Bachelor of Science

(B.Sc. – CBZ)

AQUARIUM FISH KEEPING

(DBSZSE201T24)

Self-Learning Material

(SEM II)

Jaipur National University
Centre for Distance and Online Education

Established by Government of Rajasthan
Approved by UGC under Sec 2(f) of UGC ACT 1956

&

NAAC A+ Accredited

TABLE OF CONTENT

EXPERT COMMITTEE

Prof. D.S. Bhatia
Former Director, Life and basic Sciences
JNU, Jaipur

Prof. (Dr.) Subhash Chandra
Head, Department: Zoology
Dean, PG Studies,
MDS University, Ajmer

COURSE COORDINATOR

Prof. (Dr.)Meena Godha
Dept. of Life Sciences
Jaipur National University, Jaipur

UNIT PREPARATION

Unit Writers	Assisting & Proof Reading	Unit Editor
Dr. Sunita Rao Dept. of Life Sciences, JNU, Jaipur (Unit1-2) Dr. Juhi Sharma Dept. of Life Sciences, JNU, Jaipur (Unit3-5)	Ms. Ayushi Bhatnagar Dept. of Life Sciences, JNU, Jaipur	Dr. Kritika Pathak Dept. of Life Sciences, JNU, Jaipur

Secretarial Assistance:
Mr. Suresh Sharma

COURSE INTRODUCTION

This book serves as an introduction to the diverse and captivating world of aquarium fish. This book covers the biology of aquarium fishes, their anatomy, behavior, and habitat needs. The course Aquarium Fish Keeping is of 3 Credits. This course is divided into 05 units and each Unit is further divided into sub topics.

The various types of food and feeding practices to ensure optimal health and growth and also cover the best practices for fish transportation, ensuring safe and stress-free moves. Hands-on experience in maintaining aquariums, from water quality management to equipment maintenance, ensuring a thriving environment for aquatic pets are discussed. This book is designed to give a learner the fundamental understanding of the diversity of fishes with emphasis on various ornamental species, key characteristics, maintenance and requirement to make aquaculture, fish handling and their transportation.

Course Outcomes: After the completion of the course, the students will be able to

1. Identify the grade and prominence of ornamental industry in India and global.
2. Determine the aspect related to managing the types of ornamental fish.
3. Compare the species and variability of ornamental fish to other species.
4. Analyze the keys kills and routine maintenance needed to set up an aquarium.
5. Sketch the complete nutritional requirement to formulate fish food
6. Assess the budget to setup a well-maintained home aquarium.

Acknowledgements:

The content we have utilized is solely educational in nature. The copyright proprietors of the materials reproduced in this book have been tracked down as much as possible. The editors apologize for any violation that may have happened, and they will be happy to rectify any such material in later versions of this book.

UNIT -1

INTRODUCTION TO AQUARIUM FISH KEEPING

Course Objective

- To comprehend grade and the prominence of ornamental industry in India and global;
- To acquire and determine the aspect related to managing the types of ornamental fish;
- To introduce species and variability of ornamental fish as well as aquarium managing.

1.1 INTRODUCTION

Ornamental fish culture, also known as aquariculture, revolves around nurturing beautiful, colorful fish of tranquil temperament within controlled aquatic environments. Often dubbed "living jewels," these ornamental fish play a vital role in the aquaculture industry, serving as both a source of foreign exchange and employment.

Their allure has captivated hobbyists for centuries, tracing back to ancient Rome where ornamental fishkeeping first emerged as a domestic pastime. Its popularity soared in 18th century England and Scotland, sparking a global fascination with breeding and showcasing these exquisite aquatic creatures based on their hues, patterns, and forms.

Over time, ornamental fishkeeping has evolved into a thriving global business, embraced by enthusiasts worldwide. This hobby transcends borders, leading to the capture and cultivation of vibrant and mesmerizing fish breeds across Asia and Europe.

With over 1,800 species available in the market, including freshwater favorites, this industry continues to expand, with 90% of freshwater fish now bred in captivity. The appeal of ornamental fish extends beyond personal aquariums, contributing significantly to international trade and rural employment in developing nations, particularly those in tropical regions.

Fig 1.1 aquarium fish keeping

Despite its global reach, ornamental fish culture remains accessible to individuals even in urban settings, requiring minimal equipment and a basic understanding of fish biology. Small-scale operations can thrive with essential resources like freshwater, quality breeding stock, and reliable electricity, making it an ideal venture for women, elders, and small entrepreneurs.

Through education and technical support, communities can adopt eco-friendly breeding and collection practices, fostering sustainable growth and empowering local economies.

India, with its rich biodiversity, stands poised to play a pivotal role in the international ornamental fish trade, bolstering foreign exchange reserves and creating employment

opportunities in rural areas. By leveraging its resources and expertise, India can emerge as a leading contributor to this vibrant and lucrative industry, enriching both its economy and aquatic landscapes.

The benefits of aquarium fish keeping are well-documented, with ornamental fish fetching significantly higher prices compared to food fish. Marine ornamentals, in particular, command prices around ten times higher than freshwater varieties. Establishing an ornamental fish-exporting venture can prove highly profitable, provided it adopts scientific practices and effective marketing strategies.

Fig 2 Types of ornamental fishes

The cultivation and breeding of ornamental fish are viable both on a large scale and a small scale, offering opportunities for small entrepreneurs. However, institutional support for research and development is crucial.

Commercial banks can play a role by offering financial assistance for training programs focused on ornamental fish production. Urgent attention is needed in two key areas: breeding selected marine species to alleviate pressure on wild populations and providing training for fisher folk in advanced collection and handling techniques.

Traditionally, ornamental fish are selected based on criteria such as attractive appearance, peaceful nature, compatibility with other species, and suitability for aquarium life. However, recent perspectives suggest that beauty alone does not define ornamental fish. Even a common fish with unique markings or behaviors can qualify.

Criteria for selecting indigenous ornamental fish may include distinctive appearance (like the Devil Catfish or Chacachaca), unique behaviors (such as color-changing Badis Badis), or rarity (like the coloring cheng or Channa Bleheri). These expanded criteria broaden the range of species suitable for aquarium enthusiasts, enriching the diversity of aquatic displays.

1.2 GARNERING OF ETHNIC ORNAMENTAL FISHES

Ensuring the sustainable harvesting of indigenous ornamental fishes is essential for conservation efforts. Ethical considerations are paramount in this trade, with a focus on minimizing mortality among wild-caught specimens. Progress has been made in this regard, particularly in reducing mortality rates during transit.

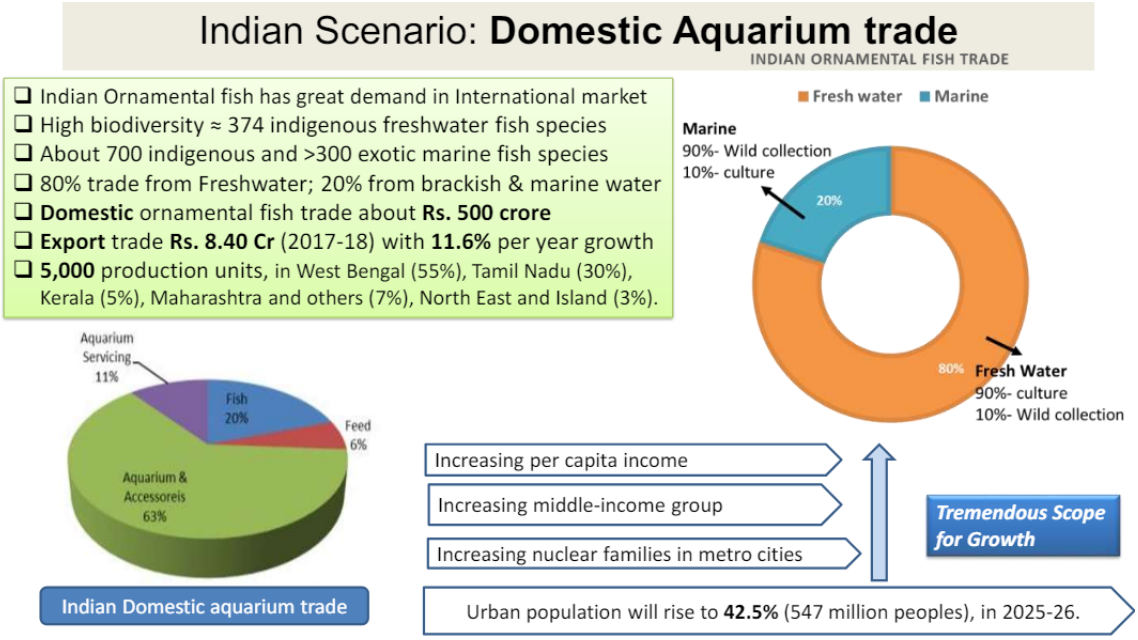


Fig 1.3 Indian status of fish keeping

Western markets and Japan prioritize high-quality fish, necessitating advancements in packing technology to support longer transit periods with higher stocking densities. Freshwater ornamental fish, in particular, are relatively adaptable to acclimatization processes. Strategic transport planning and selection of export routes play pivotal roles in optimizing the ornamental fish trade.

Various collection methods are employed, with scuba diving being common. While the industry has faced criticism for certain collection practices and mortality rates, such issues are

typically isolated rather than systemic. Skilled collection techniques are essential to minimize habitat damage, with methods tailored to specific species requirements.

Innovative tools, such as lines with small barbed hooks or tubular nets, cater to species with unique behaviors or habitats. Non-destructive nets are utilized in regions like Sri Lanka, Australia, and the Pacific to minimize environmental impact. In countries like the Philippines and Indonesia, free divers equipped with handmade goggles and fins employ traditional techniques for marine ornamental fish collection.

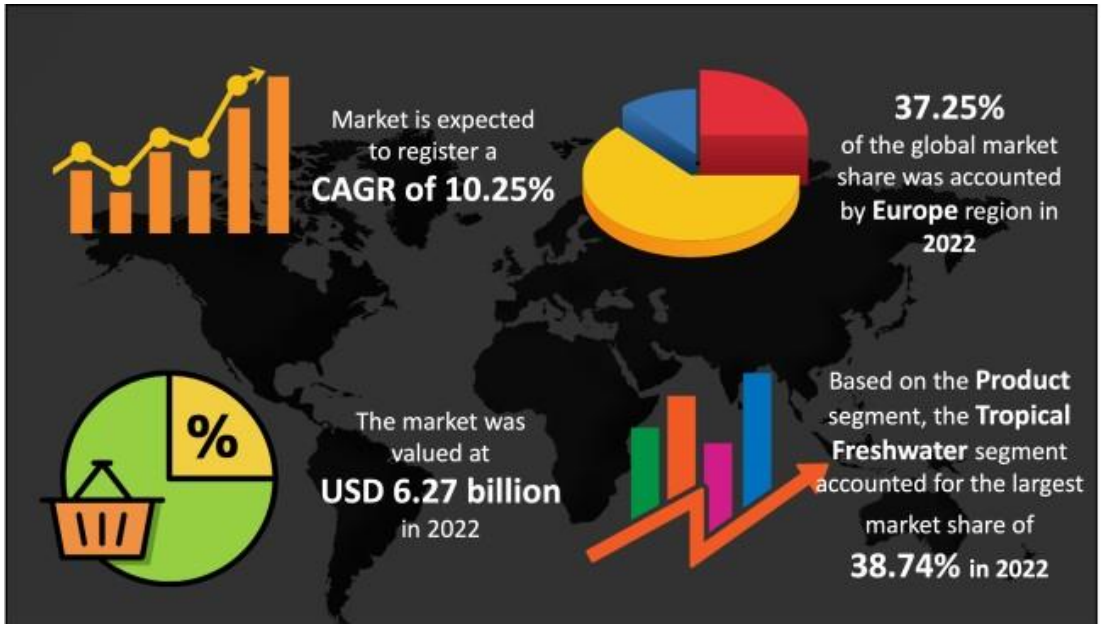


Fig 1.4 International market of fish keeping

Similar approaches can be adopted in Indian waters to sustainably harvest valuable marine ornamental fish species, ensuring both environmental preservation and economic viability.

1.3 ECO-FRIENDLY APPROACHES OF NATURAL ASSETS

Intensive and selective catching techniques, along with destructive practices like dynamite fishing, pose significant threats to the fragile balance of reef ecosystems, especially concerning the marine ornamental fish trade.

These unethical methods lead to depletion of natural stocks, exacerbating the challenges faced by the industry due to increasing demands. To mitigate these risks, it is crucial to shift

focus towards sustainable aquaculture techniques, such as brood stock management and captive breeding, to alleviate pressure on wild populations.

Priority should be given to implementing these techniques to prevent the supply of unhealthy fish to international markets, safeguard wild stocks from depletion, preserve delicate coral environments, mitigate conflicts over fishing rights, and create sustainable economic opportunities, particularly in rural areas. Emphasizing environmental protection, promoting non-destructive capture methods, monitoring exploitation, and establishing marine sanctuaries are vital steps. Additionally, policies should be formulated to regulate the exploitation and export of marine ornamental fishes to ensure better economic returns for the sector.

