Plant Science

Grade 10

Industrial Entomology and Fish Culture

Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
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Technical and Vocational Stream
Learning Resource Material

Industrial Entomology and Fish Culture

(Grade 10)

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Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline, self-reliance, creativity and thoughtfulness. It is essential to develop linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills in students. It is also necessary to bring the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This learning resource material for Plant Science has been developed in line with the Secondary Level Plant Science Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops, seminars and interaction programs attended by teachers, students and parents.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Mr. Yubaraj Paudel and members of the subject committee Pro.Dr. Kaniya Prasad Singh, Pro.Dr. Gyan Kumar Shrestha, Dr. Kishorchandra Dahal, Anita Bolakhe is highly acknowledged. The learning resource material is written by Rikhiram Neupane, Santosh Koirala, Niraj Belbase, Purnima Paudel, Mahesh Poudel, Dayamand Pokharel the subject matter of the materials, was edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala and language was edited by Mr. Binod Raj Bhatta. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

This learning resource material contains a wide coverage of subject matters and sample exercises which will help the learners to achieve the competencies and learning outcomes set in the curriculum. Each chapter in the material clearly and concisely deals with the subject matters required for the accomplishment of the learning outcomes. The Curriculum Development Centre always welcomes constructive feedback for the betterment of the material.

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Sanothimi, Bhaktapur

Table of Content

Guidelines to Teachers

A. Facilitation Methods

The goal of this course is to combine the theoretical and practical aspects of the contents needed for the subject. The nature of contents included in this course demands the use of practical or learner focused facilitation processes. Therefore, the practical side of the facilitation process has been focused much. The instructor is expected to design and conduct a variety of practical methods, strategies or techniques which encourage students engage in the process of reflection, sharing, collaboration, exploration and innovation new ideas or learning. For this, the following teaching methods, strategies or techniques are suggested to adopt as per the course content nature and context.

Brainstorming

Brainstorming is a technique of teaching which is creative thinking process. In this technique, students freely speak or share their ideas on a given topic. The instructor does not judge students' ideas as being right or wrong, but rather encourages them to think and speak creatively and innovatively. In brainstorming time, the instructor expects students to generate their tentative and rough ideas on a given topic which are not judgmental. It is, therefore, brainstorming is free-wheeling, non-judgmental and unstructured in nature. Students or participants are encouraged to freely express their ideas throughout the brainstorming time. Whiteboard and other visual aids can be used to help organize the ideas as they are developed. Following the brainstorming session, concepts are examined and ranked in order of importance, opening the door for more development and execution. Brainstorming is an effective technique for problem-solving, invention, and decision-making because it taps into the group's combined knowledge and creative ideas.

Demonstration

Demonstration is a practical method of teaching in which the instructor shows

or demonstrates the actions, materials, or processes. While demonstrating something the students in the class see, observe, discuss and share ideas on a given topic. Most importantly, abstract and complicated concepts can be presented into visible form through demonstration. Visualization bridges the gap between abstract ideas and concrete manifestations by utilizing the innate human ability to think visually. This enables students to make better decisions, develop their creative potential, and obtain deeper insights across a variety of subject areas.

Peer Discussion

Peer conversation is a cooperative process where students converse with their peers to exchange viewpoints, share ideas, and jointly investigate subjects that are relevant or of mutual interest. Peer discussion is an effective teaching strategy used in the classroom to encourage critical thinking, active learning, and knowledge development. Peer discussions encourage students to express their ideas clearly, listen to opposing points of view, and participate in debate or dialogue, all of which contribute to a deeper comprehension and memory of the course material. Peer discussions also help participants develop critical communication and teamwork skills by teaching them how to effectively articulate their views, persuasively defend their positions, and constructively respond to criticism.

Peer conversation is essential for professional growth and community building outside of the classroom because it allows practitioners to share best practices, work together, and solve problems as a group. In addition to expanding their knowledge horizon and deepening their understanding, peer discussions help students build lasting relationships and a feeling of community within their peer networks.

Group Work

Group work is a technique of teaching where more than two students or participants work together to complete a task, solve a problem or discuss on a

given topic collaboratively. Group work is also a cooperative working process where students join and share their perspectives, abilities, and knowledge to take on challenging job or project. Group work in academic contexts promotes active learning, peer teaching, and the development of collaboration and communication skills. Group work helps individuals to do more together than they might individually do or achieve.

Gallery Walk

Gallery walk is a critical thinking strategy. It creates interactive learning environment in the classroom. It offers participants or students a structured way to observe exhibition or presentation and also provides opportunity to share ideas. It promotes peer-to-peer or group-to-group engagement by encouraging participants to observe, evaluate and comment on each other's work or ideas. Students who engage in this process improve their communication and critical thinking abilities in addition to their comprehension of the subject matter, which leads to a deeper and more sophisticated investigation of the subjects at hand.

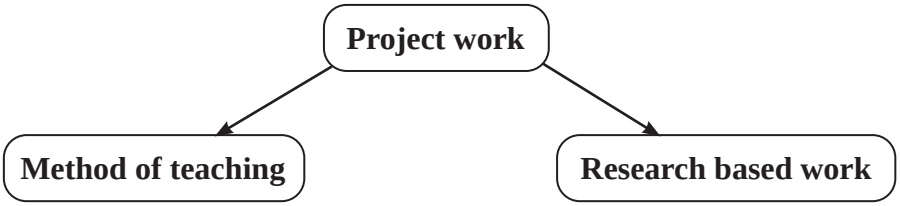
Interaction

The dynamic sharing of ideas, knowledge, and experiences between people or things is referred to as interaction, and it frequently takes place in social, academic, or professional settings. It includes a broad range of activities such as dialogue, collaboration or team work, negotiation, problem solving, etc. Mutual understanding, knowledge sharing, and interpersonal relationships are all facilitated by effective interaction. Interaction is essential for building relationships, encouraging learning, and stimulating creativity in both in-person and virtual contexts. Students can broaden their viewpoints, hone their abilities, and jointly achieve solutions to difficult problems by actively interacting with others.

Project Work

Project work is a special kind of work that consists of a problematic situation which requires systematic investigation to explore innovative ideas and solutions.

Project work can be used in two senses. First, it is a method of teaching in regular class. The next is: it is a research work that requires planned investigation to explore something new. This concept can be presented in the following figure.



Project work entails individuals or teams working together to achieve particular educational objectives. It consists of a number of organized tasks, activities, and deliverables. The end product is important for project work. Generally, project work will be carried out in three stages. They are:

- Planning
- Investigation
- Reporting

B. Instructional Materials

Instructional materials are the tools and resources that teachers use to help students. These resources/materials engage students, strengthen learning, and improve conceptual comprehension while supporting the educational goals of a course or program. Different learning styles and preferences can be accommodated by the variety of instructional resources available. Here are a few examples of typical educational resource types:

- Daily used materials
- Related Pictures
- Reference books
- **Slides and Presentation:** PowerPoint slides, keynote presentations, or other visual aids that help convey information in a visually appealing and organized manner.
- **Audiovisual Materials:** Videos, animations, podcasts, and other

multimedia resources that bring concepts to life and cater to auditory and visual learners.

- **Online Resources:** Websites, online articles, e-books, and other web-based materials that can be accessed for further reading and research.

Maps, Charts, and Graphs: Visual representations that help learners understand relationships, patterns, and trends in different subjects.

Real-life Examples and Case Studies: Stories, examples, or case studies that illustrate the practical application of theoretical concepts and principles.

C. Assessment

Formative Test

Classroom discussions: Engage students in discussions to assess their understanding of concepts.

Quizzes and polls: Use short quizzes or polls to check comprehension during or after a lesson.

Homework exercises: Assign tasks that provide ongoing feedback on individual progress.

Peer review: Have students review and provide feedback on each other's work.

Summative Test

Exams: Conduct comprehensive exams at the end of a unit or semester.

Final projects: Assign projects that demonstrate overall understanding of the subject.

Peer Assessment

Group projects: Evaluate individual contributions within a group project.

Peer feedback forms: Provide structured forms for students to assess their peers.

Classroom presentations: Have students assess each other's presentations.

Objective Test

Multiple-choice tests: Use multiple-choice questions to assess knowledge.
True/False questions: Assess factual understanding with true/false questions.

Matching exercises: Evaluate associations between concepts or terms.

Portfolio Assessment

Compilation of work: Collect and assess a variety of student work samples.

Reflection statements: Ask students to write reflective statements about their work.

Showcase events: Organize events where students present their portfolios to peers or instructors.

Observational Assessment

Classroom observations: Observe students' behavior and engagement during class.

Performance observations: Assess practical skills through direct observation.

Field trips: Evaluate students' ability to apply knowledge in real-world settings.

Unit 1

Beekeeping

1. Beekeeping

1.1 Introduction

Apiculture or bee keeping is the science and art of managing honey bee colonies to produce honey, beeswax, pollen, royal jelly, and other valuable products. It also plays a crucial role in pollination, contributing to agricultural productivity.

The word 'Apiculture' is derived from the two latin words *"Apis"* and *"Cultura"*. *"Apis"* (Latin), meaning bee and *"cultura"* (Latin), meaning cultivation or care or management.

Honey, a sweet golden liquid, has been loved by people for a very long time. In ancient times, people in Nepal knew about honey and how it was made by bees. Honey is called Madhu in Sanskrit and Maha in Nepali.

The importance of honey was mentioned in ancient scriptures like the Rig Veda. It was considered a divine substance and was used for various purposes, including as a medicine. People believed that honey could heal wounds, relief coughs, and improve overall human health.

