and an increased risk of deformities in the offspring. To mitigate this, it is recommended to avoid selecting brood fish from the same stock or their offspring. Instead, sourcing the brood fish from different origins helps to maintain genetic diversity. Segregation of the male and female brood fish from the regular culture tank for at least three months is considered vital before the breeding season. This separation helps avoid unwanted breeding and allows the brood fish to be conditioned properly for successful reproduction [23]. Secondary sexual morphological characteristics are used to identify males and females (Table 2). Males typically release milt when gently pressed on the abdomen, while females have a swollen abdomen due to developed ovaries [24]. The brood fish is maintained in suitable conditions with sufficient space and a well-balanced diet and Fed with a protein-rich diet that helps in gonadal development and ensures the production of high-quality eggs.

Table 2: Secondary external morphology of the Indian Major Carps

S. No.	Characteristics	Male	Female
1	Operculum, scale and pectoral fins	Rough on the dorsal surface of the pectoral	Smooth and slippery pectoral
2	Abdomen	Firm and round	Soft and swollen
3	Genitals	Slit elongated, non-swollen, and white in color	Pink in color and round-shaped
4	Abdomen opening on pressure application	Oozing of milky fluid via genital opening	Oozing of scarce ova via genitals
5	Size and body shape	Swollen and linear body	A stouter slightly large body

Spawning of Indian Major Carps

Originating from the Indian subcontinent, the Indian Major Carps depend largely on Humans for proliferation, chiefly through an incitation procedure labelled as induced spawning to help in the reproduction of these species. A principal determining factor for ensuring successful reproduction is the utilization of hormone-induced spawning techniques, which this process primarily depends on.

Specifically, traditionally applied spawning induction methods are cantered on the strategic introduction of gonadotropic hormones extracted from a myriad of sources, which, compellingly enough, encompass elements such as carp pituitary gland extracts, mammalian gonadotropic hormones, and notably, semi-purified fish gonadotropic hormones. Human chorionic gonadotropin- HCG assumes a crucial role in this process [25]. It's intriguing to note that the quantity of the engrained pituitary gland extract quite intriguingly is contingent upon both the physical maturity level of the Indian Major Carps themselves as well as several varying environmental circumstances like temperature and rainfall which existed in the setting [26].

Hourly allocation of administered hormones has a strategic twofold structure- initiating with an upfront primary quantity range spanning from 1 through 2 mg/kg followed by a sequent escalated dosage ideally encapsulated within 6-8 mg/kg intended per body weight of the fish amounting approximately seven hours later. The subsequent course of action pivots upon precisely shifting the sexually mature Carps, or brood fish, into what is known as a breeding hapa while preserving a ratio that establishes a count of two males for every single female. However, it is paramount to ensure implementation is rooted in data [27].

The term breeding hapa refers to a precise fish cultivation setup or manifestation, which upon closer look, resembles a cubic frame fitted with a textile wrap. A count of 50,000 to 1,00,000 eggs can be nestled and successfully hatched within a cloth-related hapa setup originating from dimensions of 2 x 1 x 1 meters respectively. It's fascinating to understand that the objective is to build a containment facility with a flexible notch at its top to promote opportunities for conveniently opening or closing the upper flap design segment only when necessary. Leaflets or corners of the body that extend from all stations on the primary fabric are completed by tying ropes around posts stationed at particular points to provide a support structure and maintain its' upright integral shape. Maintaining that the floor remains untouched in any situation for hapa efficacy. Fundamental for keeping an appropriate aquatic environment; cautiously preserving the water temperature circulating typically around 26 to 31° Celsius. Cultivating warm favorable conditions in this closer proximal range propels and greatly optimizes the potential for favorable spawning.

To notice scalable results in spawning efficiency, do observe that this phenomenon typically ensues not before sixteen to eighteen hours. Continued to come out as favorable hatchlings into external segments of the hapa setup comes along as a reactive procedure hinting at cycling- encompassing repetition of conclusive stages frequently [28]. Needless to say, further to say. If releasing hormones is restricted to appropriate administration at calculated time certainty, a sequent commencement of breeding activities reasonably ensues quite predictably overall as a standard demarcated averaging timescale result falling optimal breeding measures within specific gap time listing anywhere between four extended through six hours right from the proceeding second hormone dosage dispatch time-wise.

Methods of Injection

Often used in the sphere of aquaculture for nurturing numerous types of fish including Indian major carps and various kinds of freshwater species, there are three conventional means of injections. Injection in this respect means a procedure where hormones or types of pituitary extracts are administered to achieve the objective of cultivation.