In our country, greater attention should be given to the concept of marine public aquaria. These institutions serve as educational platforms, providing insights into diverse aquatic ecosystems and raising awareness about the importance of ecology. By offering simulated natural habitats for various species, they enable families to engage with marine life without the need for specialized equipment.

Moreover, public aquaria showcase advancements in aquaculture technology, enhancing understanding and appreciation for the field.

Efforts should be made to perfect technologies related to handling, packaging, and transporting live marine ornamentals, as well as marine aquarium setup and maintenance. These advancements need to be disseminated to fisher folk to ensure better profits and sustainable practices throughout the industry.

1.4 STRATAGEMS FOR ENHANCEMENT OF ORNAMENTAL FISH COMMERCE IN INDIA

While India possesses abundant ornamental fish resources in both freshwater and marine sectors, the industry remains largely unorganized, resulting in minimal contribution to global trade. However, with proper utilization of these resources, the country's export earnings could multiply significantly.

Fig 1.5 Steps of fish farming

To enhance the ornamental fish industry in India, several key strategies are recommended:

- Conduct systematic studies on various aspects of feeding and reproductive biology of indigenous ornamental fish.
- Establish commercial farms equipped with necessary infrastructure and supported by technical experts to enable mass production of these fishes.
- Emphasize the culture, breeding, and marketing of indigenous ornamental plants.
- Ensure ornamental fish breeding and rearing units have consistent access to quality water and electricity.
- Provide necessary support to small-scale production farms to enhance their output.
- Select superior quality brooders to yield healthy offspring with high demand in domestic and international markets.
- Ensure regular availability of feed ingredients for preparing pelleted feed, including oil cakes, rice polish, wheat bran, fish meal, and prawn-head meal.
- Implement probiotics to promote host animal well-being and protect against harmful bacterial pathogens.
- Incorporate locally available pigment-rich ingredients into diets to enhance the coloration of cultured ornamental fish, thereby increasing market value.
- Improve transportation facilities to minimize stress on live fish during domestic and international shipments.

- Gain comprehensive knowledge of market demand, customer preferences, and establish a robust marketing network through personal contacts and public relations.
- Keep breeders and exporters informed about recent developments in breeding, rearing, marketing, and research advancements in ornamental fisheries.
- Equip ornamental fish farms with fish pathology laboratories to manage disease outbreaks effectively.
- Establish health centers for quarantine certification at key locations to meet importers' standards.
- Organize frequent training sessions on aquarium management by resourceful institutes to cater to various clientele groups' needs and requirements.

Implementing these strategies would not only bolster the ornamental fish industry in India but also contribute significantly to its economic growth and global market presence.

1.5 ECO-FRIENDLY POLICIES OF NATURAL RESOURCES

Intensive fishing techniques, including selective and dynamite fishing, pose significant threats to the delicate balance of reef ecosystems, particularly impacting the marine ornamental fish trade.

These destructive practices lead to the depletion of natural stocks, exacerbating the challenges faced by the industry due to increasing demands. To address this, it's crucial to prioritize the development and utilization of aquaculture techniques such as broodstock management and captive breeding.

Fig 1.6 Set up of aquarium for fish keeping

This will help alleviate pressure on wild populations and reduce overexploitation of reef fish, safeguarding their populations and the fragile coral environment. Additionally, emphasis should be placed on environmental protection, adopting non-destructive capture methods, monitoring exploitation, promoting breeding and culture, and establishing sanctuaries.

Formulating policies for the exploitation and export of marine ornamental fishes can further enhance economic returns in the sector.

The concept of marine public aquaria deserves greater attention as well, serving as educational platforms to foster interest and knowledge about marine environments. These facilities offer insights into diverse aquatic ecosystems, providing families with the opportunity to observe simulated natural habitats and raising awareness about ecology.

Recognizing India's potential as a global hotspot for ornamental fish biodiversity, producers, collectors, and traders have identified trade opportunities both nationally and internationally. While India's ornamental fish trade predominantly relies on wild collection, there is ample scope for sustainable development and conservation efforts.

Entrepreneurship can be cultivated around indigenous fish and plant species with ornamental value, alongside the development of industries focusing on live food, artificial feed, and aquarium accessories.

Investment in intensified research and development in both freshwater and marine fish species can lead to the development of culture technologies to meet the demands of the global aquarium trade. Currently, there is a lack of proper policy for the development of the ornamental fish industry in India, especially in the export trade.

Government initiatives, such as providing incentives to establish ornamental fish production units, can attract private investment, generating additional employment opportunities and improving community livelihoods.

Through collaborative efforts of all stakeholders and encouragement of public-private partnerships, the ornamental fish farming sector can substantially grow in the region, gaining a larger share in the global market. Establishing ornamental fish production units in different parts of the region can further stimulate economic growth and provide livelihood improvements through employment generation.

1.6 CONSTRUCTION OF AQUARIUMS

Building and installing aquariums can vary depending on individual needs, from simple setups for personal use to more extensive installations for entrepreneurs catering to customers. Aquariums can be constructed from various materials such as glass, concrete, wood, fiberglass, or acrylic sheet, chosen based on factors like location, cost, and durability.

Fig 1.7 material required for aquarium set up

Glass Tanks: Glass tanks can either be metal-framed or all-glass. Metal-framed tanks use steel or iron frames to hold glass panels in place with putty (also known as battery compound). In contrast, all-glass tanks feature glass walls joined edge-to-edge using silicone rubber adhesive.

While all-glass tanks have become less common due to the popularity of metal-framed tanks, the latter are favored for their sleek appearance and suitability for marine fishkeeping.

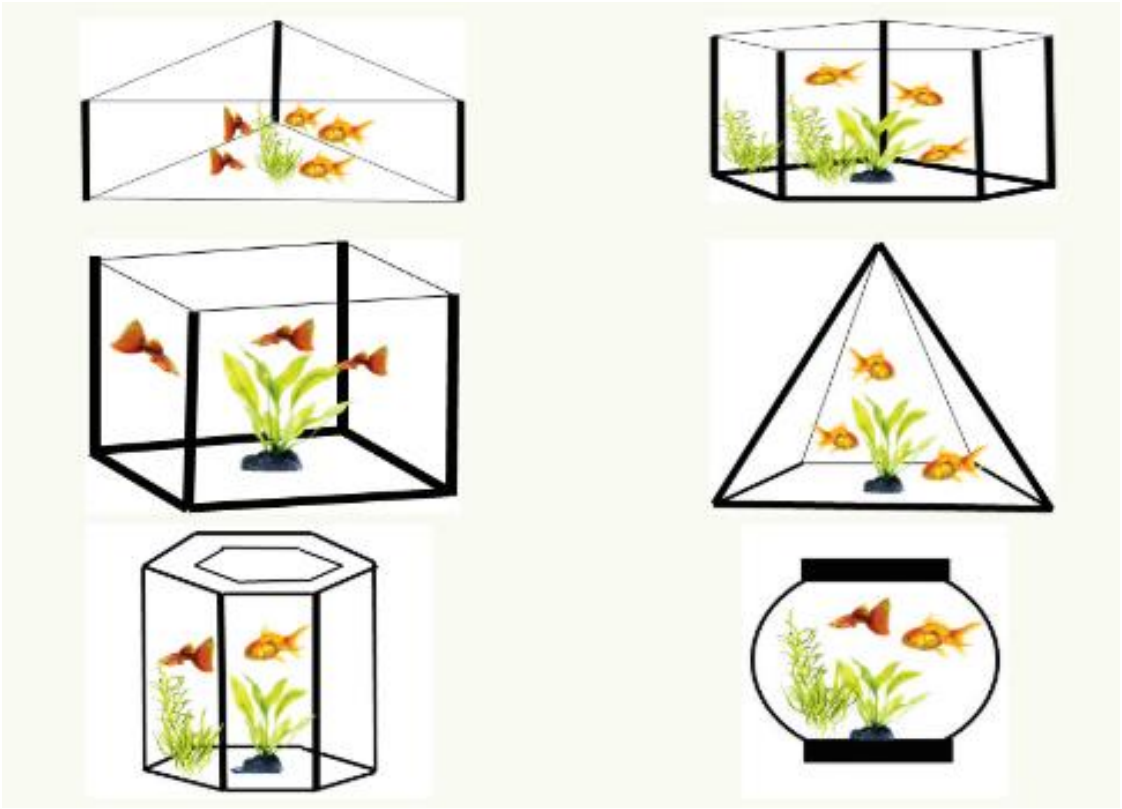


Fig 1.8 Types of aquarium

Tank Shapes: Aquarium tanks come in various shapes including circular, square, rectangular, oval, hexagonal, or octagonal. However, rectangular tanks are often preferred as they offer ample space for fish to swim freely.

MATERIALS NEEDED FOR TANK CONSTRUCTION:

- Silicone gel
- Squeezing gun
- Glass panes (5 in total) of appropriate size

Whether it's for personal enjoyment or business ventures, the process of fabricating and setting up aquariums involves selecting the right materials and construction techniques to ensure a functional and visually appealing environment for the aquatic inhabitants.

Fig. 1.9 Glass Aquarium

Lighting Setup: A lighting period of 10-12 hours is essential for maintaining a healthy aquarium environment.

Among the most popular options are fluorescent lamps and compact fluorescent lamps, which provide cool and efficient illumination.

Imported aquarium lamps are also available for those seeking specialized lighting solutions.

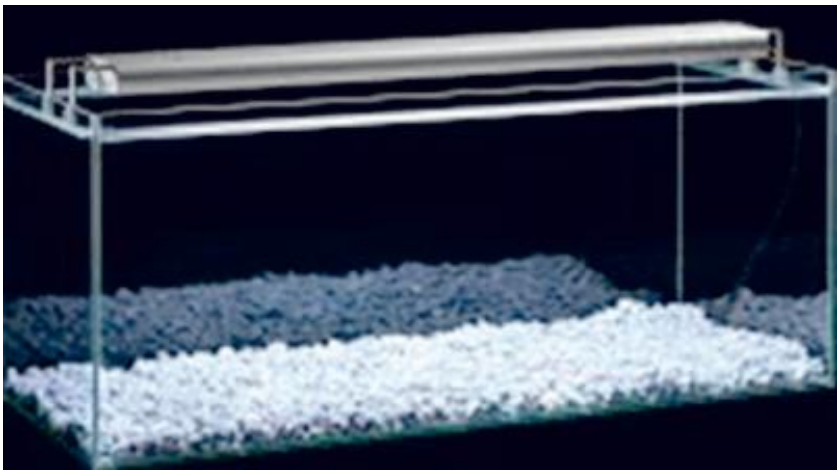


Fig 1.10 light system in aquarium

Heater with Thermostat: Installing a heater with a built-in thermostat is crucial for regulating water temperature and maintaining optimal conditions in the aquarium.

This system is typically placed inside the aquarium, either partially or fully submerged, to ensure consistent heating throughout the tank.

Fig 1.12 filter in aquarium

Aquarium Plants: Aquarium plants enhance the natural ambiance of the tank while also serving essential functions such as oxygenation.

They provide shelter and serve as a food source for aquarium fish, creating an ideal environment for fish spawning.

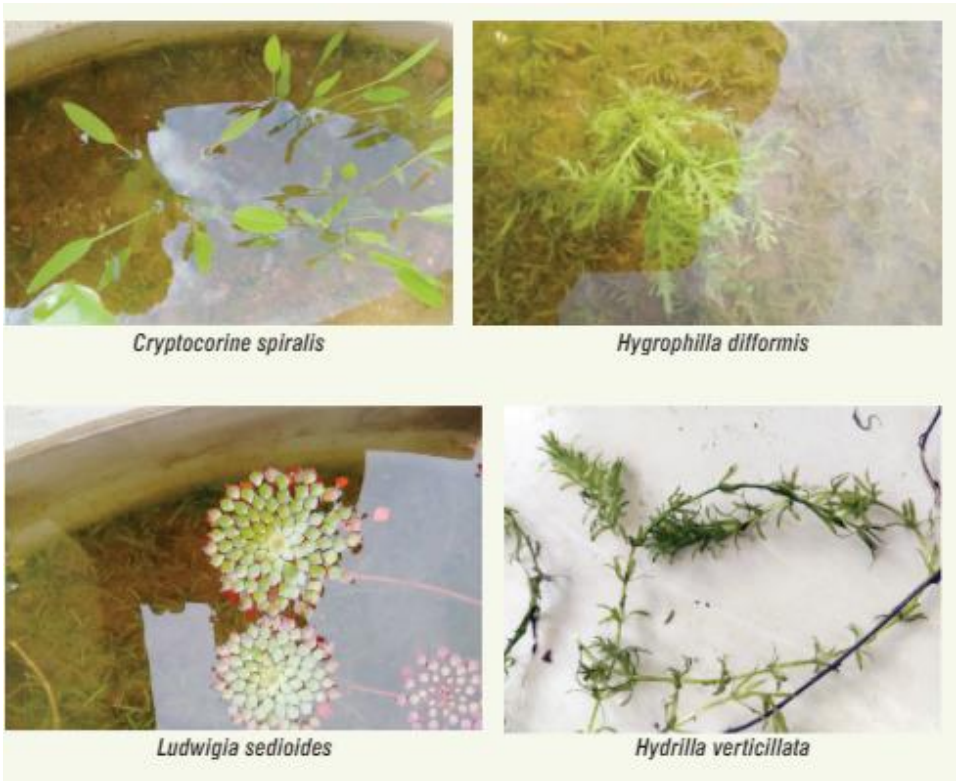


Fig 1.13 Plants in aquarium

1.7 Exotic and Indigenous Varieties of Aquarium Fish

Endemic species of aquarium fish are those exclusive to the geographical confines of India, making them unavailable elsewhere. The aquatic environment faces significant threats to ecosystem stability, leading to a decline in aquatic biodiversity.