People in Nepal have been keeping bees for many years. In ancient times, people depended on wild bees to collect honey. They would climb tall trees and cliffs to find beehives.

Slowly, people started to rear bees in locally made wooden log and box hives. Now a days modern hives is popular for commercial honey production. This practice or rearing honey bee is called beekeeping or apiculture.

Our ancestors recognized the value of honey, not just as a sweet treat but also as a medicinal and nutritional resource. During ancient time Nepali people collected honey from bees that lived in the wild. They found beehives in forests

and on hills. This practice is connected to Nepali religious and cultural traditions. During the Rana era, a period of dynastic rule in Nepal, saw a renewed interest in beekeeping. This was likely due to the influence of Western culture and the growing awareness of the benefits of honey. Places like Godavari and Nagarjun, known for their natural beauty and diverse flora, became centers of beekeeping activity. During this time, honey was stated to be valued for its nutritional properties as well as for its cosmetic uses.

In the mid-20th century (around 2000 BS.), the government of Nepal initiated efforts to modernize beekeeping. The Small and Cottage Industries Department played a key role in promoting beekeeping as a cottage industry.

Later, the Godavari Beekeeping Centre was established under the direction of the late King Birendra Bir Bikram Shah Dev in 1942 BS. However, the Godavari Beekeeping Centre was a crucial step in the institutionalization and modernization of beekeeping in Nepal.

Beekeeping in Nepal has improved a lot, but there's still room for more growth. By using new methods, building better facilities, and research in bees, Nepal can make beekeeping even better. This can help the economy of farmers and help to protect the environment. Some of the important terminologies related to beekeeping are listed below:

Beekeeping (Apiculture): Taking care of bees for honey, wax, and other useful products.

Hive: A structure where bees live and make honey.

Colony: A group of bees living together in a hive.

Queen Bee: The main female bee who lays all the eggs in the hive.

Worker Bee: Female bees that do all the work like collecting food, feeding babies, cleaning, and protecting the hive.

Drone: Male bees that only mate with the queen and they donot have stingers.

Brood: The eggs, larvae, and pupae inside the hive.

Comb: Structure of wax built by bees inside the hive where they store honey and raise baby bees.

Wax (Beeswax): A natural substance produced by bees to build the comb, where they store honey and raise brood.

Royal Jelly: A special, nutrient-rich secretion produced by worker bees and fed to queen larvae, which helps them develop into queens.

Nectar: A sweet liquid produced by flowers and collected by bees to make honey.

Pollen: Flower powder collected by bees which is rich in protein and nutrients.

Honey: A sweet substance made by bees from nectar and stored in the comb.

Apiary: A place where many beehives are kept together.

Swarming: Leaving the hive by bees with a new queen to start a new colony somewhere else.

Stinger: A sharp part used by bees to sting and protect the hive.

Foraging: The process of collecting nectar, pollen, and water by bees.

Bee Suit: Special clothing worn by beekeepers to protect themselves from bee stings.

Gloves: Protective gear worn on hands to prevent bee stings while working with the hive.

Bee veil: A hat with a net worn over the head to protect the face and neck from bee stings.

Smoker: A tool that blows smoke into the hive to calm the bees during inspection.

Hive Tool: A flat metal tool used to open hives, remove frames, and scrape wax or propolis.

Bee Brush: A soft brush used to gently remove bees from combs or frames.

Frame: A wooden or plastic structure that holds the comb inside the hive box.

Extractor: A machine that spins honey out of the comb without breaking it.

Queen Excluder: A metal or plastic grid placed in the hive to keep the queen out of the honey area.

Feeder: A container placed inside the hive to give sugar water to bees during dry period.

Propolis: Resin collected by bees from trees used to seal cracks in the hive and protect it from pathogens.

Bee bread: It is a fermented mixture of pollen and honey or nectar stored by bees in the hive, serving as a vital food source for larvae and worker bees.

Queen cage: It is a small enclosed container used in keeping a queen bee temporarily.

1.2 Importance and Scope

Beekeeping is an important activity that contributes to both the economy and the environment. Honey bee play a crucial role in pollination which is essential for the better yield of the crops. Additionally, beekeeping helps to yield different valuable products which can help to generate handsome income for the farmers. The different importance of beekeeping are described through these listed points;

1. **Natural pollinators:** Bees are known as the best pollinators for plants which supports agriculture and ecosystems.
2. **Nutritional value:** Honey and pollen are rich in nutrients which helps to improve health.
3. **Religious and Cultural Value:** Honey has religious and traditional significance in many cultures. Such as honey is used as one of the five elixirs of "Panchamrit" used for offering God and served as "Prasad", Buddhist and Christian use candles made from bee wax in their rituals.
4. **Economic Value:** High value products from hive such as honey, pollen, wax, royal jelly etc.
5. **Employment and Self-Employment:** Beekeeping can offer sustainable

jobs and self-employment opportunity.

7. **Medicinal value:** Honey is widely used in Ayurveda, homeopathy, and modern medicine for its healing properties.
8. **Tourism Value (Api-Tourism):** Beekeeping farms can attract tourists and create awareness about bees.
9. **Environmental Indicators:** Bees are sensitive to environmental changes and act as indicators of ecological health.
10. **Symbol of Unity and Hard Work:** Bees represent teamwork and dedication which can inspire human for hard work to chase the goal.

There are different scope of bee keeping which are describes as follows:

Increased Demand for Natural Products: People in Nepal are becoming more health conscious. There is a growing interest in natural products like honey, wax, and pollen. The demand for these bee products is increasing which offers a profitable opportunity for beekeepers.

Support for Livelihoods: Beekeeping can provide an additional source of income for farmers. This helps farmers to diversify their income and improve their economic condition.

Boosting Yield: Bees are essential for pollinating different crops. By enhancing better pollination it helps to improve crop yield. Beekeeping directly supports agricultural productivity and food security.

Employment Opportunities: Beekeeping creates job opportunities for people. From beekeeping and honey extraction to packaging and marketing, there are various aspects of the industry where people can find employment.

Promoting Api-Tourism: Beekeeping farms in Nepal can attract tourists who are interested in learning about honey production and the importance of bees. This helps to promote beekeeping as well as contributes to the growing eco-tourism industry in Nepal.

Expanding Market Access: Nepalese honey and bee products have the potential

to be sold in global markets as a high-value commodity. Sufficient production of honeybee products in Nepal can be sold both locally and internationally.

1.3 Varieties/Types of bees:

Bees are essential to our environment. Solitary bees and Social bees are two main types of bees. Solitary bees live alone and do not form colonies. It do not produce honey also. On the other hand social bees live in colonies. These bees include a queen bee, worker bees, and drones. These bees work together to build hive, gather food, and care for their young. The most well-known example of social bees is the honeybee, which produces honey. Both types of bees are crucial for the health of ecosystems and agriculture. These bees are describes below in detail.

1. **Solitary Bees:** These bees live alone and do not form colonies. They are important pollinators but do not produce honey. Examples include mason bees, leafcutter bees, and carpenter bees.

Mason Bees: These solitary bees use mud to build their nests in small holes. They are excellent pollinators and are often used in orchards

Carpenter bees: These bees get their name because they like to nest in wood, creating tunnels. They are often mistaken for bumblebees but are smaller and have a shiny black abdomen.

Leaf cutter bees: Leaf-cutter bees are tiny, hard-working bees that cut leaves to build their homes. They are great for gardens because they are good pollinator. Female leafcutter bee builds her own nest in hollow stems, holes in wood, or even in man-made structures.

2. **Social Bees:** These bees live in colonies with a queen bee, worker bees, and drones. They work together to build nests, collect food, and raise young.

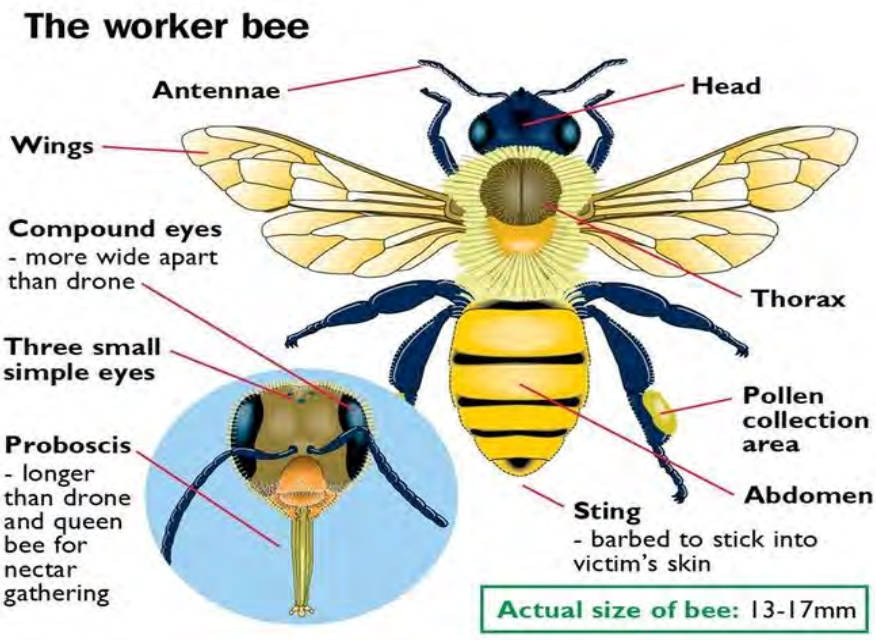
Social bees are categorized into three types:

i. **Bumble Bee (Bhamara):** Large, bees are known for their loud buzzing sound. They are important pollinators and can be seen buzzing from flower

to flower.

ii. **Stingless Bee (Putka):** Small bees that live in tropical and subtropical regions. They produce honey but do not have stingers.

iii. **Honey Bees:** Honeybees are interesting insects with specialized body parts for their unique roles. Their head composed of compound eyes for vision, antennae for sensing, and mouthparts for feeding. The thorax supports two pairs of wings for flight and six legs for walking and collecting pollen. The hind legs have pollen baskets to carry pollen, and the proboscis is used to suck nectar from flowers. The abdomen contains organs for digestion, reproduction, and producing honey and wax. Female honeybees, including worker bees and the queen bee, have a stinger for defense. All species has their own unique behavior and some species may not collect pollen and nectar for honey. They may possess parasitic characteristics.