The first method to be recorded is Intramuscular injection. Typically, in this procedure, the concoction of hormone or pituitary extract is transplanted directly into the fish's muscle. Here, the muscle grounding is located on the caudal peduncle, a specifically tapered factor of the fish's body architecture endearing itself immediately before the tail fin. Strikingly, the site picked for injection meditates a region found to bridge between the square tail end of the dorsal fin and surmounts beyond the lateral line. Acknowledged widely as one of the safest techniques with incomparable efficacy, the involvement of the risk factor for harm administration in the application of intramuscular injections naturalizes itself organically.

Second comes the Intraperitoneal injection. This strategy warrants the assimilation of the hormone or certain kindred extracts into soft and determined zones within the fish's anatomy e.g., the base foundations of the pelvic or pectoral fin. In this method, the hormone transfuminum takes place in the body cavity, also mentioned academically as the peritoneal cavity, of the aquatic being. However, this methodology might graze a sharper side of the invasive practice and subsequently be qualified with a distinctively higher risk value that measures possible damages incurred upon the gonads or anatomical factors like the liver of the said fish creature. The contrast reinforces vis-a-vis the proportion of established intrusion risks through the intra-muscular method.

The last listed method sits as the Intracranial injection. Highly pensive in its venture, this technique advances, rendering it a risk-prone concept in comparison to the other methods laid earlier. The process entails prospects of the applied hormone coursing directly to map onto the cranium or what is also biologically referred to as the 'head' area of the fish. Under most circumstances, the glory of preferred use seldomly graces the ingress of Intracranial injection owed to the lurking anxiety and unwitting potential characterized by severe impairments on the fish's cortex which can fiercely direct itself to exceedingly life-threatening harm invoking upon the fish itself.

Seed rearing of Indian Major Carps

In the early stages of life, worms rely on food in their gallbladder sacs. However, after 3-4 days, they make the adjustment based on the natural foods available in their area. Access to an environment rich in natural foods is essential to ensure maximum survival during this critical time. The nursery pond is where carp eggs are raised as fry, which usually last 15-20 days. The depth of the nursery pond is about 1 m. The size of nursery ponds varies depending on the number of crops, with ponds ranging from 0.02 to 0.1 ha suitable for small crops and up to 0.5 ha suitable for large crops moderate ponds are preferred in than permanent rearing ponds. This is because seasonal ponds provide favorable conditions for natural foraging and are more conducive to achieving a higher survival percentage of carp spawns. Furthermore, compared to larger ponds, small ponds offer many advantages in terms of efficiency. The smaller size allows for better management and control, making it easier to maintain suitable environmental conditions and optimize the availability of natural feed for the growing fry. To ensure successful fry rearing, adequate care, and preparation should be taken before the initial stocking of carp spawns. This includes creating a congenial environment with proper pond preparation, weed management, eradication of predatory and weed fish, and the application of suitable fertilizers to promote zooplankton growth, which serves as a food source for the carp spawns during their early stages. Proper acclimation and post-stocking feeding are also crucial to achieving a higher survival rate and enhanced growth for the carp fry [29].

Pond Preparation

The first step is to prepare the pond to provide a pleasant environment and abundant edible life. Wet-season ponds allow pond water to drain and dry to facilitate oxidation of organics, hydrogen sulfide and ammonia deaeration, kill pathogenic microorganisms and predatory weed fish The pond is then thoroughly drained to further aid organic matter breakdown The liming process is carried out adjust soil pH, promote mineralization of organic matter, release soil-bound phosphorus into the water, and disinfect the pond bottom Liming materials may include agricultural lime ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), calcium oxide or quick lime (CaO). Nutrients are then applied to increase pond productivity by replenishing water from a suitable source [30]. Non-aquatic or permanent remediation is carried out by removing unwanted aquatic weeds from competition with carp competing for resources [31] and removing unwanted predators or fish species from lakes to protect carp [33]. Pond productivity depends on soil quality, including pH, water retention, texture, total organic carbon, available nitrogen, available phosphorus and other factors There are Lime is used to adjust soil pH, mineralize organic matter, release soil-bound phosphorus into the water, and disinfect at the bottom of the pond Soil pH recommended for carps pond is between 6.5 and 7.0 Lime products such as agricultural lime and quicklime Can be applied in moderate amounts (usually 200 - 500 kg/ha) [31, 33].

Management of aquatic weeds

Poorly managed ponds that are infested with various types of aquatic weeds can cause several issues that negatively impact the overall health and productivity of the pond ecosystem. Some of the problems associated with weed infestations in ponds include:

1. **Reduced Phytoplankton Production:** Aquatic weeds compete with phytoplankton for nutrients and light, leading to reduced phytoplankton production. Phytoplankton is an essential food source for many aquatic organisms, including the larval stages of fish.
2. **Disturbed Oxygen Availability:** The presence of excessive aquatic weeds can lead to imbalances in oxygen availability. During the day, these weeds can cause supersaturation of oxygen due to photosynthesis, while in the early morning, they can deplete oxygen levels through respiration and microbial activity.
3. **Shelter for Predators and Insects:** Aquatic weeds provide shelter and hiding places for predatory fish and insects, making it easier for them to prey on other fish and organisms in the pond.
4. **Reduced Living Space:** The overgrowth of weeds can reduce the available living space for fish and other aquatic organisms, leading to overcrowding and reduced growth rates.
5. **Increased Siltation:** Some aquatic weeds, especially submerged ones, can contribute to increased siltation in the pond, which can negatively affect water clarity and quality.
6. **Obstructed Netting and Harvesting:** Dense weed growth can make it challenging to perform essential tasks like netting and harvesting fish from the pond.