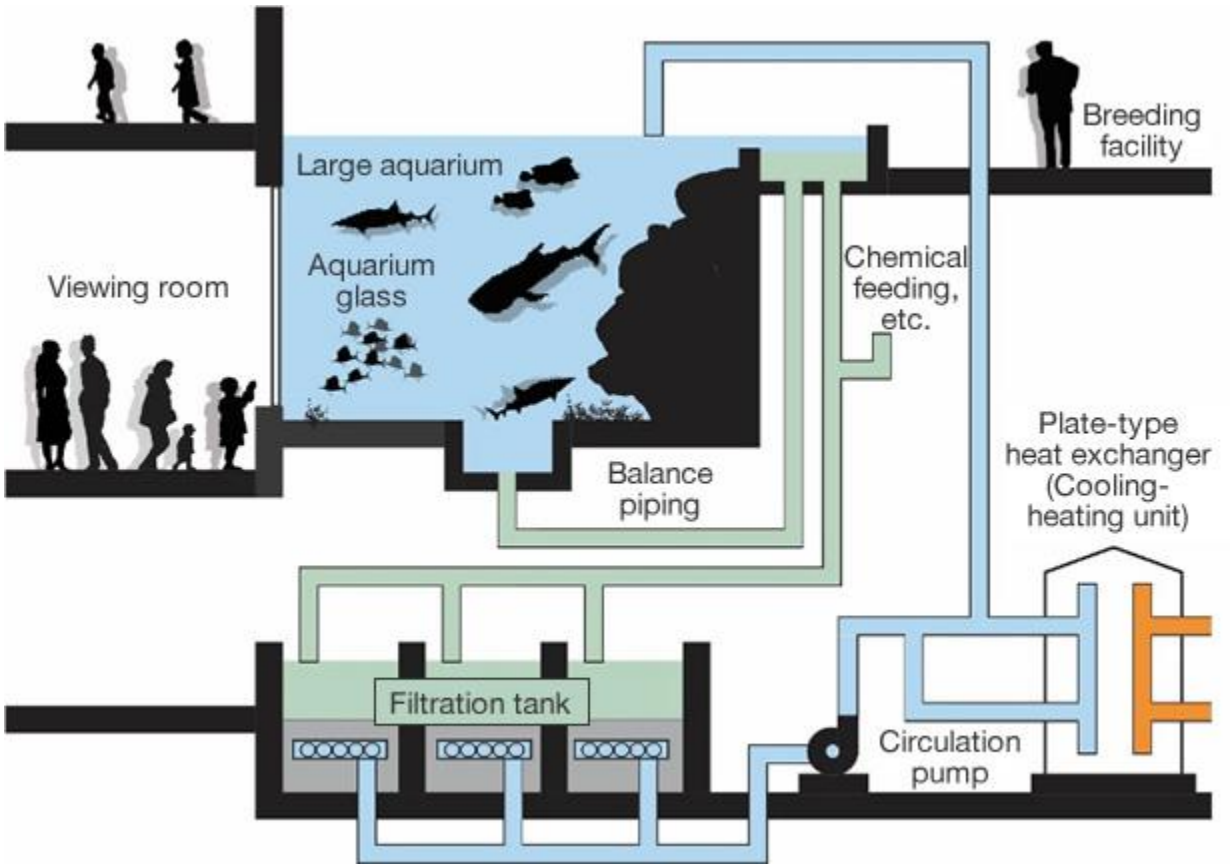


Fig 1.14 parts fish keeping

Some exotic fish species found in India include:

1. *Carassius carassius*
2. *Ctenopharyngodon idella*
3. *Tilapia mossambica*
4. *Puntius javanicus*
5. *Osphronemus gourami*
6. *Cyprinus carpio*
7. *Hypothalmichthys molitrix*

India boasts abundant water resources that support various indigenous fish species. Traditionally, fish culture in India centered around common native species like Labeo, Catla, and Mrigal. However, recent observations suggest that introducing foreign fish breeds into Indian freshwater ponds and reservoirs, either in isolation or in conjunction with native species, can yield higher production rates. Consequently, several fish species have been imported from foreign countries and introduced into Indian freshwater environments. As these fish are not native to India, they are classified as exotic fishes.

Exotic fishes have been imported to India for diverse purposes and are categorized into three main groups based on their utility:

1. Food fishes
2. Game or Sports fishes
3. Larvicidal fishes

Carassius carassius: Commonly referred to as crucian carp or golden carp, *Carassius carassius* was introduced to India from central Europe in 1874 by Maclvor in the Ooty Lake. It was later transplanted to other locations in the Nilgiris and to the Sunkesula fish farm in Andhra Pradesh. Originally intended for use as a food fish, these freshwater river fish have shown the ability to survive and reproduce in confined water environments.

In the tropics, their breeding season spans the entire year. Despite their slow growth rate, reaching a maximum length of 45 cm and a weight of 1.4 kg as observed in the Ooty Lake, they feed on insects, Cladocerans, and Crustaceans. While their culture may have limited significance due to their slow growth and less favored flesh, they can contribute positively when cultured alongside other species, aiding in predator and weed control in ponds.

Ctenopharyngodon idella: Also known as grass carp or white amur, *Ctenopharyngodon idella* is native to the flatland rivers of China and the middle and lower sections of the Amur River in Russia. Introduced to India in 1959 in Cuttack, Odisha, primarily for use as a food fish, the successful hypophysation in Cuttack led to the commencement of grass carp culture in various parts of India in 1962.

Grass carp, a freshwater fish capable of tolerating slightly brackish water, has an elongated and slightly compressed body with a broad head. Despite being dark grey dorsally with a silvery belly, they lack barbels, and their dorsal fins are short.

Cyprinus carpio: Commonly known as the common carp, *Cyprinus carpio* is native to temperate Asia but now enjoys a worldwide distribution. Initially imported in 1939 from then Ceylon and transplanted in the Nilgiris, another variety known as scale carp was brought from Bangkok to Cuttack, Odisha, in 1957. Cultivated in India for a considerable period, either singly or alongside other Indian major carps, the common carp is valued for its food quality and is suitable for culture in both cold and warm waters with an optimal temperature range of 20-25°C.

Hypothalmichthys molitrix: Referred to as the silver carp, *Hypothalmichthys molitrix* is a natural inhabitant of the Amur basins of Russia and the river systems of China.

Widely cultured in various countries, including China, Thailand, and Japan, silver carp was first introduced to India in 1959 with the importation of 360 fingerlings to the Pond Culture Division of CIFRI in Cuttack, Odisha, from Hong Kong. Known for its rapid growth and prized flesh, the fish has gained popularity globally.

Tilapia mossambica: Commonly known as tilapia, *Tilapia mossambica* originates from rivers on the East coast of Africa. Introduced to India in August 1952 from Bangkok and first introduced in Mandapam, tilapia can be cultured in both freshwater and brackish water ponds due to its hardiness and rapid growth rate.

Puntius javanicus: Also called Tawes, *Puntius javanicus* was imported to India from Indonesia in 1972 and first introduced in West Bengal ponds.

With a natural breeding cycle occurring throughout the year, it thrives in well-oxygenated water. Although not highly esteemed for its taste, it is often cultivated alongside other carps in poly-culture systems to control aquatic weeds.

Osphronemus gouramy: Known as gouramy, *Osphronemus gouramy* is native to the freshwater ponds and streams of Indonesia, Thailand, Malaysia, Cambodia, and Vietnam.

Introduced to India from Java to Calcutta and then from Mauritius to Madras in 1916, gouramy requires tropical water temperatures above 15°C for survival and reproduction. Possessing air-breathing organs, they can tolerate low oxygen content in water.

Self-Assessment

- What are types of fish used for aquarium management?
- How do you manage fish in an aquarium?
- What is the importance of aquarium fish keeping?

UNIT 2

BIOLOGY OF AQUARIUM FISHES

LEARNING OBJECTIVE

- To comprehend the key skills needed to set up an aquarium.
- To be able to identify and differentiate the different aquarium/ornamental fishes.
- To be able to formulate fish food that provides with complete nutritional benefits
- To analyse the required budget to set up a well maintained home aquarium.

2.1 INTRODUCTION

The captivating allure of ornamental fishes draws people to these living aquatic treasures. Around ninety percent of India's exported ornamental fishes hail from freshwater species captured in the wild regions of Northeast India.

However, the methods of collection, captive farming, and trade haven't reached their full potential. India boasts extensive freshwater resources that hold immense promise for the advancement of ornamental fish farming.

Understanding the biology of indigenous freshwater ornamental fishes—such as their identification, characteristics, breeding habits, and dietary needs—is crucial for both academic enrichment and entrepreneurial endeavors.

Factors like growth rate, reproductive frequency, optimal breeding conditions, and prey preferences must be thoroughly comprehended for successful entrepreneurship.

Fig 2.1 types of fishes in aquarium

These species are classified under 8 orders and 27 families, with the majority belonging to the Cyprinidae family (52 species), followed by Nemacheilidae (13 species), Sisoridae (13 species), Bagridae (11 species), Erethistidae (9 species), Cobitidae (8 species), and others.

Targeted towards students, educators, scientists, researchers, traders, and entrepreneurs, this book serves as a valuable resource for understanding the overall biology of indigenous ornamental freshwater fishes.

The debate surrounding marine ornamental fish breeding activities is multifaceted, with diverse viewpoints, stakeholders, and socio-economic interests at play.

Assessing whether these activities represent a significant development opportunity or pose a threat is complex. However, from an environmental perspective, breeding marine aquarium organisms holds potential benefits such as curbing the exploitation of natural ecosystems, reducing the bycatch of non-target species, and mitigating the environmental impact of destructive fishing practices like cyanide use.

Furthermore, breeding specific ornamental fish species can enhance scientific research quality and facilitate the discovery of new breeding techniques.

2.2 GENERAL CHARACTERISTICS OF FISH

Fish, the earliest vertebrates with jaws, encompass over 30,000 species inhabiting the waters of the world. They thrive in various aquatic environments, exhibiting both herbivorous and carnivorous dietary habits.

The diversity within this group is vast, ranging from the diminutive Paedocypris progenetica, measuring a mere 7.9 mm in length, to giants like Rhinodon typus, known as the Blue Whale.

The scientific study of fish is termed Ichthyology. These aquatic creatures, also referred to as poikilothermic, ectotherms, or cold-blooded animals, maintain body temperatures in line with their surroundings. Their physique is streamlined, lacking a distinct neck, while their skin is adorned with multicellular mucous glands.

Externally, fish are armored with dermal and bony scales forming their exoskeleton, while internally, their endoskeleton is composed of bone and/or cartilage.

Their vertebral columns are amphicoelous, featuring concave anterior and posterior faces of the centrum. Fish lack a sternum but possess ribs, along with various unpaired (dorsal, anal, and caudal) and paired (pectoral and pelvic) fins.

Characterized by homodont dentition, polyphyodont teeth replacement, and acrodont tooth attachment, fish exhibit unique dental features.

They typically possess a pair of external nostrils opening into blind nasal sacs, with exceptions seen in lungfishes and Osteolepids, which have internal nares.

The digestive system of fish includes a spiral valve in the intestine, enhancing absorptive surface area. Fish lack a tympanum or ear ossicle but feature three semicircular canals in the membranous labyrinth, primarily serving as organs of equilibrium.

Respiration occurs through gills covered by opercula or gill slits, while certain species, like lungfishes, utilize lungs or air bladders as respiratory organs.

Their coelom comprises a small anterior pericardial cavity housing the heart, and a larger pleuroperitoneal cavity enclosing all other viscera except the kidneys, separated by a septum transversum.

2.3 SEXUAL DIMORPHISM IN FISHES

Sexual dimorphism, a widespread phenomenon observed across various vertebrate groups, has long captivated the interest of evolutionary biologists, tracing back to the era of Darwin.

This phenomenon, marked by distinct differences in form and sometimes prominent features between males and females of the same species, has been extensively explored both theoretically and through comparative studies.

Numerous factors contribute to sexual dimorphism, encompassing niche differentiation, natural selection, genetic correlations, allometry, phylogenetic history, and sexual selection.

Sexual selection predominantly influences males, often through assortative mating by females or competitive mate selection, which drives the evolution of specific male traits. Alternatively, the dimorphic niche hypothesis posits that selection primarily acts on females due to reproductive constraints.