Picture source: https://www.pinterest.com/pin/400257485615923304/

Honey bee is the most well-known type of bee. They collect nectar, and pollen from flowers, which they use to make honey and other valuable products.

They play a vital role in pollination, which is essential for the reproduction of many plants. They are social insects that live in colonies. They also have a complex social structure with a queen bee, worker bees, and drones. There are different species of honeybee. Among them five species are popular and their characteristics are listed below:

1. Little Honeybee (*Apis florea*)

- Smallest of the Apis species
- Found in hills and plains at altitudes up to 1,200 masl (meter above sea level)
- Open nesting honeybee builds single small comb nests under small tree branches or bushes
- Colonies migrate frequently if the nesting site and forage area is inappropriate
- Average honey yield is 1-3 kg per colony per year
- Honey is regarded as having high medicinal value
- Efficient pollinator of crops and natural flora in the Himalayan foothills
- **Origin:** Asia
- **Found in:** South and Southeast Asia, including India, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, Vietnam, Laos, Cambodia, and the Philippines.

2. Giant honeybee / Rock bee (*Apis dorsata*)

- Largest honey bee species
- Found in hills and plains at altitudes up to 1,000 masl
- Open nesting honeybee, prefers undisturbed nesting sites, usually on top of tall trees, tall buildings, or water towers
- Builds single large comb nests, usually with several nests at one site
- Migrates to the hills in summer and to plains areas in winter
- Highly defensive and performs mass attacks

- Honey production can be as high as 30-50 kg per colony per year
- Excellent pollinators of field crops, fruit, and natural flora
- **Origin:** Asia
- Found in: South and Southeast Asia, including India, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, Vietnam, Laos, Cambodia, and the Philippines.

3. Himalayan Cliff Bee/Veer mauri (*Apis laboriosa*)

- Largest honey bee species in the world
- Similar to Apis dorsata but darker and more defensive
- Prefers nesting in the open, mainly on large steep rocky cliff faces
- Builds single large comb nests, bigger than the Apis dorsata combs, with many colonies nesting close together at one site
- Migrate from place to place depending on the season and availability of bee flora
- Average honey production is 60 kg per colony per year
- Excellent pollinators of crops and wild flora
- **Origin:** Himalayas
- **Found in:** Himalayan region, including India, Nepal, Bhutan, and China, at altitudes of 1,200 to 3,000 meters above sea level.

4. Eastern/Asian Honey Bee (*Apis cerana*)

- Smaller than Western honey bees
- Good at adapting to different climates
- Lives in colonies and builds nests in hollow trees, rock crevices, and man-made structures
- Produces honey and is an excellent pollinator
- Can be kept in beehives and managed by beekeepers
- Resistant to many bee diseases, including European foulbrood and Varroa mites

- Can survive in harsh environments
- Found in plains and hills from below 300 meters above sea level up to 3,400 meters above sea level.
- Can produce up to 15-20 kg of honey per hive per year.
- **Found in:** Southeast Asia.

5. European honeybee (*Apis mellifera*)

- Most common honey bee species used in commercial beekeeping worldwide
- Highly adaptable to different environments
- Builds multiple parallel combs in hives
- Produces honey, beeswax, and royal jelly
- Excellent pollinators of various crops
- **Origin:** Europe and Africa
- **Found in:** Most parts of the world, including the Hindu Kush Himalayan region
- **Altitude Range:** Can be kept up to around 1,500 meters above sea level.
- **Honey Yield:** Can produce up to 40 kg of honey per hive per year.

1.4 Life cycle of honey bee

Honey bees have a fascinating life cycle, the queen bee lays tiny eggs in the honeycomb. Some eggs become worker bees, others become drones (male bees), and special eggs become future queens. The eggs hatch into tiny, worm-like larvae. They're fed by worker bees. The larvae spin cocoons around themselves and change into pupa. This is where they grow wings, legs, and other adult features. The pupa emerges as an adult bee. Worker bees do all the work in the hive, like cleaning, feeding young bees, collecting nectar and pollen, and guarding the hive. Drones' only job is to mate with the queen. The queen bee is the most important bee in the hive. She lays thousands of eggs to keep the colony growing. The life cycle of honey bee completes in four stages; Egg, Larva, Pupa and Adult.

Picture source: https://onlinesciencenotes.com/life-cycle-honey-bee-uses-honey/

Every stage of Honeybee life cycle is described below in detail

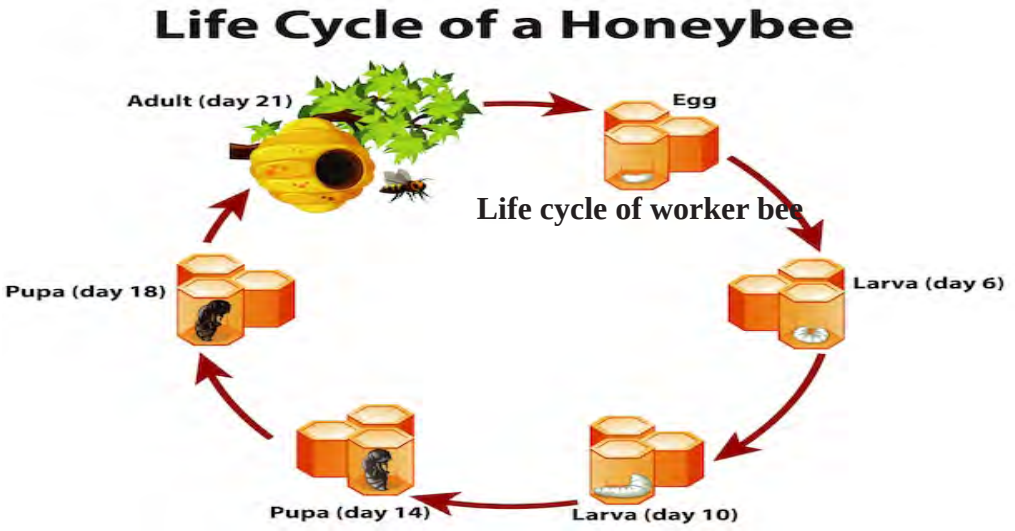
Egg Stage (3 days for all) : Egg Stage is one of the crucial stage of honeybee lifecycle. The queen bee lays eggs that develops into different types of bees such as queen, worker and drone bees. She lays fertilized eggs in special, larger queen cells for the future queen bees. The fertilized eggs are laid in smaller, hexagonal cells, where the larvae will develop into worker bees. Finally, the queen lays unfertilized eggs in slightly larger drone cells, and these eggs are hatched into drones which are the male bees.

Larva Stage: During this state bees are voracious and grow rapidly. They completely dependent on food provided by worker bees. They are fed with different types of food and these food decides what kind of bee they will become. Queen bee larvae remain in the larva stage for 5 days and are fed only with royal jelly. Royal jelly is a special, creamy, and highly nutritious food made by young worker bees from special glands present in their heads. This continuous royal jelly diet helps them develop into fertile queen bee. Worker bee larvae stay in the larva stage for 6 days. They are given royal jelly for the first few days, but then their diet changes to honey and pollen. These food helps them grow into hardworking female bees. Drone/male bee larvae, stay in the larva stage for 7 days and are fed only honey and pollen from the beginning. The length of the

larva stage and the type of food each bee gets are important in deciding whether it becomes a queen, a worker, or a drone bee.

Pupa Stage: After the larva stage, the bee enters the pupa stage. In this stage, larva spins a cocoon around itself and starts changing into a adult bee. This process is called metamorphosis. Inside the cocoon, the bee slowly develops wings, legs, eyes, and other adult body parts. Queen bee stay in the pupa stage for about 7 to 8 days. The worker bee take around 11 to 12 days and drone bee needs about 14 days to complete this transformation. The bee doesn't eat or move during this time. When the transformation is complete the adult bee chews the covering of cells and joins life in the hive.

Adult Stage: The adult stage is the fully grown stage of the bee. Queen bee come out of it's cells after 15-16 days. It is only the female in the hive that can lay eggs. A healthy queen can live for 2 to 5 years. Worker bee come out after 20-21 days. This female bee do almost everything in the hive. Worker bee usually live for about 6 weeks to 6 months. Drone/male bee come out after 24 days. The job of this drone bee is to mate with a queen. Drone bee donot have stinger. The life of drone bee usually lasts around 2 months.