Methods to control aquatic weeds

1. **Manual Removal:** Physically removing the weeds by hand or using tools like rakes and cutters is an effective but labor-intensive method, suitable for small-scale ponds.
2. **Mechanical Control:** Mechanical methods like winches and cono-weeders can be used to cut and remove weeds mechanically, often more efficiently for larger ponds.
3. **Chemical Control:** Applying herbicides is a common chemical method for weed control. Different herbicides like Anhydrous ammonia, Glyphosate, 2,4-D (2,4-Dichlorophenoxyacetic acid), Simazine, and others can be used to target specific weed types.
4. **Biological Control:** Some instances of biological control, like introducing specific herbivorous fish or insects that feed on the target weeds, can be employed to manage the weed population.

The prevention strategy depends on factors such as pond size, location of litter, available resources (time and money), and environmental considerations to minimize any negative impacts has been reduced. Manual methods are often preferred for smaller ponds due to their cost-effectiveness, while larger ponds may require a combination of different methods to effectively manage weed infestations. It's essential to use herbicides with caution, considering their potential impacts on the surrounding ecosystem and water quality. Proper management and control of aquatic weeds contribute to maintaining a healthy and productive pond environment [32].

Methods to eradicate predatory and weed fishes

It is important to control and eradicate predatory and weed fishes from the nursery pond before stocking carp seeds to ensure a higher survival rate and better growth conditions for the carp. The presence of such fishes can lead to competition for resources and space, negatively impacting the survival and growth of carp larvae. Various physical and chemical methods can be employed for eradication, depending on the feasibility and characteristics of the pond.

Physical Methods

1. **Drying:** Dewatering and drying the pond can effectively remove predatory and weed fishes. However, this method may not always be possible or practical.
2. **Hook and Lines:** The use of hooks and lines can be employed to catch and remove predatory fishes manually.
3. **Repeated Netting:** Regular netting of the pond can help in removing unwanted fish.

Chemical Methods

Containing the deadly rotenone, Derris root powder is known to eliminate zooplankton, benthic organisms, and insects. For optimal results, it is suggested to use 4-20 parts per million or 25 kilograms per hectare of the substance. Applying the mixture by spraying it onto the pond after it has been mixed with water is the recommended method. The detoxification process is expected to last around 14 days, with the best results coming from the treatment being administered when the temperature is over 25°C. Saponin is an ingredient in Mahua oilcake that is fatal to creatures such as frogs, snakes, turtles, and fish. The appropriate dose is 2500 kg/ha or 250 ppm. Soaking mahua oil cake in water for two to three hours and then scattering it in the pond is the most effective method. Detoxification typically takes around 25 days or three weeks, but you may decrease the toxin's potency by using an oxidizing agent or providing aeration. Containing saponin as well, tea seed cake proves beneficial. The detoxification process takes roughly 2 weeks after administering the requisite dose of 60 ppm or 200 kg/ha.

Under the chemical method, other substances like bleaching powder (350 kg/ha), urea and bleaching powder (added at specific doses), and anhydrous ammonia (10mg N/l) can also be used for eradication [34].

Zooplankton production and fertilization

To promote sustained zooplankton production, it is essential to ensure an adequate supply of nutrients, particularly nitrogen, and phosphorus, to support phytoplankton growth. Phytoplankton, in turn, is an essential food source for zooplankton. There are two main methods of nutrient addition: organic and inorganic.

Organic Fertilizers: Organic manure such as cow manure and poultry manure are commonly used to provide nutrients for phytoplankton growth. These wastes contain carbon, nitrogen and phosphorus, which promote zooplankton growth through the saprophytic food chain. Cattle manure and poultry manure are added to the pond for 15 days before sowing at specific rates: 5 – 6 tonnes/ha for cow manure and 2 – 3 tonnes/ha for poultry manure. Poultry manure contains 2 – 3 times more nitrogen and phosphorus compared to cow dung, so when both are used, a reduced dose of cow dung is applied in the presence of poultry manure.

Inorganic Fertilizers: Urea or ammonium sulfate is used as the nitrogen source, while the phosphorus source consisted of one salt and three phosphates. These inorganic compounds can be used to enhance nutrient concentration in the lagoon and promote phytoplankton growth, indirectly supporting zooplankton production.