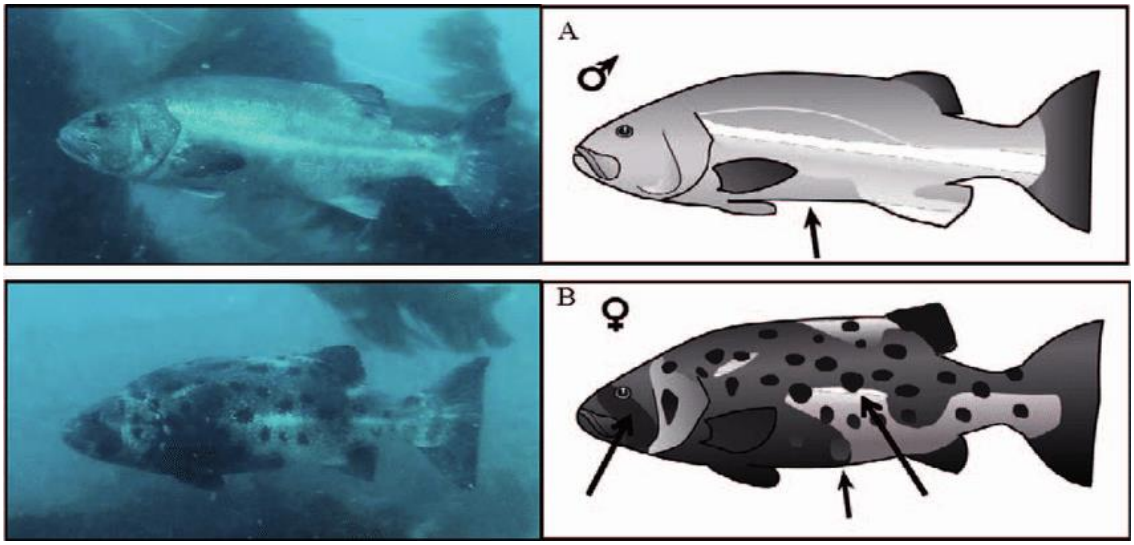


Fig 2.2 Sexual dimorphism between male (A) and female (B)

Furthermore, ecological selection can drive sexual dimorphism by exerting distinct pressures on both sexes, resulting in the evolution of dimorphic niches and trophic structures.

This systematic variation in form and coloration between male and female individuals enables their external differentiation within the same species. Examples include variations in color, size, and the presence or absence of certain body parts utilized in courtship rituals or intra-sexual conflicts.

Among the myriad of species inhabiting aquatic environments, sexual dimorphism is a prevalent characteristic observed in numerous fish species worldwide.

2.4 CLASSES OF SEXUAL DIMORPHISM

Sexual dimorphism manifests in three distinct classes:

1. Monomorphic fish exhibit no discernible differences in form or coloration between the sexes.

2. Temporarily dimorphic or dichromic fish display color variations and/or changes in form, typically observed during the breeding season or confined to courtship and spawning rituals.
3. Permanently dimorphic or dichromatic fish consistently differ in color and/or form throughout their lives.

Identifying gender in many fish species can be challenging, as most are not sexually dimorphic. The presence of sexual dimorphism may be temporary or permanent, varying among species.

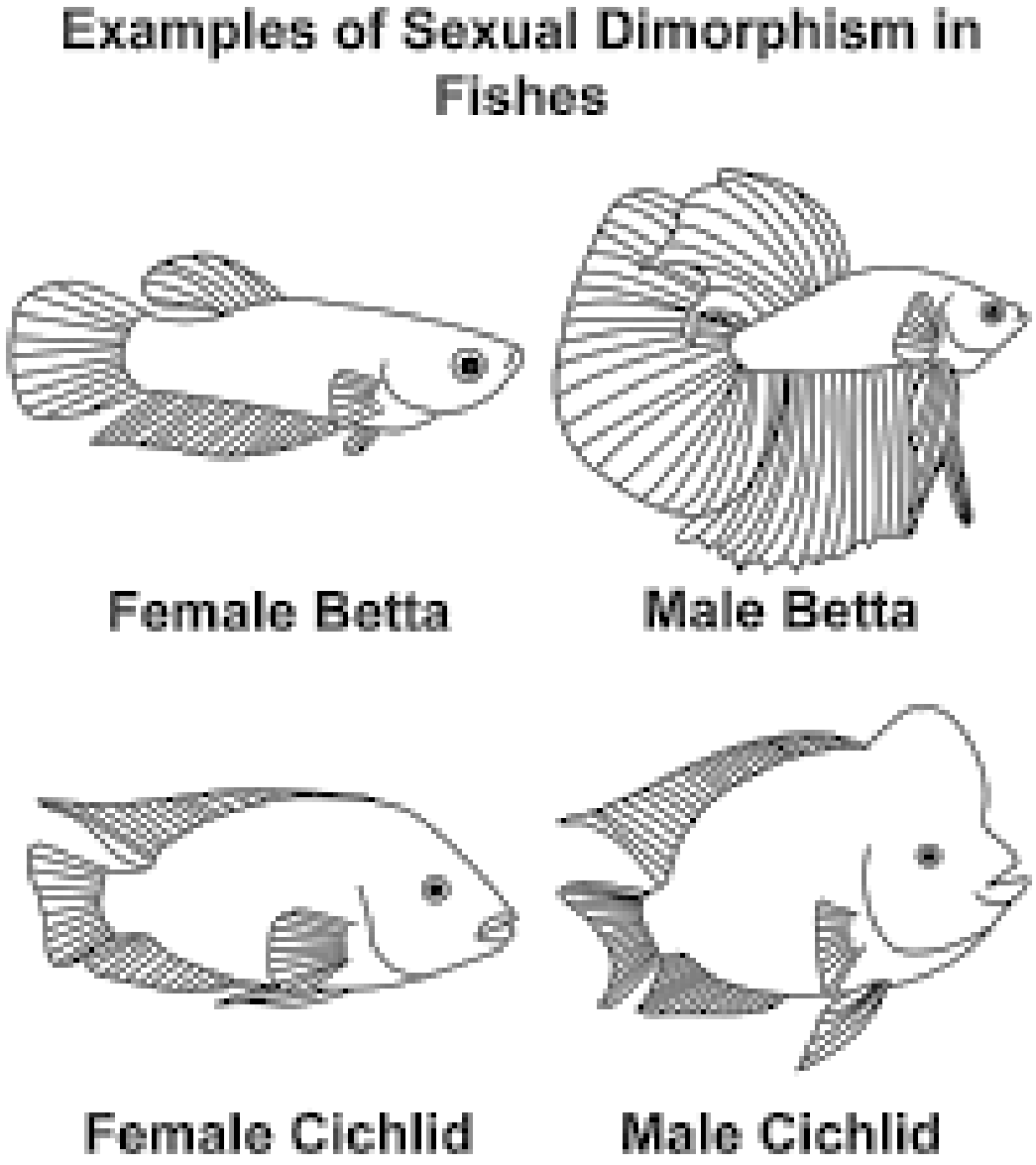


Fig 2.3 Sexual Dimorphism

Temporary sexual dimorphism is evident solely during the breeding season, characterized by changes in coloration or the emergence of breeding tubercles—small, hardened protuberances of keratin found primarily on male fish's head, fins, and body scales.

These tubercles aid in stimulating females during spawning, as well as in territorial defense and nest maintenance.

In contrast, permanent sexual dimorphism involves intermittent organs such as claspers (found in elasmobranchs) or gonopodiums (observed in guppies), facilitating internal fertilization.

Sexual dimorphism contributes significantly to biological diversity and can result from both sexual and natural selection pressures.

Factors such as distinct reproductive roles, niche specialization between sexes, preference for specific traits, and intra-sexual competition contribute to sexual differences in external structures. In breeding programs for food fish, identifying sexual dimorphic features aids in selecting high-quality brood fish capable of producing healthy offspring.

Similarly, in ornamental fish breeding programs, understanding sexual dimorphism informs decisions regarding male-male competition, mate selection, and sexual dynamics.

Furthermore, knowledge of sexual dimorphism is crucial for comprehending species ecology, behavior, and life history.

Additionally, understanding how sexual dimorphism manifests during ontogeny is essential for accurate morphological comparisons between populations

2.5 SEXUAL DIMORPHISM IN GUPPY FISH

The distinct phenotypic differences between sexes in guppy fish stem from varying gene expression patterns. Investigating the molecular evolution and genomic localization of these sex-biased genes is pivotal in understanding intersexual divergence under sex-specific selective pressures. Teleost fish, with their diverse sex-determination mechanisms, offer a unique lens to explore this divergence.

Poecilia reticulata, commonly known as the guppy, exemplifies sexual dimorphism in size, ornamentation, and behavior, traits honed by both natural and sexual selection in their native habitats.

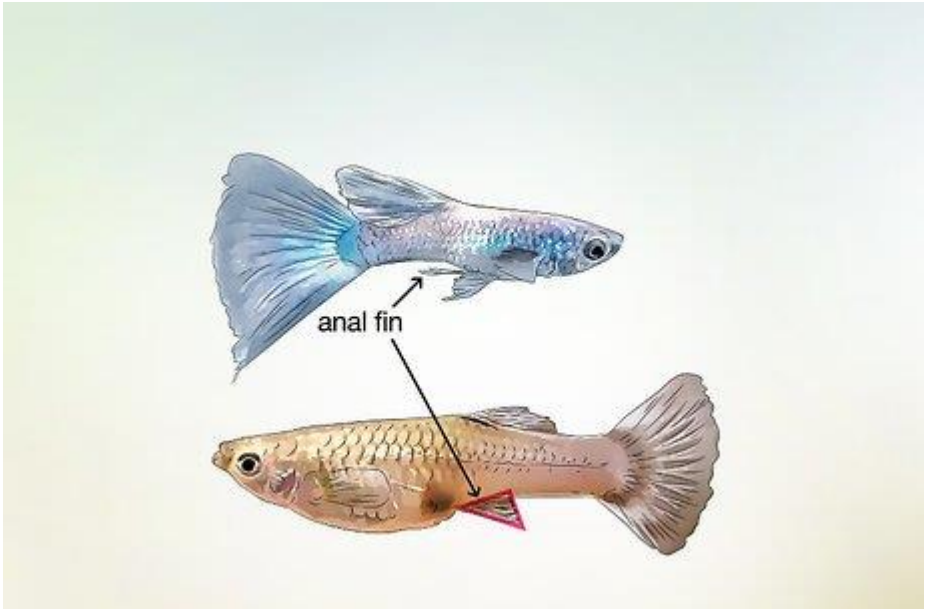


Fig 2.4 Male guppies and female guppies

Male guppies sport vibrant color patterns designed to captivate females but pose risks in the presence of predators. These male-specific traits, advantageous in mating contexts, are believed to have co-evolved with female mate preferences.

Additionally, guppies exhibit sexual size dimorphism, with females experiencing continuous growth throughout their lives while male growth slows during maturation. Behavioral disparities between male and female guppies extend to mating, foraging, shoaling, and predator avoidance activities.

2.6 SEXUAL DIMORPHISM IN POECILIA SPHENOPS (COMMON MOLLY)

Poecilia sphenops, also known as the Common Molly, showcases sexual dimorphism characterized by size discrepancies and coloration variations between males and females.

Male molly fish typically exhibit smaller body sizes (8cm compared to females' 12cm) and boast more vibrant colors, particularly evident in their larger caudal fins. These fish

predominantly inhabit freshwater systems, favoring shallow areas over coastal brackish waters.

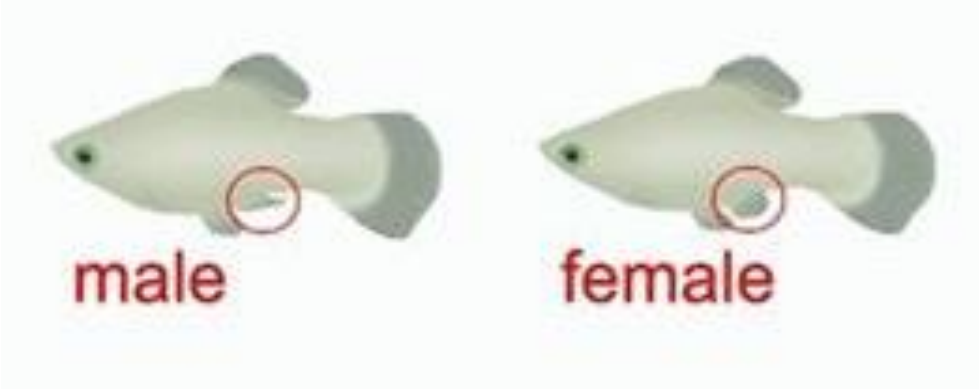


Fig 2.5 Male Poecilia and female Poecilia

Male *Poecilia sphenops* often deploy their raised dorsal fins in confrontations with rival males, showcasing their prowess to attract potential mates.

The sexual dimorphism observed in *Poecilia sphenops* aligns with the broader trends seen in the Poeciliidae family, where females tend to be larger than males.

Male molly fish utilize their colorful dorsal and caudal fins as secondary sexual features to court female mates. Female Poecilia sphenops bear a distinctive dark patch, known as the gravid spot, between the abdomen and the anal fin.

This patch is a temporary indicator of pregnancy, resulting from the pressure exerted by the dark uterine tissue against the abdominal muscle wall.

Fertilization in *Poecilia sphenops* occurs internally via the gonopodium, a modified anal fin structure in males. Female mollies produce broods ranging from 10 to 140 live young, with litter size influenced by the female's maturity and size.