Picture source: https://byjus.com/biology/honey-bee-life-cycle/

Development of Queen in Hive

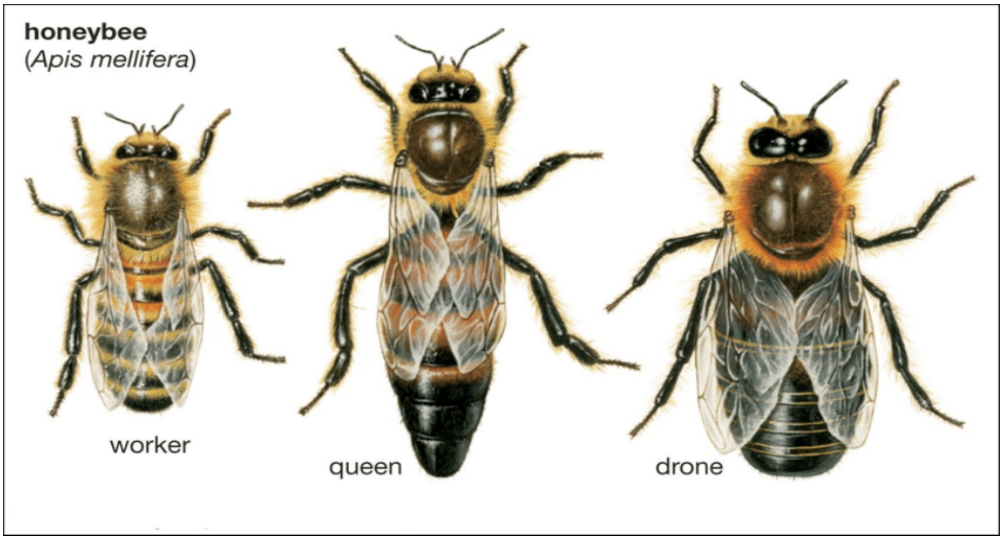
Worker bees carefully select a specific larvae to become the future queen. They choose a healthy, well-developed larva and start feeding it exclusively with royal jelly. This special diet triggers the larva to develop into a queen bee. The old queen may leave the hive with some worker bees to start a new colony, or she may be killed by the new queen.

The queen bee is very smart! She knows the size of the cell and decides where to lay her eggs. She lays fertilized eggs in smaller cells, which will become worker bees. She lays unfertilized eggs in larger cells, which will become drones. However, she also lays fertilized eggs in specially constructed, larger queen cells, which will become future queens.

The queen bee has a special organ called a spermatheca where she stores sperm from mating with drones. When she lays an egg, she can choose to fertilize it or not. If she fertilizes it, it will become a female worker bee or a future queen. If she doesn't fertilize it, it will become a male drone.

Table no.1 Life cycle stages and life span of honeybee

Types of honey bee	Egg stage (Days)	Larval stage (Days)	Pupa stage (Days)	Adult (Days)	Life span
Queen	3	5	7-8	15-16	2-5 years
Worker	3	6	11-12	20-21	6 weeks to 6 months
Drone	3	7	14	24	Around 2 months



1.5 Bee Colony and Management

A honeybee colony is a group of bees that work together to survive and grow successfully in a hive. All the bees in the colony work as a team. Each bee contributes to the survival of hive and protects it from danger. As we know that, Beekeeping is the art and science of caring for honey bee colonies. It involves providing bees with a suitable home, protecting them from pests and diseases, and ensuring they have enough food.

There are various good management practices of bee colony for better yield which are described below;

1. **Site Selection:** Choosing the right location for beehives is crucial, as considering these factors can lead to better yields.
   - Bees require a reliable nearby water source, such as a pond, river, streams etc.
   - Ensure a diverse range of flowering plants is within a reasonable distance to supply ample nectar and pollen.
   - Protect hives from strong winds and direct sunlight by choosing a shaded area or using windbreaks.

- Place hives in quiet locations, away from noise and areas with high human activity.

2. **Safety Precautions before Approaching a Hive :** There are different safety precautions before approaching a hive which are listed below:
   - Before working with bees, take the following precautions:
   - Always wear a beekeeping suit, including a bee veil, gloves, and boots.
   - Smoke calms bees, making them less likely to sting.
   - Avoid sudden movements that may agitate the bees.
   - Choose a calm, windless day for inspections.

3. **Hive Inspection: During Hive Inspection, the Beekeepers should be Aware of the Following Things**
   - **Queen Health:** Make sure the queen bee is healthy and laying eggs, which keeps the colony strong.
   - **Brood Pattern**: Check how the baby bees are developing to spot any problems early.
   - **Honey Stores**: Seek wheather there's enough honey and pollen for the bees to survive through winter.
   - **Pests and Diseases**: Observe the presence of pests like mites or signs of diseases that could harm the bees.

4. **Feeding:** Beekeepers need to feed their bees, especially during periods of food scarcity, in early spring to stimulate growth and brood rearing, in late autumn and winter to provide energy for survival through the cold months, and after harsh winters to aid in recovery and rebuilding. There are different precautions that should be taken during feeding honey bees which are listed below:

   Sugar syrup is a simple mixture of equal parts of sugar and water. It is a common food source for honey bees, especially during times of nectar scarcity. Beekeepers can provide this syrup using feeders attached to the hive.

Pollen is the source of protein for bees. It can be substituted either purchased from beekeeping stores or homemade. Homemade patties, made from soy flour, brewer's yeast, and water, can be a cost-effective solution. Beekeepers can place these pollen patties in feeders attached to the hive.

Precautions that Should be Taken During Feeding Honey Bees

- Avoid Overfeeding: Excess food can attract pests and diseases
- Maintain Clean Feeders: Clean feeders prevent the spread of diseases.
- Monitor Food Consumption: Regular monitoring ensure adequate food intake.
- Consider Local Conditions: Adapt feeding strategies based on local climate and natural food sources.

5. **Diseases and Pests Management:** There are different disiases and pests that can affect the honeybees and hive. Varroa mites, American foulbrood, and small hive beetles are the most common threats to bee colonies. To protect these vital pollinators, beekeepers must implement a comprehensive management strategy. Regular hive inspections, maintaining good hive hygiene, and using appropriate treatments can help control these pests and diseases. Additionally, selecting genetically resistant bees and practicing integrated pest management can further enhance colony health and productivity.

6. **Swarm Prevention:** Swarming is a natural process where a colony divides, with the old queen and a portion of the worker bees leaving the hive to establish a new colony. While natural, swarming can weaken the original colony. Swarming can be controlled by adopting following techniques;

   - **Providing Ample Space:** Ensuring the hive has enough room for the colony to expand.
   - **Clipping the Queen's Wings:** Preventing the queen flying with the swarm.
   - **Artificial Swarm Control:** Dividing the colony into smaller units.

7. **Honey Harvesting:** Honey harvesting is a careful process of collecting honey without hurting the bees. Use of smoke helps to calm the bees and then gently the honeycombs are removed from the hive. These honeycombs are spun in a special honey extraction machine to extract the honey. The honey is then filtered and bottled. This practice ensure that both the bees and the honey are safe and healthy.

1.6. Selection of Hive and Baiting: Choosing the right hive is crucial for successful beekeeping. A well-designed hive provides a secure and comfortable home for honeybees which leads to their better health and productivity.

1.6.1 Selection of Hive: Selecting the right hive is crucial for the proper growth and development of honey bees and achieving high honey production. A good hive provides a safe, comfortable, and efficient environment for bees to thrive. It should be spacious enough to accommodate the colony. Proper ventilation is necessary to maintain fresh airflow and prevent damp conditions. The hive should also be durable, made of strong materials to protect bees from harsh weather and predators. Additionally, it should allow easy inspection, enabling beekeepers to monitor the health of the colony, manage pests, and harvest honey without disturbing the bees.

1.6.2 Baiting of Honeybees: Baiting of honeybees means attracting a swarm of bees to settle in a specific location or beehive, usually for beekeeping purposes. Beekeepers often use baiting techniques to catch wild swarms or encourage bees to occupy an empty hive.

Purpose of Baiting

- To capture natural swarms
- To increase the number of colonies in their care.
- To capture wild swarms which may be healthier and less affected by diseases or pests.

Methods of Baiting Honeybees : There are different methods of baiting honeybees which are described below:

1. **Using Bait Hives:** Empty hives or boxes are placed in suitable locations, often kept near forage sources.
2. **Adding Attractants:** There are different types of attractants that can be used for baiting honeybees they are described below;
   i) Pheromone-Based Lures: These lures contain synthetic versions of the queen bee's pheromones or other chemicals that attract worker bees.
   ii) Natural Attractants: Old honey comb carries the scent of beeswax and honey, which is highly attractive to swarming bees.

   The lure is kept inside a bait hive or applied it near the entrance. The hive is Positioned in an ideal location, such as a shaded spot near forage and water resource.

1.7 Colonization and stocking: Bees Stocking is the act of placing the bees into a new hive and Colonization is the process of the bees settling in and starting their work in that hive.

1.7.1 Stocking of Bees: It refers to the process of introducing honeybees into a new hive, area, or habitat to establish a productive colony. It is done after the bees are baited or captured. The baited bees are settled in a prepared hive or environment where they can live, grow, and thrive in productive manner. There are different steps to be followed during stocking which are listed below:

- A hive (natural or artificial) is cleaned and set up with frames or combs for the bees to use.
- The captured or baited swarm is gently placed into the hive.
- If using a package of bees (bees purchased or transported), they are carefully poured into the hive, along with the queen bee.
- The queen is crucial for the colony. She is introduced in a protective cage so the worker bees can adjust to her presence.

- Once they accept her, the queen is released into the hive to start laying eggs.
- The hive is sealed with enough ventilation to prevent the bees from escaping initially.
- Beekeepers should monitor the colony to ensure the bees are settling in.
- Bees may need sugar syrup as food until they find flowers for nectar.