Balanced Fertilization: Excessive fertilization can lead to blue-green algae blooms, which can negatively impact the lake ecosystem. To avoid this, a balanced approach is recommended. A combination of organic and inorganic fertilizers is suggested to ensure intensive phytoplankton production. For example, the recommended mixture could be 755 kg of soil cake or mustard oil cake, 210 kg of dried cow manure and 55 kg of superphosphate per hectare.

By carefully managing nutrient addition using a combination of organic and inorganic fertilizers, pond managers can support phytoplankton growth, which in turn enhances zooplankton production. This availability of zooplankton creates a favorable environment for successful fry rearing in the pond. Regular monitoring of nutrient levels and the pond ecosystem is crucial to maintaining a balanced and healthy environment for fish fry [35, 36].

Stocking of spawns

Before transferring spawns to the pond, the water is hydrogenated to prevent changes that could affect life expectancy. Stocking should be done in the morning or evening. In modified ponds, pay attention to low dissolved oxygen in plankton-rich ponds in the morning and high-water temperatures in the evening [37]. Test these factors and address these factors prior to storage and has given you a greater life. Recommended investments: 3 – 5 million/ha or 300-500/m^2 for growing ponds, and 10 – 20 million/ha or 1000-2000/m^2 for cement ponds.

Post Stocking of Spawns

Artificial food is important in pond rearing eggs because of its abundance. The meal consists of a 1:1 ratio of corn oil cake and fried rice. Initial dose of 6 kg/ml/day for the first 5 days, followed by 12 kg/ml/day for the remaining period to increase survival and growth If reared longer in hills lake, it reduces growth and survival. After 15 days, the eggs will be 25 centimetres long enough to be fingered. Harvesting is done with 1/8" diameter tools, and 40-50% is more common in well-designed ponds. Clay ponds can have 2-3 crops, while cement ponds can have 4-5 crops [38]. They are monocultured to raise the spawn.

Fry to Fingerlings rearing

Even though insect control is usually not necessary, fingerlings are stocked and reared in much the same way as for nursery ponds. The cow dung (averaging 3-4 tons/hectare) takes approximately ten days to decompose and, depending on local conditions, single superphosphate (30-40kg per hectare) is incorporated prior to stocking. After stocking, smaller amounts of cow dung (around 500 kg per hectare) and single superphosphate (10 kg per hectare) are applied twice each month. When poultry guild uses chicken manure, only half the quantity of cow dung is used Although some carps require a longer period for fingerling growth than is fit for most shrimp, polyculture changes this. It is important to acclimate the seeds from those distant places very well. For optimal growth of 25 mm fingerlings, stocking density varies between 0.1-0.3 million/ha without aeration, or 0.5-0.6 million/ha with aeration. In order to make polyculture succeed at a commercially valuable level, you need to:.3, .3, or .3: a ratio of 1:1:1 Catla, Rohu, and Mrigal at least To supply supplementary food to Carp fry, rice bran or wheat bran mixed in a 1:1 ratio with groundnut oil cake, mustard oil cake and cottonseed oil cake is appropriate. Carp fry is essentially planktophagic; they are bitten by zooplankton in nature.

Additional ingredients like soya flour, fishmeal, vitamins, and minerals can be added for better growth. Feeding quantity is 8-10% of biomass body weight in the first month and 6-8% in the second and third months. Two-time feeding or two rations per day are recommended [38].

Harvesting of Fingerlings

To obtain larger fingerlings, their rearing duration can be prolonged, but typically they're harvested when they grow to be around 80-100 mm. This process generally takes 2 to 3 months. If transportation is necessary, it's best to halt food intake for a couple of days before the harvest for better conditioning. Adhering to proper procedures can yield survival rates of at least 60-70 percent according to source [38].

Farming Carps in the Grow outs

In grow-out ponds, the same preparation practices as nursery and fingerling ponds are followed. The ponds are stocked with a balanced combination of surface feeders (30-40%), column feeders (30-35%), and bottom feeders (30-40%). The ideal fingerling size for stocking is between 60-100 mm, as smaller sizes result in higher mortality and poor growth initially. For cement cisterns, 50-100 g fingerlings are suitable, achieving a survival rate of about 95 percent. Recent trends in carp culture technology include moving from single-stock multiple harvests to multiple-stock multiple harvests. Different stocking and harvesting methods have been adopted to enhance fish production and income:

1. **Single stocking and single harvesting:** 8000 fingerlings are stocked and harvested once, yielding about 5 tons/ha/year in total fish culture.