Gestation periods typically span 3 to 4 weeks, subject to temperature variations. Female mollies can store sperm and give birth multiple times throughout the year. The young molly fish tend to form schools with similarly sized peers.

2.7 Gold Fish:

Female Fish: When viewed from above, the body's enlarged abdomen seems shorter and asymmetrical; the vent is rounded, and the abdominal ridge is hidden. The pectoral fins are round and short. A sizable, projecting, convex papilla houses the genital entrance (Fig 2.6).

Fig 2.6 Female Gold Fish

Source:https://fisheries.ap.gov.in/publications/Compendium%20on%20ornamental%20fishes%20english.pdf

Male Fish: The body is longer, leaner, and symmetrical. The operculum has tubercles or bumps; when the fish are ready to breed, tubercles can also occasionally show up on the head, fins, or even gills. The abdomen has a hump and is firm, tiny, and narrow. Compared to females, pectoral fins are longer and more pointed. They have an aggressive disposition (Fig 2.7).

Fig 2.7 Male Gold Fish

Source:
https://fisheries.ap.gov.in/publications/Compendium%20on%20ornamental%20fishes%20english.pdf

2.8 Angel Fish:

- Angel fish only come in one form. Fish cannot be identified as male or female based only on their outward appearance.
- Fish only distinguish between male and female while spawning.
- The female has a thick, "tear drop"-shaped ovipositor on its body, while the male has a cone-shaped tube. Ages 8 to 12 months mark the attainment of sexual maturity.
- Males have an angular body shape, whereas females have a round body shape (fig 2.8).
- The skull and skin of a female have a flat shape, while those of a man has a hump.
- Females have a flat nose/eye band that lines up with their foreheads, whereas males grow a ridge as they mature.
- While the dorsal fin of a male fish is fully erect and forms an almost 90-degree angle with the head hump, the fin of a female fish is held slightly backward.
- In females, ventral fins are located closer to the body, but in males, they are erect and make a clear angle with the body.
- The nose of the female is somewhat higher than the tail. The nose and tail of males are positioned horizontally.

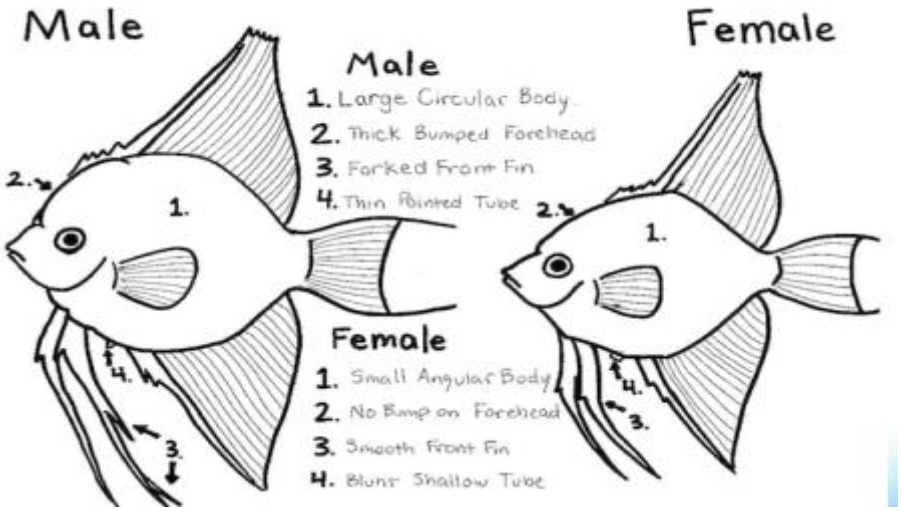


Fig 2.8 Angel Fish

Source:
https://fisheries.ap.gov.in/publications/Compendium%20on%20ornamental%20fishes%20english.pdf

2.9 Butterfly Fish:

It is monomorphic in sexual sense. Males have occasionally been observed to be larger. A few days before spawning, females exhibit stomach swelling (Fig 2.9).

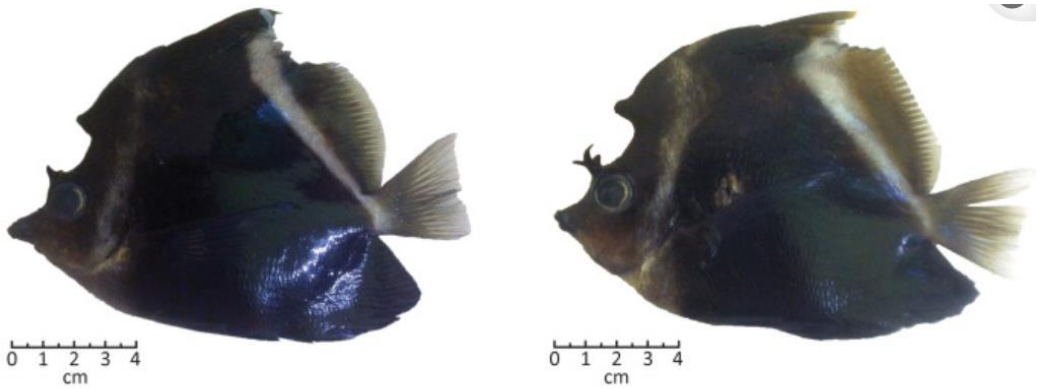


Fig 2.9 Sexual dimorphism in female and male of butterfly fish

Source:
https://fisheries.ap.gov.in/publications/Compendium%20on%20ornamental%20fishes%20english.pdf

2.10 Sword Fish:

It shows sexual dimorphism.

Male: The males' longer caudal fins have a major impact on their ability to mate. The caudal fin extends into a structure resembling a sword. The male fish's anal fin has changed into a tube (gonopodium) (Fig 2.10).

Fig2.10 Male sword fish

Source:
https://fisheries.ap.gov.in/publications/Compendium%20on%20ornamental%20fishes%20english.pdf

Female: At three months of age, a female reaches sexual maturity. The female is larger than a male. Female has anal fin-like fan and deep body. Sex reversals happen all the time. Change from female to male is frequent (Fig 2.11).

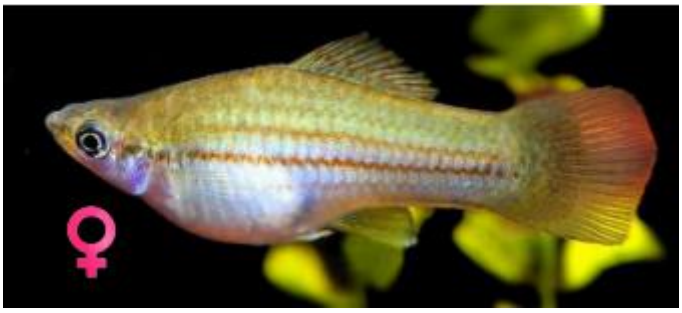


Fig 2.11 Female Sword Fish

Source:
https://fisheries.ap.gov.in/publications/Compendium%20on%20ornamental%20fishes%20english.pdf

2.11 Anemone fish

- It is also known as Protandrous hermaphrodites, or clown fish (Fig 2.12) are those in which the dominant fish in a group mate and become female.
- Clown fish are capable of alternating sexes. Clown fish typically reach adulthood between the ages of one and two years.
- When they get bigger, clownfish only transition from being male to female.
- A huge female, a smaller male, and a few juveniles without a gender usually occupy a host anemone in the wild. A hierarchy of dominance is developed, with the female at the top, the male beneath her, and the smaller juveniles beneath both the male and the larger juveniles.
- A monogamous pair bond is formed between the male and female, and it last until one of them passes away.
- The largest and most dominant juvenile turns into a male and mates with the freshly converted female if the female dies before. The male then quickly transforms into a female.
- When two clownfish are kept together as juveniles, they will eventually work out their relationship. One fish will emerge as the dominant female and the other as the male after they reach sexual maturity.

Fig 2.12 Anemone Fish

Source:

https://fisheries.ap.gov.in/publications/Compendium%20on%20ornamental%20fishes%20english.pdf

SELF ASSESSMENT

- Scope of Aquarium Fish Industry as a cottage industry
    - Types of aquarium feed – Live & Artificial feed
    - What are the various Aquarium Filters and types of filtration methods
    - Write the Common characters and sexual dimorphism of Brackish ornamental fishes
    - What are Exotic and Endemic Aquarium Fishes

Unit-III

FOOD AND FEEDING OF AQUARIUM FISHES

Learning Objectives:

- To understand the feeding habits of young fishes.
- To understand the types and composition of feed.
- To understand the preparation of formulated fish feeds

3.1 Use of live feed for fishes

- To give the fish some color and prepare them for breeding, a variety of live feeds can be used. Giving fish only a small variety of live meals and excluding all other food types is unlikely to give them a balanced diet and could possibly cause internal problems in the fish, such as nutritional imbalances.
- Since a lot of live foods come from ponds, streams, or rivers, they could also include pests for aquariums like hydra, snails, or microorganisms that cause disease.
- Gathering live meals from fish-free water can lessen the risk of carrying disease organisms, but there is still a chance of introducing pests to the aquarium.
- Using live foods that have been cleaned up before consumption might be safer.
- A great live food source for all types of fish, including goldfish, is earthworms.
- The earthworms need to be stored in an airtight container for some time after collection.
- There ought to be little air holes in this. The worms will purge themselves of solids and wastes during this period, making them more appealing to fish. Depending on how big they are and size of a fish, the worms can be served whole or diced.
- Most tropical fish enthusiasts are familiar with sludge worms as a live food source, specifically Tubifex along with other tubificid worms (fig 3.1).
- These tiny worms are fed to adult breeding fish live and are frequently used to entice fish like discus to eat. Since tubifex worms are difficult to successfully cultivate, they are typically purchased from an aquatic store.
- Unfortunately, the majority of tubifex used in aquariums is taken from these unsavory sources because these worms inhabit contaminated sections of streams and rivers in

their natural habitat. Therefore, rather than being a regular food, tubifex should only be used sparingly as an occasional feeding in aquariums.

- The aqueous larval stages of a two-winged fly is called a bloodworm. They are best acquired from aquatic stores and can be challenging to culture. They are especially helpful during the winter while other food sources may be limited.
- In fish species that lay eggs, the nutrients contained in the egg sac are often adequate for the hatchlings.
- Green water containing microscopic algae species such as *Protococcus, Tetrosphaerium, Chalmydomonas, Chlorella, Volvox, Eudorina*, *Pandorina*, etc. is then fed to the fragile hatchlings. It is well known that some *Spirogyra* species of filamentous algae are excellent sources of food for fry and young fish. A good source of nourishment is the green water above, especially in the initial two weeks of growth.
- Live foods can be offered to aquarium fish based on their preferences and feeding habits. Examples include, tubifecids, daphnids, bloodworms, microworms, rotifers, Cyclops, fruit flies, earthworms, mosquito larvae and white worms alternatively use moist or dry pellets, flakes, and chopped pieces of fish, shrimp, beef, oyster, crab, and bovine liver, spleen, lung, heart, and brain.

Fig 3.1 Tubifecids worms

Source: https://www.thefishguide.com/tubifex-worms-live-fish-food/

3.1.1 Feeding of Young ones or fry:

- Fish fries need the tiniest meal. Fry from live bearers are often larger than those from egg layers. Food is consumed by live bearers right away after being released from their parents. When an egg layer hatches, the fry consumes the yolk from its neck

region. They start looking for food after three to five days, when they can swim freely.

- The following items can be fed to the fry as soon as they are able to swim freely:

i. Green water: It is extracted from tanks, ponds, and swimming pools. Green water is produced in tiny containers. Green algae scrapings are inoculated, and then superphosphate and urea are applied as fertilizers. The green water is ready to be fed to the fry after five days.

ii. Infusoria – It can be harvested and fed to fry, or they can be cultured.

iii. Baker's yeast suspension: This creamy liquid is made by dissolving yeast in water and then using it as food.

iv. Egg yolk suspension: Using bolting silk cloth, the yolk of a boiled egg is mixed in fry tank.

3.1.2 Frequency of Feeding:

The above mentioned feed is given till 7 to 10 days. Since they are relatively larger in size, the following foods can be fed in place of the ones mentioned above when it comes to cichlid fry and live bearers fry. *Artemia nauplii* and *daphnia* that have hatched early (soon after hatching) can be given. Live bearers fry can be fed finely ground formulated diets for ten or fifteen days after birth. After 25 to 30 days of life, the following foods can be given: artemia, blood worms, earth worms, tubifex, mosquito larvae, and daphnia.

3.1.3 Live food feeders

a. Worm feeder:

- Care must be used while feeding live food, such as tubifex. The worms sink to the bottom and penetrate into the substratum when tubifex is dropped, protecting them from surface and midwater fish predators.
- Worm feeders are used to feed the surface and midwater fish easier. A worm feeder gets a conical plastic device with tiny holes punched through it.
- When the worms are placed inside the feeder, they escape the openings and as a result fish gets lots of time to eat.