1.7.2 Colonization of Bees: The process by which a group of honeybees settles into a new hive, establishes their colony, and begins their activities of building comb, storing food, and reproducing under the leadership of the queen bee is known as colonization of bees. Colonization in hive is possible due to the following reasons:

- Once the bees accept the hive, they start making wax combs inside it. These combs are used for storing honey and pollen and raising bees.
- The queen bee starts laying eggs in the new hive. Worker bees feed the larvae and care for the hive.
- The bees explore the nearby area to find flowers for nectar and pollen, which they bring back to the hive.

1.8. Swarming: Swarming is a natural process in which a large group of bees with their queen, leaves the hive to form a new colony. It happens when the hive becomes overcrowded, or the colony needs to reproduce and expand. Before leaving, the bees prepare by raising new queens, stockpiling food, and scouting for a new home. Swarming is essential for the survival and growth of bee populations**.**

Causes of Bees Swarming

- **Population Growth:** If the population becomes too large for its hive to maintain the hive according to its capacity may lead swarming.
- **Reproductive Strategy:** If the colony wants of reproducing on a larger

scale, It may swarm by splitting into two groups.

- **Queen Pheromones:** In a dense colony, the queen's pheromones, which help maintain social order, may not adequately reach all workers, triggering swarming behavior

Swarming Managament

When a bee colony becomes too crowded in its hive, it needs to grow. This happens during the spring or early summer when there is plenty of food around. The bees prepare to split into two groups: one will stay in the old hive, and the other will start a new colony. The procedure of swarming is described in detail below:

1. **New Queens are Raised:** When the colony is big enough and the availability of food is plenty, worker bees start raising new queens. They do this by feeding some of the larvae a special food called royal jelly. This makes those larvae develop into queen bees instead of regular worker bees. The bees build special cells, called queen cells, where these new queens grow.
2. **The Old Queen Gets Ready to Leave:** After the queen cells are capped (which takes about 8 days), the old queen prepares to leave the hive. She will take about half of the worker bees with her to form a new colony. Before she leaves, her pheromones (special scents) help keep the hive calm and organized, so the workers know what to do.
3. **The Swarm Leaves the Hive:** The old queen and her group of worker bees leave the hive in a swarm. This happens usually 1-7 days before the new queens emerge. The swarm gathers in a nearby place, like a tree branch or a bush, while they rest and wait for the next step. They don’t settle yet; they are just temporarily staying in one place.

4. **Scout Bees Search for a New Home:** While the swarm is resting, some worker bees (called scout bees) leave to find a good location for the new hive. They look for a safe place, like a hollow tree or a sheltered spot, where the bees can build their hive and store food. Once a scout finds a good spot, it comes back to the swarm and dances to show the others where it is.
5. **Swarm Decides a New Home:** The rest of the bees in the swarm watch the scout bees' waggle dance, which helps them decide which spot is best. Once they all agree, the swarm moves to the new location and begins building a new hive.

Swarming management in bees is essential to prevent loss of the colony. It helps to ensure the stability of beehive. There are different effective methods for managing swarming which are described below:

Regular Hive Inspections: Hive should be monitored regularly during spring and early summer. Check queen cells, if they are found it indicates the bees are planning to swarm.

Remove Queen Cells: If queen cells are found, remove them to prevent the bees from making a new queen and swarming.

Split the Colony: If the hive is too crowded, divide the colony into smaller parts. This gives the bees more space and helps to prevent them from swarming.

Provide Adequate Space: Add extra frames in the hive to prevent overcrowding of the bees. They can grow and survive well in adequate space.

Increase Ventilation: Bees can swarm if the hive gets too hot. Ensure proper airflow by adding ventilation holes or using a hive entrance reducer to keep the temperature comfortable and prevent swarming.

Regular Requeening: Sometimes the bees want to swarm because the queen is old or weak. Replace it with a younger and healthier queen.

Feed the Bees: Feed the bees with sugar syrup and pollens if necessary in dry periods.

Use Swarm Traps: Place swarm traps around the hives. These traps helps to catch them before they leave the hive.

Watch for Early Signs: Regularly check for queen cells or bees clustering outside the hive. If noticed, remove queen cells, split the colony, or add space to prevent swarming.

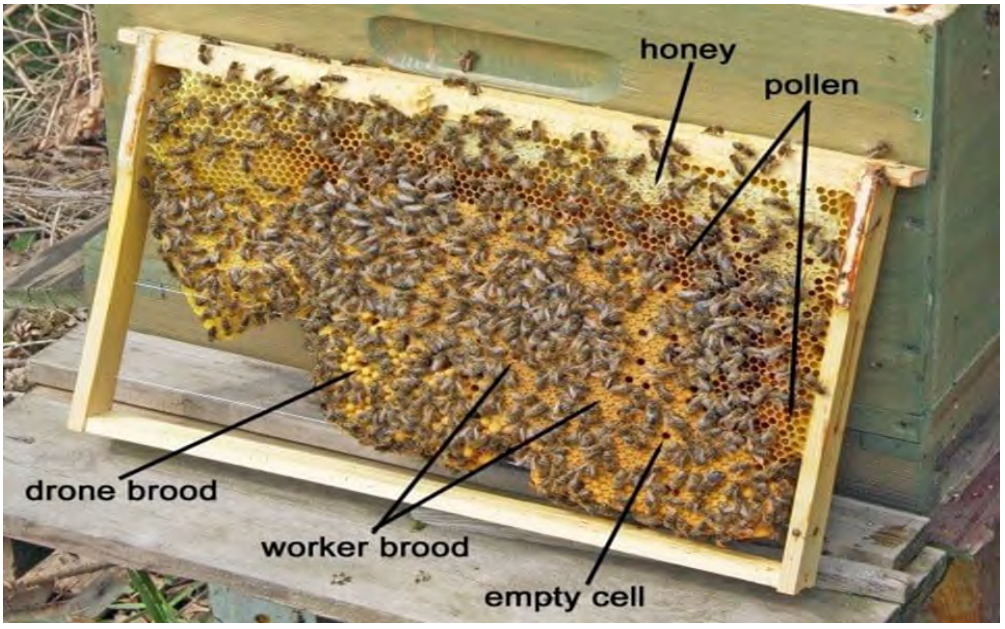
1.9. Combs and their Management: A bee comb is a structure made of hexagonal cells built by bees using beeswax. It stores honey, pollen, and houses the developing brood (baby bees). Comb management involves inspecting, replacing old combs, and ensuring the hive has enough space for the bees to grow and thrive.

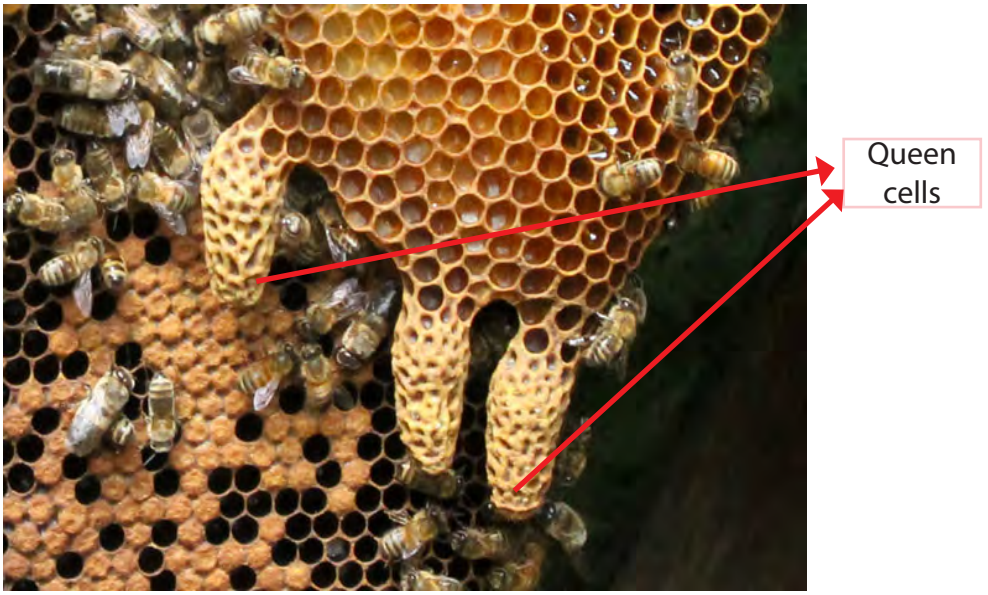
1.9.1 Bee Comb: A bee comb is a structure made by honeybees from beeswax. It is where the bees store their food (honey and pollen), and where they raise their young (brood). The comb is made up of many hexagonal (six-sided) cells. They are built by worker bees to fulfill the different crucial needs of the hive. There are different parts of the bee com which are described below:

1. **Honey Cells:** These are the cells where the bees store nectar that they convert into honey. Honey is used as food for the bees, especially during the winter when flowers aren't blooming. Honey cells are usually filled when there is a surplus of nectar.
2. **Pollen Cells:** These are cells used to store pollen, which is collected from

flowers. Pollen is an important source of protein for the bees. It is often stored near the brood cells because it's used to feed the developing larvae.

3. **Brood Cells:** These are the cells used to raise the baby bees. There are three types of brood cells.
   - **Worker Brood Cells:** These are smaller cells where female worker bees are raised.
   - **Drone Brood Cells:** These are larger cells where male bees (drones) are raised.
   - **Queen Brood Cells:** These are larger, vertical cells used to raise new queens. Larvae in these cells are fed royal jelly, which makes them develop into a queen instead of a worker or drone.





Building Honey Comb

Young worker bees have specialized glands on their abdomens called wax glands that secrete small, waxy scales. These scales are then chewed and shaped by the bees into the hexagonal cells that form the honeycomb.