2. **One fish and many harvests:** Stocking density is higher than one stocking, to harvest 50 percent of the fish after 6 months.
3. **More stockings and more fruit:** Stocking density like one stock (8000/ha). Harvested when fish reach 500g. Stockings are replenished to maintain stocking levels after each harvest.
4. In temporary ponds with a stocking density of 10,000 – 12,000 fingerlings, fish can reach about 300 – 400 grams in 5 – 6 months. For larger sizes, stocking size should exceed 100 g, with a density of 3000 – 4000, and yield about 1 kg of fish in 10 – 12 months [38].

Cultural Practices for Carp grow outs

Carp culture technology is regionally classified as low-input, medium-input, and high-input systems.

1. **Low Input System:** Minimal inputs are used, and 500 – 600 kg/ha/year of fish can be produced without feed. The pond is well prepared and supplemented with mahogany oil cake (2500 kg/ha) or urea and bleaching powder (5mg/l each). Stocking density of 3000/ha, minimum 50 mm.
2. **Easy input:** Production can be 4 – 8 tonnes/ha/year plus fertilizer.
3. **High-input carp culture:** Also known as intensive or semi-intensive culture, this system uses periodic exchange of fertilizer, feed and water Fish production can reach a maximum of 8 tons/ha/year so that an impressive 4000 carp/ha are stored density and 20 percent water exchange.

Food is an important factor in fish growth, as natural food sources are insufficient. Additional feeding is necessary to increase fish production and twice daily is recommended. Proper feed management is important to avoid overfeeding and underfeeding as it can affect fish growth [38].

Carp Harvesting

Fish are harvested after 10-12 months in single-stocking unit harvesting systems, with catla reaching about 1 kg, rohu and mrigal growing to about 600-700 g and harvested regularly in stocking and multiple fruit cropping systems [38]. When collecting fingerlings of 150-200 g, fish weighing more than 1 kg in culture can be obtained in a year.

Water quality management

Maintaining optimal physicochemical parameters of lake water is essential for fish growth and survival [39]. (Table 3). Water quality is an important concern when storage is high. Dissolved oxygen (DO) is an important factor which should ideally be about 5 mg/L. Plankton and macroorganisms can do this through climate change and photosynthesis. Aeration methods such as paddle wheel aerators, aspirators, and submerged pond aerators can help maintain adequate levels of DO. Paddlewheel aerators are suitable for shallow ponds (1 to 1.5 m deep), other aerators have higher air injection capacity and can be used as appropriate Hydraulic circulation can also be pumped to draw water from the bottom of the pond for irrigation back into it. Under conditions of increased aerated storage facilities ensuring a healthy environment for fish [40].

Table 3: Optimum Parameters (Range) For Fish Water Quality

S. No	Analysis	Water Parameters	Fish (Fresh Water)	Fish (Brackish water)
1	Water Quality Analysis	Temperature (°C)	20 – 33	20 – 33
2		pH	7 – 9	8.3 -8.7
3		Salinity (PPT)	< 0.5	15 PPT
4		Total Dissolved Solids	< 500	< 500
5		Carbonate CO_3 (mg/L)	20 – 40	20 - 40
6		Bicarbonate HCO_3 (mg/L)	150 – 500	150 - 500
7		Total Alkalinity mg/L)	50 – 300	50 - 350
8		Total Hardness (PPM)	Based on Salinity	Based on Salinity
9		Calcium Hardness (PPM)	Based on Salinity	Based on Salinity
10		Magnesium Hardness (PPM)	Based on Salinity	Based on Salinity
11		Dissolved Oxygen (PPM)	5 – 10	5 – 10
12	Mineral Profile Analysis	Calcium (PPM)	Based on Salinity	Based on Salinity
13		Magnesium (PPM)	Based on Salinity	Based on Salinity
14		Phosphates (PPM)	0.3 – 5	0.3 - 5
17		Potassium	Based on Salinity	Based on Salinity
18		Sodium	Based on Salinity	Based on Salinity
19		Chloride (PPM)	Based on Salinity	Based on Salinity
20	Toxic Gases Analysis	Total Ammonia (PPM) NH_4	0 – 1.0	0 – 1.0
21		Unionized Ammonia (PPM) NH_3	0 – 0.1	0 – 0.1
22		Nitrate (PPM) NO_3	0.1 – 3.0	0.1 -3.0
23		Nitrite (PPM) NO_2	0 – 0.5	0 – 0.5
24	Toxic Elements	IRON (PPM)	0 – 0.1	0 – 0.1
25		H_2S (PPM)	<0.02	<0.03
26		Residual Chlorine (PPM)	< 0.2	< 0.2

Nutritional Requirements of Indian Major Carps

Protein and amino acids

The appropriate amount of dietary protein needed for Indian major carps can vary depending on their specific life stage, as outlined in Tables 4, 5, and 6 [41]. Adult carps require a diet with at least 30% protein to ensure adequate growth and survival. On the other hand, fingerlings and fry have higher demands, requiring diets containing around 35% and 40% protein respectively in order to promote optimal growth [2]. Numerous studies have been conducted to determine both the qualitative and quantitative amino acid requirements of these carp species. These investigations have revealed that all ten essential amino acids are necessary for their overall well-being and optimum growth [43]. Additionally, it has been estimated that cystine replacement accounts for approximately half (50%) of the total requirement among Indian major carps [44]. In order for ingested proteins to be effectively utilized by these fish species for synthesis purposes, it is crucial that sufficient levels of energy sources such as lipids and carbohydrates are present within their diet. This allows for efficient utilization of the ingested proteins during various metabolic processes related to protein synthesis.