3.1.4 Types of feed:

a. Dry feed with 8–10% moisture content is further divided into five groups:

i. Pellets: Floating or Sinking

ii. Flakes: Round in form. It floats for a while before gradually sinking. It comes in a variety of colors.

iii. Freeze-dried feed: It retains its nutritious value for an extended period of time without losing it. They come in cube form that sticks to a glass tank. As it disintegrates, fish eat on it.

iv. Tablet form: It is able to become stuck at various water levels.

v. Crumble or granular feed: tiny bits that are appropriate for larvae.

b. Moist feed: Fish can be fed this regularly prepared meal. The feed has a moisture content of 35 percent. Its high moisture content prevents it from being stored for extended periods of time.

c. Paste or semi-moist feed: For young fish, this can be given through meshing.

3.1.5 Enrichment of live feed organisms:

- The essential fatty acid content, especially that of eicosapentanoic acid (EPA) and docosahexanoic acid (DHA), also known as highly unsaturated fatty acids (HUFA), is the primary factor influencing the nutritional value of live feeds for aquaculture techniques.
- Enhancing the nutritional content of livefood organisms by different methods of enrichment and bioencapsulation has received a lot of attention in recent years.
- It is possible to make available the nutrients that food organisms lack or are present in insufficient amounts by letting them grow for a certain amount of time in a medium that contains the right amounts of the necessary nutrients.
- These days, a variety of emulsified formulations and microparticulate forms are used to supplement these living meals with vital components like vitamins and color as well as important fatty acids.

- Artemia's filter-feeding behavior makes it possible to easily control the biochemical makeup. In order to enhance the lipid content of *Artemia nauplii* and juveniles, scientists have created a variety of enrichment products, such as compound diets, micro particle diets, and unicellular algae.
- Utilizing liposomes as enrichment products offers a variety of benefits and opportunities.
- This remarkable accomplishment in the field of larviculture has led to improvements in growth rate, survival, and resilience to illness and stress.
- The enrichment approach is being increasingly widely used to intensify culture procedure and it will eventually aid in the beginning of the commercial culture of new species of marine fish.

3.1.6 Limitations of live feed cultures:

- Live feed continues to be the most practicable method for raising larvae in aquaculture species, taking into account a number of parameters. In intense culture systems, it might be challenging to consistently give sufficient amounts of live feed at the right moments.
- The main impediment to the production of micro algae is its expense, particularly in smaller hatcheries. Other major areas of concern are the difficulty in obtaining pure strain and the absence of infrastructure facilities such as controlled environmental laboratories for culture maintenance.
- Maintaining hygiene is crucial during the generation of fish and shellfish larvae, as live feed can also transmit infections to them.
- The new enrichment process technology is expensive for small and medium-sized farms. Similar to this, the necessity for appropriate modified culture technology is demonstrated by the high infrastructural and labor requirements, as well as the variable cost of producing live feed.
- Aqua hatcheries rely more on imported cysts than on domestic strains of artemia, despite the fact that multiple strains are present in India. Selection and compatibility of the domestic strains are key concerns.
- Summarizing the dietary requirements of the live feed organisms is necessary for feeding fish and shellfish larvae at different stages of development.

3.2 Preparation and composition of formulated fish feeds

- Fish keeping in aquariums was once primarily seen as a hobby, but it has now developed into a significant industry. Additionally, the domestic market for ornamental fish has grown.
- Consequently, the aquarium fish maintaining business is growing. This sector's primary concern is with the availability of appropriate food resources (table 1).

Sizes	Protein	Fat	Carbohydrate
Small fishes	40-45	4-6	40
Adult fishes	30-35	6-8	50

Table 1: Nutritional requirements of food for fishes.

Source:http://www.ngbu.edu.in/newsite/Ontuto/M.Sc.%20II%20sem%20Paper%20VI%20Preparation%20of%20food.pdf

- Providing fish with live food on a daily basis is a challenging task for hobbyists, particularly in urban areas. Therefore, there is no other choice except to search for artificial feed, often known as formulated feed.
- Feeds must contain things like meal from fish, oil from fish, prawn flour, and soy. The right nutrients, such as protein, amino acids, fats, essential fatty acids, carbohydrates, and minerals, should be included in the diet.

3.2.1 Requirement of Protein:

- It is one of the fish nutrition areas that is being studied extensively. Due to their high requirement for critical amino acids, fish generally require more protein in their diet than do warm-blooded mammals (table 3.1).
- Carnivorous fish typically need 40–55% of their food to be protein, but omnivorous fish only need 35–45%. Animal tissue weight is composed of 65-75% protein from the diet.
- To achieve protein requirements, one can consume pulses and grams, which are frequently employed as protein sources in cuisine
- .Red lentils, beans, and peas are medium-level protein sources, while soy flour, milk powder, and other similar items are rich in protein.

- Utilizing protein sources is primarily done to meet the requirements for vital amino acids. Therefore, it would be wise to incorporate more plant-based protein.

Serial no.	Fish	Optimum protein level[%]
1	Chinook salmon [*Oncorhynchus tschawytscha]*	40 at 8.3 degree c 55 at 14.1 degree c
2	Japanese eel [*Anguilla Anguilla]*	45
3	Glit head bream[*Chrysophorys aurata]*	40
4	Sea bass[*Dicentrarchus labrax]*	47-50
5	Grass carp fry [*Ctenopharyngodon Idella]*	41-43
6	*Tilapia mossambica* fingerlings	29-38

Table 3.1 Protein requirements of different fishes

Source:

https://www.surendranathcollege.ac.in/wpcontent/uploads/2022/05/PREPARATION-AND-COMPOSITION-OF-FORMULATED-FISH-FEEDS-biswajit-santra.pdf

3.2.2 Requirement of Amino acid:

- Research has shown that fish fed a diet lacking in any one of the ten necessary amino acids arginine, phenylalanine, methionine, threonine, histidine, valine , tryptophan, lysine, and threonine do not grow until the missing amino acids are provided by the diet.
- However, fish that were provided a diet lacking in any of the non-essential amino acids—alanine, glutamic acid, citrulline, cysteine, aspartic acid, glycine, proline, hydroxyproline, serine, and tyrosine grew in the same way as those that were fed a complete diet.

- Thus, to prepare a protein mixture, it is essential to have a thorough understanding of the amino acid requirements for fish. Therefore, it is preferable to include more plant protein in order to meet the needs for essential amino acids.

3.2.3 Requirement of Fatty acid and Lipid:

The tropical fish mainly eats fat, protein, and a small amount of carbohydrates. Dietary fat varies from 3 to 15%.

Fatty acids and lipids in food feeds are often significant for two reasons:

(1) As a means of metabolic energy

(2) To preserve the integrity and structure of cell membranes.

The most popular types of culinary oil—palm, peanut, soybean, cod liver, and mustard oils—can be utilized as lipid sources in prepared ornamental feeds. You can utilize sesame or groundnut seeds as a source of protein and fat.

3.2.4 Requirement of Carbohydrate:

- Despite this, protein and fats have more energy per gram than carbohydrates do. It remains the most affordable way to get energy from food.
- In general, 1g of carbohydrates provides 1.6 kcal of energy to fish. Carbohydrates are actually not that important in a diet.
- Less suited to metabolize larger amounts of carbohydrates are carnivorous animals. Therefore, the lack of carbohydrates has no negative effects. Fish may therefore readily survive on a diet low in carbohydrate.

3.2.5 Requirement of pigments:

- A range of synthetic and natural pigments, sometimes known as carotenoids, can be used to improve the color of salmonid fish meat and the skin of ornamental freshwater and marine fish.
- The hues red and yellow are produced by the pigments that are most commonly utilized. The most widely utilized ingredient is astaxanthin, a synthetic pigment that contains 100–400 mg/kg.

3.2.6 Requirement of binding agents:

- Excellent natural sources of colors include cyanobacteria, dried shrimp meal, shrimp and palm oils, and extracts from red peppers, marigolds, and Phaffia yeast.

- A binding agent is another crucial component of fish meals since it stabilizes the pellet and lessens nutrient leaking into the water.
- Historically, farm-produced feeds have utilized beef heart as an efficient binder and as an alternative source of protein. Other common binding agents include carbohydrates and a variety of other polysaccharides, including extracts or derivatives from plants, animals gelatin, and seaweeds.

3.2.7 Requirement of Vitamins:

- The maximal tropical fishes require four fat-soluble vitamins and eleven water-soluble vitamins.
- A deficiency in these 15 vital vitamins might cause symptoms such as decreased growth and depressed aptitude.
- Additional signs include fatty liver, uneasiness, aberrant coloring, and heightened vulnerability to different infections.
- All fish, but especially guppies, exhibit low development and high mortality rates when their diet is deficient in vitamin A. Thus, vitamins are crucial for a diet high in fish.
- A diet rich in vitamin A should contain between 2000 and 4000 IU/kg to maintain optimal growth. A diet containing 40–80 mg/kg of vitamin E.
- Various supplements used as a vitamin source is broccoli, spinach, china rose, beet root, yeast powder, lemon juice and multivitamins tablets.

3.2.8 Requirement of minerals:

- Nearly 22 minerals are necessary for the natural growth of fish. There are 15 trace elements and 7 main elements.
- The primary seven elements control osmotic balance and aid in bone formation; on the other hand, traces elements are needed in small amounts as parts of the hormone and enzyme systems.
- Normal growth requires phosphorus levels in the range of 0.53-2.23%.
- Fish bodies are quite significant in terms of magnesium. Low growth, sluggishness, high mortality, etc. are caused by magnesium deficiency.
- Fish that have a magnesium content of 0-0.18g/kg are known to exhibit symptoms similar to tissue calcinosis. It needs 0.36 g/kg of magnesium to repair and 0.54 g/kg to develop to its full potential.

- Other choices include calcite, egg shell, lime stone, or calcium supplements. Hydrated lime, which is frequently used with paan leaves, can be utilized in order to satisfy mineral requirements. Salt can be also added. Different supplements can be utilized to fulfill the different needs for minerals.
    - Preservatives, like antioxidants and antimicrobials, are frequently added to fish diets to prolong their shelf life and lessen the lipids' rancidity.
    - Use of vitamin E in formulations made in laboratories, but it's a costly yet efficient antioxidant. Ethoxyquin and butylated hydroxyanisole (BHA), also known as butylated hydroxytoluene (BHT), are commercial antioxidants that are widely accessible.
    - In addition to ethoxyquin, which is added at 150 mg/kg of the food, BHA and BHT are added at 0.005% of the dry weight of the dietary supplement or not more than 0.02% of the fat content.
    - Regularly available antimicrobial agents added at less than 0.1% to fish feed manufacturing are potassium and sodium salt of propionic, benzoic, or sorbic acids.

3.2.8 Requirement of preservatives:

- Preservatives, like antioxidants and antimicrobials, are frequently added to fish diets to prolong their shelf life and lessen the lipids' rancidity.
- Use of vitamin E in formulations made in laboratories, but it's a costly yet efficient antioxidant. Ethoxyquin and butylated hydroxyanisole (BHA), also known as butylated hydroxytoluene (BHT), are commercial antioxidants that are widely accessible.
- In addition to ethoxyquin, which is added at 150 mg/kg of the food, BHA and BHT are added at 0.005% of the dry weight of the dietary supplement or not more than 0.02% of the fat content.
- Regularly available antimicrobial agents added at less than 0.1% to fish feed manufacturing are potassium and sodium salt of propionic, benzoic, or sorbic acids.

3.2.9 Steps for preparation of fish food (fig 3.2):

Fig 3.2 stepwise procedure for preparation of feed

Source:https://www.surendranathcollege.ac.in/wpcontent/uploads/2022/05/PREPARATION-AND-COMPOSITION-OF-FORMULATED-FISH-FEEDS-biswajit-santra.pdf

1. Use a kitchen balance to measure all the ingredients according to the recipe, or measure at home with widely accessible measuring tools.
2. If grinding the protein sources separately proves challenging, they can be combined and powdered instead of being ground individually.
3. Use the provided sieve to strain the powdered items. The powdered mash can be sieved using the tea strainer or the regularly used sieve for atta or maida.
4. It is necessary to homogenize/emulsify wet components, such as fish waste, green leafy vegetables, and eggs, individually in the grinder by incorporating an appropriate amount of water.
5. In a large saucepan, thoroughly combine the powdered mix with oil added.
6. Now, sprinkle in another 100 to 150 milliliter of water and stir.
7. Use the pressure cooker for cooking the mixed mash for five minutes.
8. If clumps start to form, physically stir it again before adding 400–500 milliliter of water to make it resemble semi-moist dough.
9. By applying a hand press machine, pelt the dough. If the process of creating pellets proved problematic, additional water could have been added. Better pellets are produced by a hand press machine when the moisture level is between 50 and 60%.
10. Water must be introduced appropriately and collected in a tray.

11. The pellets can be dried immediately in the oven, using a fan, or by leaving them outside in the sun.
12. The dry pellets should be manually crumbled to the desired particle size, sieved to provide a variety of particle sizes, and then stored in an airtight feed storage container.
13.

3.2.10 Feed Storage:

The prepared feeds are kept in freezer bags, and utilizing a airtight beg can significantly increase the shelf life of the materials and the feed. The feed should be thrown out after six months even though it can be double bagged and kept in the freezer. Dried larval diets should ideally be refrigerated for no more than three months rather than being frozen.

Questions:

1. Explain the different nutritive feed requirements of fish.
2. Explain the steps for preparation of fish feeds.
3. Illustrate the use of live feed for fishes.
4. Write the limitations of live feed cultures.