Feeding Royal Jelly to Brood

Young worker bees (typically aged 6-12 days old) have specialized glands in their heads called hypopharyngeal glands. These glands produce royal jelly, which is a thick, milky substance. The worker bees secrete the royal jelly from these glands into their mouths. The jelly is made up of water, proteins, sugars, lipids, vitamins, and minerals, which provide nutrition. Worker bees feed royal jelly to larvae. Worker and drone larvae receive it for a few days, then get honey and pollen. Queen larvae are fed royal jelly throughout her lifespan.

1.9.2 Management of Comb

Beekeepers should manage combs to ensure the colony stays healthy and productive. The following steps helps to ensure the better management of the comb:

1. **Inspecting the Comb**: Beekeepers check combs to make sure they are in good condition and not infected with pests or diseases.
2. **Replacing Old Combs**: Over time, combs become dark and less effective. Beekeepers should replace old combs to keep the colony healthy.
3. **Preventing Overcrowding**: If the hive becomes too crowded, the bees may swarm. Beekeepers should add extra space (like new frames and boxes) to prevent swarm.
4. **Harvesting Honey**: Beekeepers extract honey from the comb through harvesting. This also helps the bees continue building new comb for the next season. Beekeepers typically wear protective clothing, known as Personal Protective Equipment (PPE), to safeguard themselves from bee stings. This gear includes a bee suit, gloves, and a veil to cover the face and head. When harvesting honey, beekeepers use a hive tool to gently pry open the hive and lift and shift frames. Use a knife to carefully scrape away the wax caps sealing the honeycombs. The frames filled with honey are then placed in a honey extractor, a machine that spins the frames to force the honey out of the comb. The honey flows into a container, leaving the honeycomb intact. The empty frames, still containing the honeycomb structure, are returned to the hive. The bees can then clean and refill the cells with new honey. By using these techniques and protective measures, honey can be safely extracted by minimizing disturbance to the bee colony.



1.10 Pest, Predators and Disease

Honey bees are vital for pollination and honey production. However, they face numerous threats, including pests, predators, and diseases. Understanding these threats and implementing effective management strategies is crucial for

maintaining healthy bee populations. This information will help you identify and address common issues affecting honey bees in Nepal.

Pest of honeybee: There are different pests that can harm the honey bee colony which are described below;

1. Varroa Mite (*Varroa destructor*):

Description: These are small reddish-brown mites that attach to bees and suck their blood, weakening them and spreading diseases.

Symptoms:

- Deformed wings and bodies in adult bees.
- Reduced bee population due to weakened immune systems.
- Increased bee mortality rate.
- Presence of reddish-brown mites visible on bees.

Management:

- Dust bees with powdered sugar to encourage grooming.
- Regularly inspect the hive and remove infested brood.
- Select or breed bees resistant to Varroa mites.
- Mix 35 grams of oxalic acid in 1 liter of sugar syrup (50% solution) and apply 5 mL of the solution per colony.

2. Wax Moth: (*Galleria mellonella*) Greater Wax Moth and *Achroia grisella* (Lesser Wax Moth)

Description: These moths lay eggs in the hive, and the larvae eat beeswax, pollen, and honey.

Symptoms:

- Larvae of moths feeding on honey, wax, and pollen.
- Damaged and weakened combs due to moth larvae activity.
- Presence of webbing and cocoons inside the hive.
- Bees seem agitated and unable to keep the hive clean.

Management:

- Keep the hive strong and healthy to fend off moths.
- Store empty combs in cold or lighted areas to deter moths.
- Use traps and Place **60 mL of formic acid** in a sealed bag with **5 frames of combs**, seal it, and let it fumigate for **24-48 hours.**
- Regularly check and clean the hive to remove moth larvae.

3. Small Hive Beetle *(Aethina tumida)*:

These are tiny, dark beetles that lay eggs in hives. Their larvae eat honey, pollen, and wax, making a mess of the hive.

Symptoms:

- Beetles present inside the hive, especially on the frames and combs.
- Larvae of the beetles seen eating honey, pollen, and wax.
- Fermented honey, producing a foul odor.
- Bees abandoning brood frames due to beetle infestation.

Management:

- Maintain strong and well-ventilated hives to help bees defend against beetles.
- Use beetle traps placed in the hive.
- Remove and clean infected combs and frames.
- Place 60 mL of formic acid in a sealed bag with 5 frames of combs, seal it, and let it fumigate for 24-48 hours.

Predators of Honeybee: There are different predators of honeybee hive which are described below as follows:

1. Ants: Ants raid hives to steal honey and disturb the bees.

Symptoms:

- Ants observed raiding the hive for honey and brood.
- Bees becoming agitated or stressed by the presence of ants.
- Damaged honeycombs due to ant activity.

- Presence of ant trails near or inside the hive.

Management:

- Use sticky barriers around the base of the hive to prevent ants.
- Clear vegetation and debris around the hive to reduce ant pathways.
- Apply 10-15 drops of peppermint oil or cinnamon powder in 500 mL of water and spraying around the hive's perimeter.
- Place hives stand's legs in water-filled containers by ensuring the water depth is around 1-2 inches in shallow containers.

2. Lizards

Symptoms:

- Lizards seen near hive entrances, preying on foraging bees.
- Reduced bee activity around the hive due to predator presence.
- Presence of dead bees outside the hive, indicating predation.
- Lizards leaving visible marks or tracks around the hive.

Management:

- Keep the apiary clean and free of hiding spots (e.g., wood piles).
- Use netting or fencing around hives to prevent access.
- Place hives in locations where lizards are less likely to find them.
- Monitor and remove any lizards around the hive.

3. Mice and Rats: These rodents enter hives during colder months to feed on honey, wax, and brood.

Symptoms:

- Rodents seen entering hives, especially in winter.
- Chewed or damaged combs and honey stores.
- Droppings or gnaw marks near the hive entrance.
- Reduced activity in the hive due to rodent disturbances.

Management:

- Install mouse guards or mesh over hive entrances.
- Keep the apiary clean and free from food scraps.
- Inspect hives regularly during colder months.
- Set traps for mice and rats around the apiary.

9. Spiders: Spiders create webs near hive entrances to catch foraging bees.

Symptoms:

- Webs found near the hive entrances, trapping foraging bees.
- Decreased bee traffic due to spider webs blocking the entrance.
- Presence of spider webs on honeycomb frames.
- Bees struggling to navigate due to webs.

Management:

- Regularly remove webs from the area around the hives.
- Keep the apiary area clean and well-organized.
- Use spider traps to capture those near the hives.
- Inspect hive entrances regularly for webs and remove them.

Diseases of Honeybee: There are different diseases of honeybee. Some of them are caused during brood stage and others in adult stage of honeybees. Brood diseases include American Foulbrood (AFB)**,** European Foulbrood (EFB)**,** Chalkbrood, and Sacbrood Virus (SBV), while adult bee diseases include Nosema and Deformed Wing Virus which are described below:

1. American Foulbrood (AFB): Causal Organism: *Paenibacillus larvae* (Bacteria)

Symptoms;

- Larvae turn brown, sticky, and emit a bad odor.
- Cell caps appear sunken or have holes.
- Dead larvae stretch out in a “rope test.”

- Honey becomes foul-smelling and fermented.

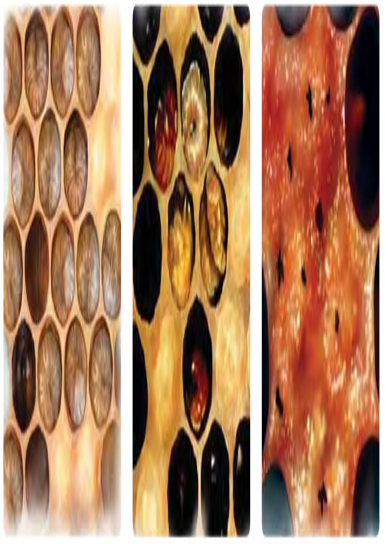
Management

- Burn infected combs and frames.
- Practice good hive hygiene and keep colonies strong.
- Regularly inspect the brood for signs of disease.
- Feed antibiotics like oxytetracycline at a dose of 1 gram per 1 liter of sugar syrup.

2. **European Foulbrood (EFB):** Causal Organism: *Melissococcus plutonius* (Bacteria)

Symptoms;

- Larvae are yellow or brown and twisted.
- Larvae die before being sealed in their cells.
- A foul smell (less intense than AFB) is noticeable.
- Dead larvae can be easily removed from cells.

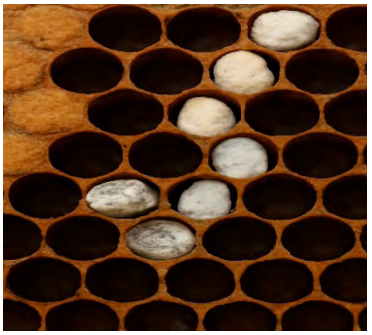


Management;

- Remove infected brood and hive parts.
- Improve hive ventilation and reduce stress.
- Strengthen the colony with proper nutrition.
- Feed Oxytetracycline at a dose of 1 gram per 1 liter of sugar syrup.

3. **Chalkbrood:** Causal Organism: *Ascosphaera apis* (Fungus)

Symptoms



- Larvae turn white and becomes hard and looks like chalk.
- Dead larvae are often thrown out of the hive.
- Disease is more common in damp, cold conditions.
- Larvae may appear like mummified.

Management;

- Improve ventilation in the hive.
- Remove infected combs and replace them.
- Maintain a dry and warm environment for the hive.
- Avoid overcrowding in the hive.