Table 4: Amino acid (Dietary) requirements of *Catla catla* (% dietary protein).

Amino Acids	Fry (%)	Juvenile/Adult (%)
Arginine	4.81	5.62
Histidine	2.44	2.37
Isoleucine	2.34	2.74
Leucine	3.71	4.37
Lysine	6.22	6.85
Methionine	3.54	3.01
Phenylalanine	3.71	4.51
Threonine	4.94	4.51
Tryptophan	0.96	1.02
Valine	3.54	3.61

Table 5: Amino acid (Dietary) requirements of *Labeo rohita*

Amino Acids	Diet (%)	Dietary Protein (%)
Arginine	2.31	5.76
Histidine	0.91	2.24
Isoleucine	1.21	3.01
Leucine	1.84	4.62
Lysine	2.26	5.57
Methionine	1.14	2.87
Phenylalanine	1.61	4.01
Threonine	1.72	4.27
Tryptophan	0.44	1.12
Valine	1.51	3.74

Table 6: Amino acid (Dietary) requirements of *Cirrhinus mrigala*

Amino Acids	Diet (%)	Dietary Protein (%)
Arginine	2.11	5.24
Histidine	0.84	2.12
Isoleucine	1.11	2.74
Leucine	1.71	4.26
Lysine	2.34	5.87
Methionine	1.28	3.17
Phenylalanine	1.61	4.01
Threonine	1.64	4.12
Tryptophan	0.44	1.09
Valine	1.41	3.51

Lipids and fatty acids

Lipids or fats are important for major Indian carps as they provide essential energy and fatty acids. In addition, fat acts as a carrier for fat-soluble vitamins and helps maintain the structural integrity of the cell membrane. The macro lipid requirement of large Indian carps is about 7-8% of their diet [45]. Young fish generally need more fat and protein compared to adults. Large Indian carps show improvement when 1% of their diet per diet contains n-3 and n-6 fatty acids [46]. N-3 and n-6 fatty acids in the body of these carps [47]. However, there has been little research on their dietary fat requirements. Notably, high-unsaturated fatty acids (HUFA), such as eicosapentaenoic acid (EPA) (20:5n-3) and docosahexaenoic acid (DHA) (22:6n-3) were not found to be essential for large Indian carps such as these carps are predominantly freshwater species, so they can thrive even in the absence of HUFA [48].

Carbohydrates

Carbohydrates are an expensive and inexpensive source of energy for large Indian carps, which are herbivores/eaters and easily digest critical amounts of carbohydrates in their diet Optimum amounts of carbohydrates in the diet for their growth about 22-30% However, when the carbohydrate content exceeds 35% of the diet, delayed growth and reduced feed intake are observed. Indian major carp readily assimilate starch and dextrin, but in a practical diet, wheat flour, tapioca flour and rice flour are often used as cost-effective sources of carbohydrates, which also act as natural products binding in food in the absence of ret, Protein can be used as an energy source.

Vitamins and minerals

Thiamine is essential for growth and survival of freshwater fish including Indian major carp, and the dietary requirement for thiamine has been estimated to be around 8-12 mg kg^{-1} diet depending on life span Riboflavin is also essential for Indian major carp, and its requirement has been calculated at about 6-8 mg kg^{-1} of food. The requirement for niacin is 10-12 mg kg^{-1} diet, while the dietary requirement for pantothenic acid is 9-11 mg kg^{-1} diet. Indian major carp have been found to require about 300 mg of ascorbic acid (vitamin C) per kg-1 of diet for normal growth and survival [50 Ascorbic acid deficiency can cause various health issues in Indian major carp [51].

The recommended dietary intake for pyridoxine (vitamin B6) is 6-8 mg kg^{-1} diet. The dietary requirements of vitamin B12, inositol, biotin and folic acid in Indian major carp have been reported to be 0.01-0.02 mg, 300-350 mg, 5-8 mg and 0.5-1 mg per kg^{-1} of feed a they eat, respectively. The recommended dietary choline requirement for large Indian carps is 500-600 mg kg^{-1} diet [52]. For fat-soluble vitamins, the dietary requirement for vitamin A (retinoic acid) is 1500 IU, while for vitamin D, 400-500 IU per kg^{-1} diet is recommended Diet the recommended threshold for vitamin E is about 40-1. 50 mg kg^{-1} diet, and the vitamin K dietary requirement for Indian giant carps is in the range of 5-10 mg kg^{-1} diet.