UNIT IV

Fish Transportation

Objective:

- To understand the fish handling during transportation
- To identify the methods for transport

4.1. Introduction

- Deliver freshly caught fish live to the market for sale. There are numerous fish transportation techniques available. Here are descriptions of a few of these techniques.
- Fish are typically transported in a variety of containers, including fibreglass boxes, bamboo sections, animal skins, bottles, jugs, cans of various sizes, ceramic or metal pots, wooden or metal buckets, vats, barrels, and plastic bags.
- Basically, you may use any clean, watertight container. Certain containers, like wood or styrofoam, offer good heat insulation.
- Because they are poor insulators, materials like plastic and metal containers may need to be packed with ice or covered with damp towels to keep the temperature down.
- Fish are transported to their destination using the quickest method that will offer a reasonably direct and smooth journey after they have been placed in their transport container.

4.2. Transport Consideration

Tolerance Capacity

- If they are to stay robust and healthy, they require kind, caring care.
- Fish's capacity to withstand or adjust to harsh environments is correlated with their travel tolerance.
- The tolerane of the fishes is dependent different stages of fish cycle
- Tolerance level of fishes are as following:

Table 4.1 Tolerance level of Fish

Name	Tolerance Capacity
Oreochromis	High
Catfish	High
Gourami	High
Common	High
Bighead	Medium
Grass	Medium
Silver	Low
Mud	High
Black	High
Indian carps	Medium

Presence of Food in the intestine

It is recommended that the fishes to be transported should not be feed for one or two full days before being relocated.

Crowding brood stock in a seine net and releasing them is a common method of conditioning them for transport to spawning facilities.

Before relocating them from their pond to the hatchery for spawning, this process is carried out for two days in a row.

By stopping their food, the fish are able to cope with the stress of artificial spawning.

Weight of Fishes

Fishes are categorized as sac fry (newly hatched), fry (post larve weighing less than 1g),fingerling (3-4 week old weighing more than 1g) and brood stoch (mature fishes)

For transportation,lower weight of small fish can be higher than per unit volume of water than large fish.

Table 1 provides a guide to establish number of fishes may be transported according to the age.

These figures are based on transporting fish in sealed plastic bags containing oxygen and about 8 liters of clean water at approximately 18 degrees C.

Table 4.2 Quantities of different aged fishes with approx 7.6lts water and pure oxygen

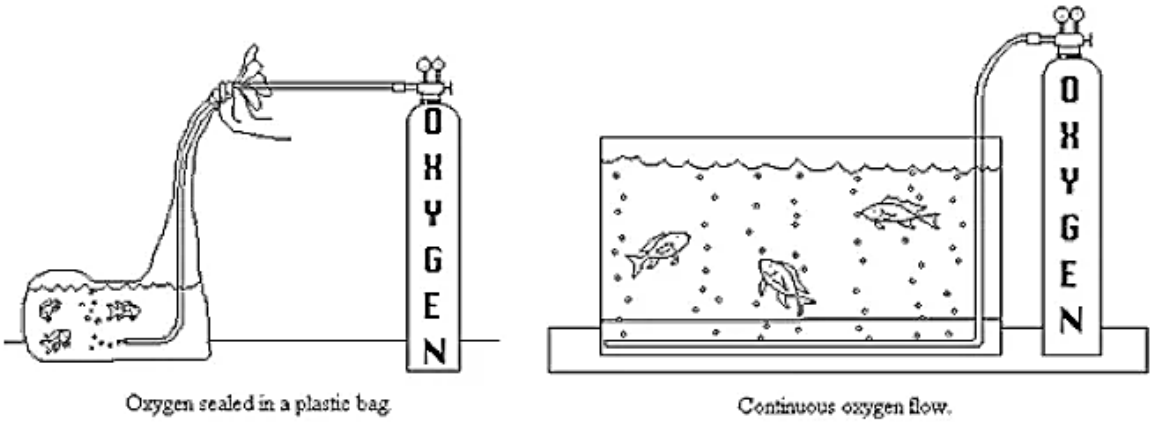
Fishes	Duration of Transport		
	1hrs	12hrs	24hrs
Sac Fry	120	80	40
Fry	60	50	40
Fingerling 1”	120	100	75
Fingerling 2”	120	105	90
Fingerling 3”	120	105	90
Large Fishes	480	180	120

Table 4.3 Quantities of different aged fishes with approx 7.6lts water tank with diffused oxygen

Fishes	Duration of Transport		
	1hrs	12hrs	24hrs
Sac Fry and fry	NR	NR	NR
Fingerling 1”	120	30	30
Fingerling 2”	240	120	120
Fingerling 3”	360	120	120
Large Fishes	480	360	240

Methods used for transporting fish

- Enough oxygen must always be supplied in the water transporting fishes.
- Using pure bottled oxygen is the recommended method for aerating water while transporting fish where oxygen is constantly bubbled into an open container or it can be injected into a plastic bag filled with fish and water and sealed airtight.



Oxygen sealed in a plastic bag. Continuous oxygen flow.

- Typically, one-fourth of the bag is made up of fish and water, and the remaining three-quarters are oxygen.
- A twisted rubber band, string, or other material is used to close the bag shut when oxygen is added.
- When feasible, it is best to put the first plastic bag inside a second bag to prevent leaks.
- After which, the sealed double bag of fish is loaded onto a vehicle for transportation and protected further by being placed inside a box, woven grass bag, or other container.
- Fish can be transported in these containers for 24 to 48 hours without water exchange if they are wrapped appropriately and kept cool.

Water condition

It is advisable to start with water that has the following qualities for extended periods of transportation.

(a) It is recommended to use cool condition for transportation as, fish and bacteria won't be as active, thus lowering consumption of DO and henceforth ammonia and carbon dioxide release.

For cold water fish like trout, 5 and 10℃ is recommended while for warm water fish like common carp 15-20℃ is recommended.

avoid subjecting fishes to abrupt temperature changes.

(b) The pH ranges from 7 to 7.5, and hazardous free ammonia and C02 are present in comparatively small amounts.

(c) The water has a total alkalinity of at least 90 mg of calcium carbonate per litres, which contributes to the water rather alkali pH.

(d) Water should be devoid of suspended solids,

(e) Water used should be pesticides, dissolved iron,and hydrogen sulfide less.

Live fish Organization

- As you gather and grade your fish, take special care of them.
  Acclimate the fish gradually by varying the temperature by more than 2-3℃.
- Before placing the fish in the transit container, thorough cleaning in clean water is recommended.
- Prior to travel the fish away from loud noises and in the dark to help them stay quiet.
- Cut down on the overall amount of time spent traveling by minimizing pauses and preventing delays.
- Maintain transport containers in motion to ensure that the water is regularly agitated, which raises the DO content and improves water quality.
- Refrain from jarring containers too much as this could seriously harm your fish due to high water movements and splashing.
- Replace the transport water with colder, more oxygenated water, making sure the water quality is appropriate.
- Select the loading rate with caution.

Choosing a transport method

Select the method of transport according to **the kind of container** available and **the kind of fish** to be moved:

(a) **Broodfish** are the most difficult to transport.They are required restrain from jumping from water.

(b) **Fry and fingerlings** can be easily transported on the farm as they are easy to handle

(c) **Food fish** are transported to markets if found a healthy it reduce loading rates

4.3. Methods of transportation:

Broodfish transport on the farm

To transport fish following devices according to size, number and distance

- *a small bag*: it is made of waterproof canvas or plastic
- *a larger canvas bag* which is hung from two wood or bamboo poles
- Hammock: If need, cover the top with a flap to keep the fish from jumping out. If required, include a flap to cover the top and keep the fish from emerging. To stop the fish from jumping out, add a flap if needed to cover the top.

Transport of fishes small containers

- Fish can be transported in a variety of small vessels constructed of fired clay, wood/bamboo, plastic, or metal.
- Transportation within the farm typically takes no longer than 30min, and modest distance

Following methods are used:

(a) Tiny baskets composed of different plant materials can be utilized to transport tiny quantities of resilient fish, like tilapias, across extremely short distances without the need for water.

(b) Round earthenware vessels are used in Asia. They can be hung on a bamboo shoulder pole

(c) Round tin Containers: These are Iron sheets that is galvanized with tin. It is an eight-inch-tall, spherical container with an 18-inch diameter. Numerous tiny holes in the lid are helpful for letting air in. Only eight of the nine liters of water that this container can hold are actually filled.

(d) Double tin carriers: Consisting of an exterior and an inner tin galvanized with iron. The exterior is 13" x 13" x 8. The entire tin has two tiny apertures, and the inner tin is sealed. After being stored in the outer tin, the inside tin is filled with water and fish seed is added. It is typically used for manually transporting and has a capacity of around 6 gallons.

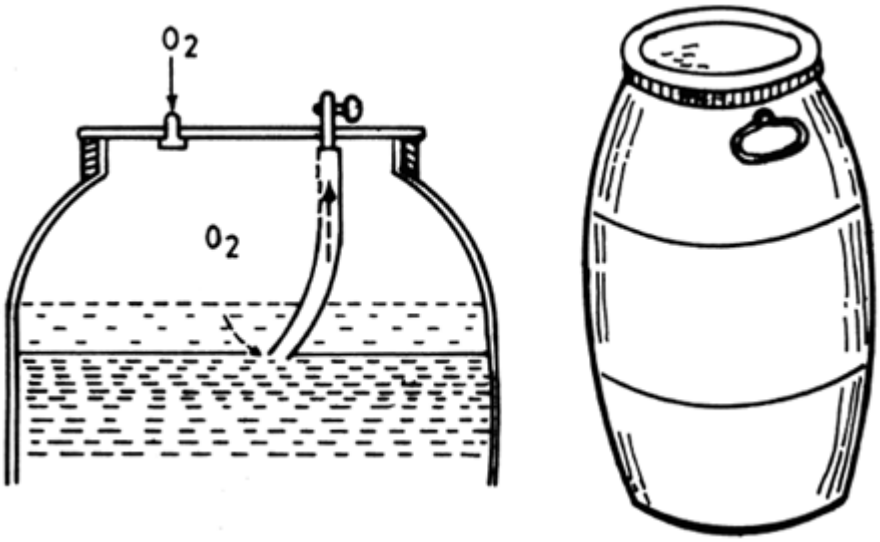


Figure 4.1. Double tin carriers

(e) Oxygen tin carriers: It uses large polythene bags 17"X15" and tins measuring 18" X28". After being placed in the tin and loaded with water, seed, and oxygen, thereafter transported.

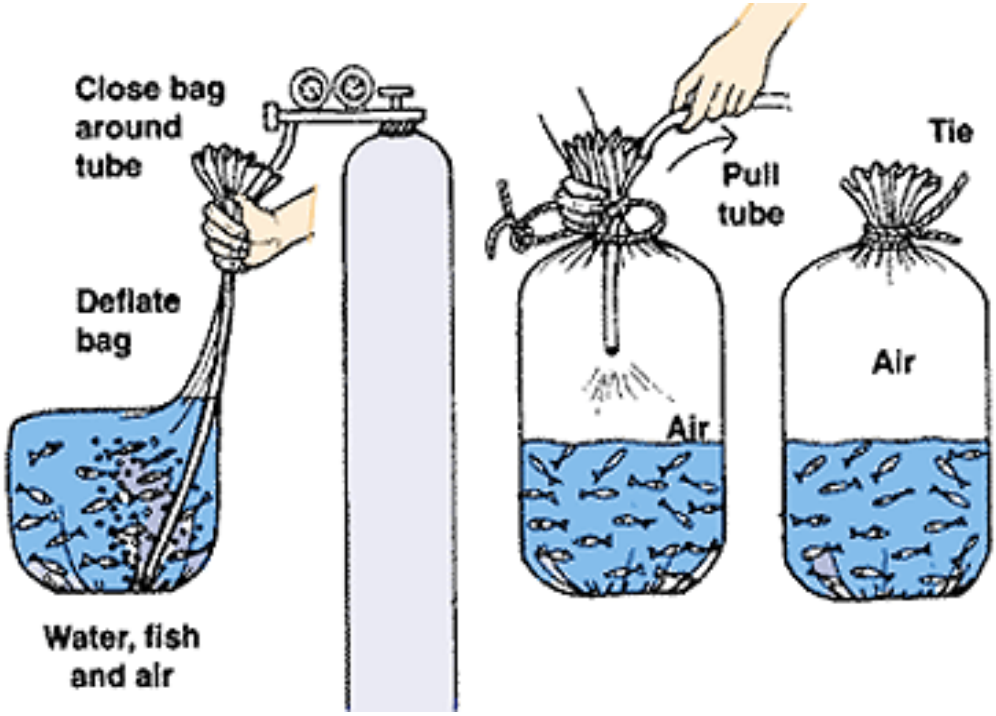


Figure 4.2 Oxygen tin careers

(f) Plastic bags for the transport: Either single or doubled wall bags can be used.At present insulates box are also used to pack the plastic bags to avoid damage

usually cork or polystyrene sheet are used. Some times ice packs are also recommended to mant the temperature for longer transport.