4. Sacbrood Virus (SBV): Causal Organism: *Sacbrood virus* (Viral)

Symptoms;

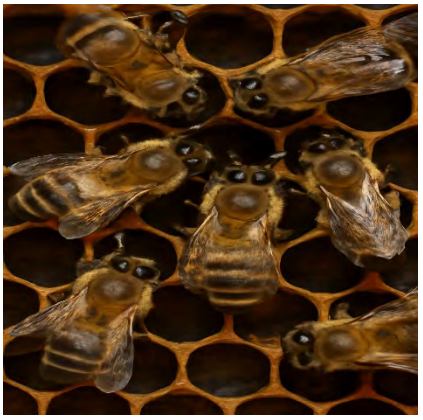
- Larvae fail to pupate and die forming a sac-like appearance filled with fluid.
- Dead larvae may be stretched and look dry.
- Adult bees are less active and productivity drops.
- Larvae can be seen with a shriveled appearance.

Management;

- Remove infected larvae from the hive.
- Provide adequate nutrition to strengthen the colony.
- Avoid overcrowding to reduce stress.
- Maintain good hygiene and regular hive inspection.

5. **Nosema Disease: Causal Organism:** *Nosema apis* and *Nosema ceranae* (Fungul disease)

Symptoms:



- Bees exhibit weak flight and poor coordination.
- Abdomens of infected bees appear distended.
- Dead bees found outside the hive.
- Increase mortality rate of adult bees.

Management:

- Keep hives clean and free from contamination.
- Improve colony nutrition to boost immunity.
- Regularly inspect hives for early signs of infection.
- Feed Fumagillin at a dose of 1 gram per 1 liter of sugar syrup for about 7-10 days.

6. **Deformed Wing Virus (DWV):** Caused by virus and transmitted by Varroa mites.

Symptoms:

- Bees have deformed wings and are unable to fly.
- Infected bees have shriveled wings or exhibit abnormal body structures.
- Reduced bee activity and weakened colony strength.
- Larvae may die or exhibit malformed features.

Management:

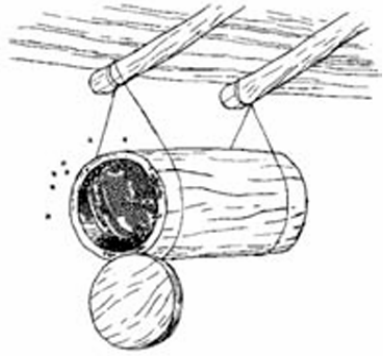
- Control Varroa mites, as they are vectors for the virus.
- Remove and destroy infected bees.
- Strengthen colonies by providing proper nutrition.
- Improve hive conditions to reduce stress.

1.11 Hives, their Types and Selection: Hives are the homes where honey bees live and work. There are different types of hives, and choosing the right one is important for the health of the bees and honey production. The most common types are Langstroth hives, which are great for large-scale honey production, Cerana Box hives, designed for native bees in Nepal. When selecting a hive, it's important to consider the size, material, cost, and how easy it is to manage. The right hive results in the better growth and yield of the honey and other valuable honeybee products. The different types of hives are described below;

1. **Traditional Log Hives:** These are made from hollow logs of tree trunks. Bees naturally build their comb inside. This is one of the traditional methods of bee keeping in rural areas where there is available of local materials. This method has been used for centuries.

Advantages

- It is made from locally available materials like tree trunks or logs. It is cost effective to construct.
- It uses natural materials, which are biodegradable and sustainable.
- It easy to build without specialized tools or skills.



Disadvantages

- The fixed comb structure makes it hard to inspect for diseases, pests, or

the overall health of the colony.

- Harvesting honey often damage or destroy the parts of the comb.
- The lack of movable frames makes it hard to spot mites, wax moths, or fungal diseases effectively.

2. **Wall Hives:** This is also one of the traditional methods of beekeeping where bees are kept in cavities built into the walls of houses, typically made from mud or stone. Bees enter and exit through small holes. In this type of hives bees live in small spaces built into the walls of houses, usually made of mud or stone. Tiny holes are made for them to come and go. These types of hive are mostly used in temperate region of our country Nepal.

Advantages

- Uses materials like mud or stone, which are easily available in rural areas, making them is cost effective.
- Saves space since the hives are part of house walls. It can be built especially in areas with limited space.
- The thick walls provide good protection from extreme weather, keeping bees warm in winter and cool in summer.
- Requires minimal management.

Disadvantages

- Hard to monitor bee health or detect problems like diseases or pests.
- Produces less honey compared to modern hives.
- Harvesting honey can damage the hive.
- Wall hives cannot be moved to better forage areas.
- Predators like rodents or birds can attack wall hives easily.

3. **Cerana Box Hive:** The Cerana box hive is a modern beekeeping hive designed specifically for the native Asian honey bee, *Apis cerana*. This hive is smaller in size compared to the Langstroth Hive. It is ideal for the smaller *Apis cerana* species commonly found in Nepal. It is lightweight, easy to manage, and cost-effective, making it a popular choice for small-scale beekeepers. The hive allows beekeepers to inspect the colony, manage pests, and harvest honey without causing harm to the bees. By using the Cerana Box Hive, beekeepers can preserve native bee populations while improving honey production in an eco-friendly way.

The Cerana box hive is made from lightweight, durable wood like pine or local hardwood that provides insulation and protection for the bees. The exterior is often painted with non-toxic paint for weather resistance, while the interior is left untreated. Optional materials like metal sheets for the top, wire for reinforcing frames, and mesh at the entrance can be added for durability and predator prevention. Nails and screws are used to assemble the hive, making it affordable, easy to construct, and ideal for small-scale beekeeping in Nepal.

Advantages

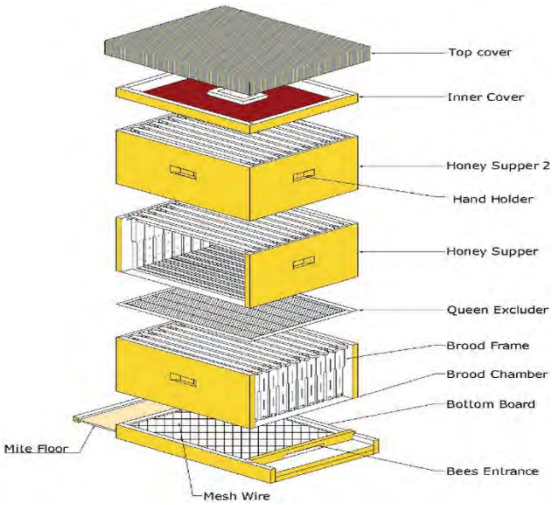
- Designed for *Apis cerana*, the native Asian honey bee.
- Affordable and easier to manage for small-scale beekeepers.
- Lightweight and can be moved if needed.
- Helps preserve native bee species, which are more resilient to local pests and diseases.

Disadvantages

- Produces less honey compared to Langstroth hives.

- May not be ideal for *Apis mellifera*, which are larger and produce more honey.

4. **Modern Langstroth Hives:** The Modern Langstroth Hive is a beehive made of stacked wooden boxes with removable frames. It was invented by Lorenzo Lorraine Langstroth in 1851 and changed beekeeping forever. Langstroth introduced the idea of "bee space," a gap of about 3/8 inch between hive parts. This space lets bees move easily without filling the space with comb or propolis. This design allows for removable frames, making it easier to check the hive, collect honey, and manage the bees without disturbing them too much. It is the most popular beehive in the world because it keeps bees healthy and helps produce more honey.



Source: https://www.researchgate.net/publication/350769458

Advantages

- Proper design helps maintain a healthy environment for the bees in different weather conditions.
- Compatible with modern tools and equipment, making beekeeping more efficient.
- Made from sturdy materials, it can last for many years with proper care.
- Removable frames make it simple and easy to inspect insects, pests and diseases.
- Easy to collect honey without damaging the hive or disturbing the bees.

- Designed to maximize honey yield, making it ideal for commercial beekeeping.
- Additional boxes (supers) can be added easily to accommodate growing colonies or increase honey storage.

Disadvantages

- The initial cost for purchasing or building a Langstroth hive is higher compared to traditional hives.
- Requires technical knowledge and skills to manage properly, especially for beginners.
- Bees may find it less natural compared to traditional hives, which could lead to stress if not managed carefully.
- Requires a dedicated area for setup, which might not be feasible for everyone.

Over all, Langstroth Hive can be ideal for large-scale honey production. This hive features removable frames where bees can build their combs, making inspection and honey extraction easy. It prevents overcrowding and allows bees to focus on storing honey, leading to higher yields. For small-scale beekeepers or those raising native bee species like *Apis cerana*, the Cerana Box Hive is an excellent choice. It is specially designed for the smaller Asian honey bee and is cost-effective while still supporting good honey production.

1.12 Foraging of Bees: Bee foraging is the process where worker bees leave their hive to collect nectar, pollen, water, and propolis from flowers and other sources in the environment. These resources are essential for the survival and growth of the bee colony. The collected nectar is a sweet liquid that flowers produce. Bees use it as their main source of energy. The pollen is a fine powder which is male reproductive part of the flower. It is collected to feed the hive as a supplement of the protein.

Bees have amazing senses that help them find flowers. They can see colors and smell scents from far away. They also use a special dance to tell other

bees where to find good flowers.