As for minerals, the dietary requirements of Calcium of Indian giant carps have not been studied, but it is estimated that about 4000-5000 mg calcium per kg^{-1} diet Phosphorus requirement is in the range of 5000-6000 mg kg^{-1} diet, while 500 mg kg^{-1} dietary magnesium levels The optimal copper requirement for Indian giant carp is around 3-4 mg kg^{-1} diet and cobalt at optimal level.

Supplementary feeding

Feed supplementation is necessary to increase carp production in ponds (Table 7). However, the average life span of Indian giant carps at startup is low, with about 30% surviving from hatch to hatch and about 50% from hatch to fingerling Thus this high mortality rate is due to inadequate and nutritional imbalances, as well as poor work practices. Traditionally, small rural fish farmers use a mixture of rice bran and oil cake in equal proportions (1:1 by weight) as feed for Indian carp especially This feed usually contains protein crude 25–28%, but not nutritionally balanced. Conventional diet is provided raw, twice daily in nursery pools at a rate of 10–20% of biomass [54]. To address this issue, Carp has developed a nutrient-dense diet for teens, which includes a variety of ingredients.

One study has shown that pelleted feeds containing fish meal or other sources of protein can yield up to 50% higher yields compared to traditional rice bran and oil cake mixture [55] and low-cost carp feed using locally available ingredients, such as silkworm pupae, soybeans, fish, shrimp meal, and dried aquatic grasses have been developed [56].

Food preferences change with the abundance of carp fry. Fry like catla, rohu and mrigal feed mainly on unicellular algae when they are 5–10 mm and 10–20 mm in size, respectively. Young Indian giant carp can accept artificial feed within two days of starting outdoor feeding and thrive very well on oil cake, rice flour and black gram [57].

Typical active brood-stock diets contain 25–30% crude protein which are locally available and inexpensive substances (Table 8) Fed 2% of body weight per day, thus this feed helps to enhance the growth and spawning of Indian giant carps, resulting in increased fertility, seed quality and quality [57].

Hand feeding is the most common practice in carp culture, especially for small-scale artisanal carp farmers. Feeds ranging from 2% to 4% by biomass are fed once daily. Another method is bag feeding, where the feed is placed in a plastic bag with holes and suspended in a pond. In addition, hormones and growth factors have been used in carp diets to alter sexual cycles or to increase growth and survival, but their use must be carefully considered.

Table 7: Ingredients availability for carp diets in India.

Ingredients	Moisture Content (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	Ash (%)	Nitrogen-Free Extract (%)
Rice polish	12.5	14.4	17.1	7.4	n/a	n/a
Rice (Broken)	10.2	12.5	11.2	19.2	10.1	36.4
Defatted rice bran	7.1	12.2	1.2	15.1	23.7	40.3
Wheat bran	12.2	15.7	4.2	8.6	n/a	n/a
Wheat (Broken)	9.1	11.4	1.8	4.1	0.3	73.3
Wheat flour	12.5	14.4	3.2	2.6	2.2	64.1
Groundnut cake	10.1	42.1	7.2	13.1	2.4	25.1
Sunflower extract	8.1	31.1	2.2	18.3	1.4	39.1
Soybean meal	11.7	46.2	1.2	5.1	n/a	n/a
Rapeseed cake	11.1	35.8	1.1	13.1	6.8	32.2
Sesame cake	8.2	41.8	9.1	6.1	14.7	19.5
Mustard cake	8.4	30.7	9.2	6.1	10.2	34.8
Cottonseed cake	7.1	37.1	6.4	13.1	1.1	35.2
Gingely cake	9.1	34.1	7.4	7.8	3.2	38.1
Niger extract	7.1	35.1	2.1	19.1	3.4	33.4
Copra cake	12.1	22.1	6.4	12.1	5.1	42.2
Maize meal	13.4	9.4	4.1	4.1	1.4	67.4
Maize	10.3	4.5	7.7	3.4	1.1	72.6
Sorghum	10.1	9.1	2.7	3.1	0.2	75.2
Spirulina	8.6	50.4	1.1	2.2	11.1	26.6
Tapioca flour	11.4	3.2	2.2	2.1	2.2	78.7
Coffee pulp	2.2	14.1	1.3	20.7	8.1	43.4

Table 8: Dietary ingredients for a typical brood-stock diet.