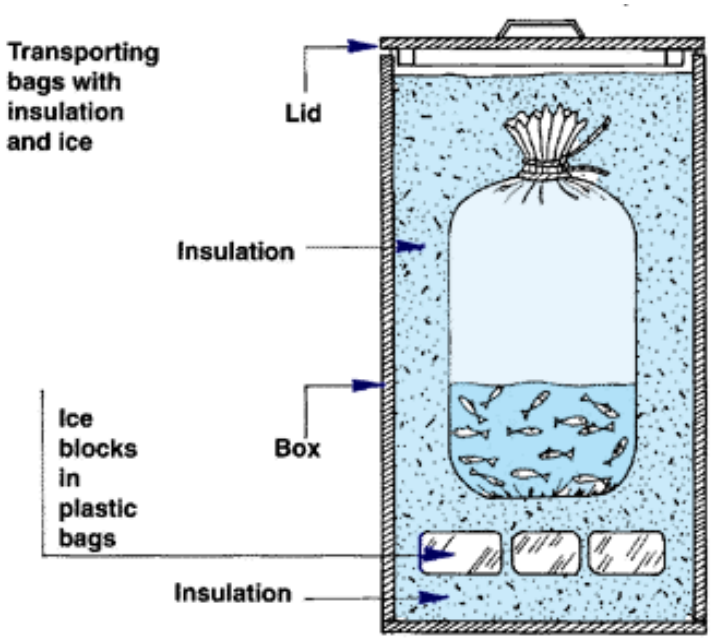


Figure 4.3. Plastic bags for transport

Self-Assessment:

- What are the major caution to be considered during transport of fishes
- Write a note on various method for live fish transportation

Unit V

Maintenance of Aquarium

Objective:

- **To understand routine maintenance of aquarium.**
- **To understand the requirnemt to make aquaculture as a cottage business**

5.1 Introduction

- Aquarium are a small glass or fibre tank which are use to keep living aquatic animals or plants

Condition to conctruct an aquarium are as follows:

- The aquarium needs to be large enough to hold every fish in it.
- In the fish tank, fish need to be able to swim freely.
- Fish with crowded living quarters will not be in good health.
- Use watertight glue to assemble the glass pieces together.
- The ceiling of the aquarium needs to be exquisite so as to allow for the feeding of fish,

List of general fishes for aquarium

1) Goldfish have a vivid orange color. They make adorable and cuddly additions to any aquarium. They are an essential component of many exquisite aquariums.

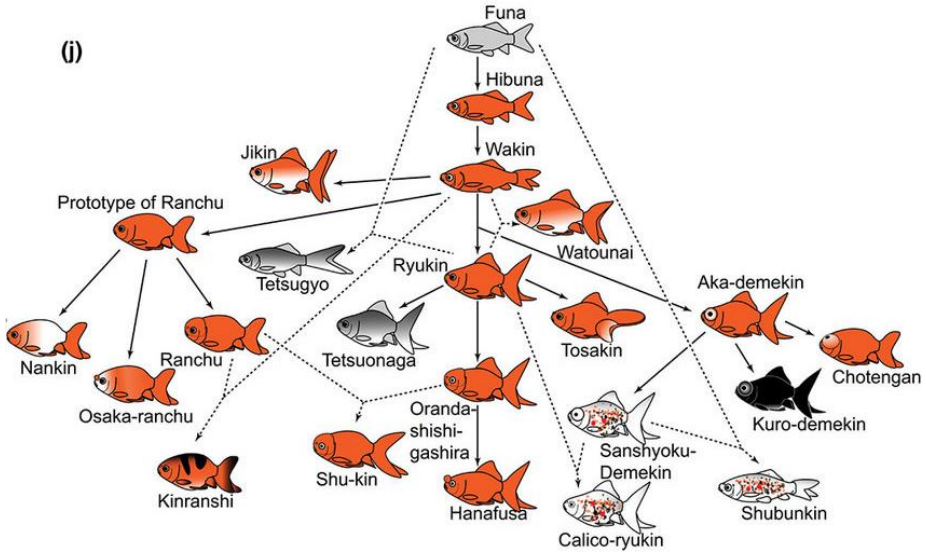


Figure 5.1 Types of Gold fishes

2) The angel fish has several colors. Their broad, diamond-shaped body frequently resembles an

angel with four wings. They are classy and dignified additions to any aquarium.

Figure 5.2 Types of Angel Fishes

3) The eel fish is well-known for looking like a snake. In an aquarium, they are elegant and full of pride. Avoid putting other weak fish alongside eels since some species have the ability to generate electricity.

Figure 5.3. Types of Eel Fishes

4) Catfish have lengthy whiskers and an inquisitive appearance. Typically, they have a grey or black color.

Figure 5.4. Types of Catfishes

5) Guppy Fishes blends in nicely with the artificial ecosystem.

6) Betta Fihes are fluffy, electric blue. They make a charming and colorful addition to your aquarium.

Figure 5.5 Types of Betta Fishes

5.2 Taking care of Aquarium

Maintaining an aquarium is a crucial procedure. Typical advice for maintaining an aquarium is:

Pumps filters

- Pumps for filters remove extra carbon dioxide from the water with simultenousl addition of oxygen. As a result, they support the preservation of the water's ideal oxygen content.
- After installing effective filter pumps, an aquarium's water has to be changed just once a week.
- Filter cleanings may be need weekly for maintain the efficiency
- Use of chemical cleaners, soap, or bleach will destroy the good bacteria needed for aquarium life, so avoid using these.

Minimizing the amount of ammonium

Ammonia is hazardous to fishesAn aquarium's rising ammonia content has to be examined. When numerous tiny leaves and plant remnants decompose, ammoniac content is produced. The fish's health will be impacted by this, particularly their eyesight. By altering the water, one can reduce the contamination.

Examining a fungus infestation

If the plant's leaves turn yellow before they deteriorate, an aquarium plant's fungal infection is the cause. Fish suffer from this as well.

Aquarium Maintenance tip

1) Avoid keeping carnivorous fish and fish that are in conflict with one another in the same aquarium.

3) Avoid placing aquariums in hazardous locations, at high elevations

4) Avoid placing the fish tank in an area that receives direct sunlight. Fungus will grow as a result of this.

5) Never fill an aquarium with chlorine water.

6) Use potassium permanganate before planting.

7) Avoid touching fish with your bare hands..

Maintenance of Aquarium

Regular duties for maintaining an aquarium should be done on a daily, weekly, biweekly, and monthly basis.

- Modifications in behavior are a reliable sign of a possible issue.
- Every other week, test your water for the following essential factors: nitrite, nitrate, pH, and carbonate hardness.
- Tidy the walls of the tank
- Take a gravel vacuum
- Change 10–15% fresh water
- Use the collected water to rinse the filter inserts.
- Change the Algone, floss, carbon, cartridges, and filter inserts.
- Verify that airstones, skimmers, tubing, connectors, and other components are operating properly.

5.3. Cost of setting an aquarium

Seting up an aquarium requires may equipments such:

Aquarium containers: These days, standard glass aquarium tanks are not very popular. The majority of people like acrylic aquariums for walls and corners. They start at roughly 2000-7000 INR..

Pumps for Filters: Water purification is the purpose of filter pumps. They come in a variety of intriguing models. There are filter pumps on the market designed like sea horses, scuba divers, oysters, treasure boxes, and wrecked ships. The cost of filters may range between Rs500-700

Thermometer: It is used to determine the aquarium's temperature it is crucial and may cost: about 150-200rupees

An eclectic heater is also required the water's temperature as it drops. The water temperature in the tank is sensed by a thermostat that is attached to the electric heater.

lighting in the right manner.

Fish nets: It is required for moving fish from one fish tank to another, fishnets are utilized. They are affordable, with a starting price of 50 Rs.

5.4. Fish farm as a cottage industry

It is profitable to start a small-scale ornamental fish farming business from home, and anyone can do it.

Tanks

The tanks might have flat bottoms, contains inlet and output pipes. They may be made of clay, cement, fiberglass, or plastic..

Aquariums

For breeding, glass tanks of various capacities are needed. For example male fighter fish, can be stored 250 ml glass bottles are utilized..

Water Source

The best place to get water is from deep tube wells. Water recycling can be attempted by users using biofilterr. Also, a system of pipelines is required to feed the culture tanks equipped with a small pump to raise the water to the overhead tank.

Task Shed

The layout of the work shed should be such that the tanks receive filtered sunlight.

Aeration apparatus

It is essential to have a blower pump with an aeration tube network..

5.5. How to start ornamental fish farming business

Enough room, good water, and enough food are the fundamental needs for ornamental fish breeding and rearing to be successful.

Business plan

- Ideally, one should begin small. Make a budget and, of course, decide on a marketing strategy.

Select farm location

- . One could initiate the business nearby a market. Once after success one can get a permanent location

Prepare fish tank or Pond

- One could use glass, cement, or plastic container for initial cultivation.
- It is advisable to utilize a glass tank if you wish to offer retail sales from your farm. But you can also make use of the pond.

- It is ideal to buy both large and small tanks for different requirnment i.e. fingerlings are typically grown in tiny aquariums and giant fish in a large tank or pond.

Select fishes

- Carefully choose the fish based on the demands of the local market or solely focused on exports

Promote ornamental fish farming business

- Product promotion done right is crucial. An excellent choice is an aquarium store. It is crucial for retail establishments.
  Signing up for local B2B directories to list company is a must.
- Finally, to help your ornamental fish farming business, strive to create a strong and broad distribution channel.

Self-Assessment

- **Explain Fish farm as a cottage industry**
- **.Describe Cost of setting an aquarium**

REFERENCES

- G. Helfman, Bruce B. Collette, D.E. Facey, B. W. Bowen (2022) The Diversity of Fishes: Biology, Evolution, and Ecology, John Wiley & Sons. ISBN 10: 1119341914 ISBN 13: 9781119341918
- 2. R. J. Wootton: Fish Ecology, Springer
- W. Vishwanath, W.S. Lakra and U.K. Sarkar(2010) Fishes of North East India, NBFGR Publication, Lucknow
- Handbook of Fisheries and Aquaculture (2006) ICAR
- A. D. Dholakia (2021) Ornamental Fish culture and Aquarium Maintenance , Daya pub. House, New Delhi
- A. Saxena (2003), Aquarium Management. Daya pub. House, New Delhi
- K. Rataj, and R. Zukal: Aquarium Fishes and Plants. Spring Books, London,

GLOSSARY

1. **Aquarium Fish Industry**: The collective term referring to the commercial aspects of breeding, trading, and selling aquarium fish, including both large-scale enterprises and smaller cottage industries.
2. **Cottage Industry**: A small-scale business or production process, often operated from a home or small workshop, focusing on handmade or artisanal goods. In the context of aquarium fish keeping, it refers to small-scale breeding operations.
3. **Exotic Species**: Species of aquarium fish that are not native to the local habitat and are often imported from other regions or countries for their unique colors, patterns, or behaviors.
4. **Endemic Species**: Species of aquarium fish that are native and unique to a specific region or habitat.
5. **Biology of Aquarium Fishes**: The study of the physical characteristics, behaviors, physiology, and ecological roles of aquarium fish species.
6. **Sexual Dimorphism**: Differences in physical characteristics between males and females of the same species, often related to breeding behaviors or reproductive roles.
7. **Guppy**: A small, live-bearing freshwater fish known for its vibrant colors and prolific breeding habits, popular among aquarium hobbyists.
8. **Molly**: Another live-bearing freshwater fish species, similar to guppies but often larger in size and known for their peaceful temperament.
9. **Swordtail**: A freshwater fish species named for the distinctive sword-like extension on the tail fin of males, popular for their ease of care and variety of colors.
10. **Goldfish**: A freshwater fish species of the carp family, characterized by their bright colors, distinctive shapes, and long history of domestication as ornamental fish.
11. **Angel Fish**: A group of freshwater and marine fish species known for their distinctive, disc-shaped bodies and elongated fins, popular among aquarium enthusiasts for their graceful appearance.
12. **Blue Morph**: A term used to describe aquarium fish species that exhibit variations in coloration, particularly those with blue hues or color patterns.
13. **Anemone Fish**: Also known as clownfish, these colorful marine fish are often associated with symbiotic relationships with sea anemones and are popular for their striking appearance and interesting behaviors.

14. **Butterfly Fish**: A group of marine fish species known for their vibrant colors, intricate patterns, and delicate, butterfly-like fins, often found in coral reef habitats.
15. **Live Fish Feed Organisms**: Small organisms used as food for aquarium fish, such as brine shrimp, daphnia, or bloodworms, often prized for their high nutritional value.
16. **Formulated Fish Feeds**: Commercially prepared fish food products containing a balanced blend of nutrients, vitamins, and minerals to meet the dietary needs of aquarium fish.
17. **Fish Transportation**: The process of moving aquarium fish from one location to another, often involving careful handling, packaging, and transport to minimize stress and ensure the health and safety of the fish.
18. **General Aquarium Maintenance**: Routine tasks and procedures involved in the upkeep of aquariums, including water quality management, filtration system maintenance, and cleaning of tank surfaces and decorations.
19. **Budget**: A financial plan outlining the expected costs and expenses associated with setting up and operating an aquarium fish farm as a cottage industry, including equipment, supplies, and overhead expenses.