Ingredients	%
Rice bran	25.1
Groundnut (peanut) cake	25.1
Fish-meal	10.2
Maize	10.1
Broken rice	10.2
Horse gram	10.1
Black gram	10.1
Vitamin and mineral mix	< 1

Treatment and Disease Control of Indian Major Carps

Indian carps in particular, which include species such as catla (*Catla catla*), rohu (*Labeo rohita*), and mrigal (*Cirrhinus mrigala*), are susceptible to a variety of diseases that can affect their health and growth [58] Some common diseases occur in special Indian foods and their treatments [59] include:

1. **Aeromoniasis:** Caused by Aeromonas bacteria, it leads to symptoms like skin ulcers, fin rot, and haemorrhagic septicemia. Treatment involves administering antibiotics like oxytetracycline or florfenicol in the feed.
2. **Dropsy:** It is characterized by swelling of the abdomen and body, along with exophthalmia (pop-eye). Treatment includes improving water quality, maintaining proper nutrition, and administering antibiotics.
3. **White Spot Disease (Ichthyophthiriasis):** Caused by the protozoan parasite *Ichthyophthirius multifiliis*, it leads to white spots on the body and fins. Treatment involves using commercial anti-parasitic medications containing malachite green or formalin.
4. **Columnaris Disease:** Caused by *Flavobacterium columnare*, it results in symptoms like cotton-like growth on the skin and gills. Treatment includes using antibiotics like florfenicol or oxolinic acid.
5. **Argulus (Fish Lice) Infestation:** External parasites that can cause skin irritation and reduced growth. Treatment involves physically removing the lice and using anti-parasitic medications.
6. **Gill Rot (Branchiomycosis):** Caused by the fungus Branchiomyces, it affects the gills, leading to breathing difficulties. Treatment includes using antifungal medications like potassium permanganate.
7. **Motile Aeromonad Septicaemia (MAS):** Caused by Aeromonas hydrophila, it results in symptoms like red spots, ulcers, and tail and fin rot. Treatment involves administering antibiotics like enrofloxacin or florfenicol.

To prevent diseases in Indian major carps, good pond management practices, regular health monitoring, and maintaining optimal water quality are essential. Early detection and prompt treatment are crucial in managing diseases and preventing their spread. It is advisable to consult a qualified aquaculture veterinarian for proper diagnosis and treatment of fish diseases [60].

Discussion

The comprehensive review of Indian major carps provides valuable insights into an integrated approach to pond cultivation, nutrition, and health management for sustainable aquaculture. The review highlights the challenges faced by small and rural fish farmers in achieving high survival rates of carp fry and fingerlings. Inadequate and nutritionally unbalanced diets, along with poor management practices, have been identified as significant factors contributing to the low survival rates. One of the key findings of the review is the traditional use of a mixture of rice bran and oilcake as a diet for Indian major carps. While this diet is commonly used, it lacks nutritional balance, leading to suboptimal growth and survival rates. To address this issue, researchers have developed nutritionally balanced diets that incorporate a variety of locally available ingredients. These balanced diets, containing fish-meal, silkworm pupae, soybean, and aquatic weeds, have shown promising results, significantly increasing carp production compared to the conventional diet.

The review also discusses the importance of providing appropriate diets at different life stages of carp fry. As the fry grows, their feeding preferences change, and it is crucial to offer suitable diets to support their development and survival. Proper feeding practices from hatchlings to fingerlings are essential for achieving optimal growth rates and reducing mortality. Moreover, the review emphasizes the significance of brood-stock diets in advancing the maturation and spawning of Indian major carps. A practical formulation with 25–30% crude protein from locally available ingredients has been found to improve fecundity and seed quality, which are critical factors for successful breeding programs. The discussion also includes the different methods of feeding used in carp culture, such as hand-feeding and bag feeding. These methods are commonly employed by small and artisanal farmers. Additionally, the use of hormones and growth promoters to manipulate sex or enhance growth and survival is discussed, with a reminder of the importance of using such additives with caution and consideration of their potential impacts.

Conclusion

In conclusion, the comprehensive review of Indian major carps highlights the importance of an integrated approach to pond cultivation, nutrition, and health management for sustainable aquaculture. Proper supplementary feeding with nutritionally balanced diets is essential to improve the survival and growth of carp fry, ultimately leading to increased production of Indian major carps in ponds. The traditional diet of rice bran and oilcake lacks nutritional balance, resulting in poor growth and survival rates. However, the development of nutritionally balanced diets incorporating various ingredients has shown promising results in increasing carp production. Feeding practices must be tailored to the different life stages of carp fry, ensuring the provision of appropriate diets to support their development and survival. Brood-stock diets also play a crucial role in advancing maturation and spawning, thereby contributing to increased fecundity and seed quality. Furthermore, proper management practices, including feeding methods and the cautious use of hormones and growth promoters, are essential for achieving sustainable aquaculture of Indian major carps. Overall, the review serves as a valuable resource for fish farmers, researchers, and policymakers, providing practical insights and recommendations to improve the productivity and sustainability of the Indian major carp culture. Further research and collaboration among stakeholders are encouraged to continue advancing the knowledge and practices in this field.

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