Bees use a fascinating dance language to communicate information about food sources to their hive-mates. Here are the two primary types of bee dances and their meanings:

1. **Round Dance:** This dance is used to indicate a food source within a short distance (about 10 meters) from the hive. The bee runs in small circles, alternating directions. The dance doesn't specify direction, only the proximity of the food source.
2. **Waggle Dance:** Used to communicate the location of a food source that is farther away from the hive (more than 100 meters). The bee performs a figure-eight pattern, with a straight run in the middle called the "waggle run." The angle of the waggle run relative to vertical indicates the direction of the food source in relation to the sun's position. The duration of the waggle run corresponds to the distance of the food source. The longer the waggle, the farther away the food.
3. **Transitional Dance:** There's a transitional dance between the round and waggle dances, called the sickle dance, used for food sources at intermediate distances.
4. **Tremble Dance:** Used to signal a large nectar flow or the shake dance to encouraging more worker bees to leave the hive and go for foraging.

1.12.1 Importance of Bee Foraging

- Bees help plants grow by spreading pollen.
- Bees collects and make valuable products like honey, pollen, propolis etc. from foraging.
- Bees are a vital part of our ecosystem. They help to keep plants healthy and productive.

1.12.2 Managing Bee Forage: Managing bee forage helps to find enough food

for bees. The following management practices can access the enough food for the bees:

- Plant a variety of flowers that bloom at different times of the year.
- Avoid Using Harmful Pesticides
- Bees need water to drink. A shallow dish of water with some stones or sticks for them to land on can be a great help.

Exercise

Choose the correct answer from the given alternatives.

1. What is the practice of keeping honeybees called?

   a. Apiculture b. Honey Production

   c. Pollination d. Foraging

2. Honeybees are classified as which type of insect?

   a. Solitary b. Social

   c. Both A and B d. None of the these

3. Which of the following is NOT a product that can be obtained from a beehive?

   a. Honey b. Pollen

   c. Silk d. Royal Jelly

4. What is the primary reason honeybees swarm?

   a. To search food source b. To escape predators

   c. For mating d. To reproduce and expand the colony

5. What is the main material used by honeybees to construct their honeycomb?

   a. Wood b. Beeswax c. Mud d. Leaves

Write short answer to the following questions.

1. Briefly describe the difference between solitary bees and social bees.
2. List three reasons why beekeeping is considered an important activity.
3. What is the role of a queen bee in a honeybee colony?
4. Explain the process of beekeeping in a few sentences.
5. What are some of the challenges faced by honeybee colonies?

Write long answer to the following questions.

1. Describe the life cycle of a worker honeybee, including the different stages and their durations.
2. Explain the different methods used for attracting a swarm of bees to a new hive (baiting)
3. List the various pests, predators, and diseases of honeybee with disease symptoms. How can beekeepers manage them? Explain.

Project Work

1. Guide students to study and create a presentation on the different species of honeybees found around your locality. Include information on their characteristics, habitat, and importance.
2. Ask student to design a bee-friendly garden plan, focusing on planting flowers that attract honeybees and other pollinators.
3. Assign students to write a creative story or poem about the life of a honeybee and present in classroom.

Unit 2

Sericulture

2.1 Introduction

Sericulture, also known as silk farming, is the cultivation of silkworms to produce silk. The word 'sericulture' is derived from the Latin words 'sericus' (silk) and 'cultura' (cultivation or culture).

Sericulture, or silk farming, is an interesting process that involves raising silkworms to produce silk. Silk production has been practiced for over 5,000 years and has been an important part of trade and culture around the world. Sericulture is said to be originated in China. However, the Nepal government has a short history of supporting sericulture.

The major effort in silk farming began in 1967. The department of agriculture tested the process using mulberry leaves from Rana palaces and silkworms brought from India. In the 1970s, Nepal had a big plan called the 10-Year Agriculture Plan. This plan aimed to improve how farming was done in the country. As part of this plan, the Khopasi Sericulture Center was established in 1975. Initially, the center focused on both silkworms and bees. The organizational structure of the Agriculture Department was changed in the fiscal year 2052/53, its name was changed to 'Sericulture Development Center' and the program has been operating since then.

The Khopasi Sericulture Center, now known as the Sericulture Development Center, plays a vital role in supporting farmers across the country. It is located in Khopasi, Kavrepalanchok district. This center provides valuable guidance and resources to those involved in silk farming.

Farmers receive expert advice on raising silkworms, ensuring healthy growth and high-quality silk production. The center also plays a crucial role in producing

and distributing healthy silkworm eggs which is a vital step in the silk-making process. The Sericulture Development Center helps farmers by giving them the knowledge and tools they need to succeed. This helps rural communities, especially women, earn a good living. It also helps keep the traditional skill of silk making alive in a way that is good for the environment.

To produce and supply mulberry plants, to raise and distribute small silkworms, to provide training to farmers on silk farming, and to manage the market for cocoons produced by farmers, eight silk farms have been established in addition to Khopasi. In the fiscal year 2041/42, the Silk Development Program in Syanja, in 2049/50 the Mulberry Nursery Management Center in Bhandara, in 2050/51 the Silk Development Program in Dhankuta, in 2052/53 the Silk Development Program in Pokhara, in 2052/53 the Brood Cocoon Source Center in Bandipur, in 2052/53 the Silk Processing Center in Itahari, in 2053/53 the Brood Cocoon Source Center in Dhunibesi, and in 2061/62 the Commercial Grainage Center in Chitapol were established.

Mulberry silk, produced by the domesticated silkworm *Bombyx mori*, is the most common type of silk globally. It contributes about 90% of the world's silk production. In Nepal, mulberry silk is widely cultivated because of its high quality and its use in traditional clothing and cultural textiles.

2.2 Importance and Scope

Importance of Sericulture in Nepal

Sericulture, or silk farming, is a valuable practice that offers significant economic, social, environmental, and cultural benefits, fostering rural livelihoods, preserving traditional skills, and promoting sustainable development in Nepal. There are various importances of sericulture some of them are described below:

Economic Importance

Sericulture is an important source of income for rural communities, especially in developing countries. It supports the silk textile industry, which earns substantial revenue from both local and international markets. Additionally, it encourages

entrepreneurship and small-scale industries, helping to boost rural economic growth.

Employment Importance

Sericulture generates employment opportunities across rural and urban areas, encompassing diverse roles such as farming, spinning, weaving, and dyeing. Moreover, it provides a stable income source for marginalized communities, particularly women, who often constitute a significant portion of the workforce within this sector.

Environmental Importance

Mulberry plants, vital for sericulture, plays a key role in afforestation and preventing soil erosion. They support sustainable agriculture by minimizing the use of harmful chemicals, as silkworms are highly sensitive to pollution. Additionally, cultivating these plants helps maintain ecological balance.

Cultural Importance: Sericulture often involves community-based activities, with families and neighbors sharing knowledge and resources. It's a practice that has been passed down through generations, contributing to the cultural identity the different communities.

Social Importance

Sericulture can help to reduce rural-to-urban migration by creating sustainable income opportunities within villages. It fosters community involvement and encourages cooperative work, strengthening the social bonds and harmony in rural areas.

Scope of Sericulture in Nepal

Sericulture, or silk farming, offers several opportunities for economic growth and development in Nepal. Four key scopes are described below:

Economic Growth

Sericulture has the potential to significantly boost Nepal's economy. By creating numerous job opportunities, particularly for women in rural areas, it can increase

household incomes and reduce poverty. Furthermore, the growing global demand for high-quality, natural textiles like silk presents a lucrative export opportunity for Nepal. By increasing silk production and improving product quality, Nepal can tap into international markets, earning valuable foreign currency and stimulating economic growth.

Poverty Reduction

Sericulture can play a crucial role in alleviating poverty in Nepal, especially in rural areas. By providing a reliable source of income for smallholder farmers and women, it can empower them and improve their livelihoods. Additionally, sericulture can help reduce rural-to-urban migration by creating economic opportunities in rural areas, allowing people to stay in their communities and contribute to local development.

Cultural Preservation

Sericulture is deeply intertwined with Nepal's cultural heritage. The traditional skills and knowledge associated with silk production, from mulberry cultivation to silk reeling and weaving, have been passed down through generations. By promoting sericulture, Nepal can preserve these valuable cultural traditions and ensure that they continue to thrive for future generations. Moreover, the production of exquisite silk products reflects Nepal's rich cultural identity and can contribute to the country's tourism industry.

Environmental Sustainability

Sericulture can be a more environmentally sustainable alternative to other textile industries. Mulberry cultivation, the primary source of food for silkworms, can promote sustainable agricultural practices and help conserve forests. Additionally, silk production generates less pollution and waste compared to synthetic textile manufacturing, making it is more eco-friendly option. By embracing sericulture, Nepal can contribute to environmental conservation and promote sustainable development.

2.3 Mulberry cultivation

The cultivation of Mulberry plant is also known and Moriculture. Mulberry trees (*Morus spp.*) are vital for sericulture in Nepal as they provide food for silkworms. These fast-growing trees can grow well in Nepal's varied climates, from warm lowlands to cooler hills. Proper cultivation, such as selecting a suitable location and harvesting carefully, is essential for growing high-quality mulberry leaves for silkworms. The cultivation practices for Mulberry plants are clearly described below:

Site Selection

The ideal location for a mulberry garden should have fertile soil, good drainage, and easy access to water. It is also important to choose a site close to silkworm rearing units to minimize transportation time for fresh leaves.

Climate and Soil

Mulberry thrives in a warm, humid climate with optimal temperatures ranging from 20 to 30 degrees Celsius. It prefers well-drained, fertile, loamy soils rich in organic matter. While tolerant of a range of conditions, it may not perform optimally in areas with extreme temperatures, prolonged drought, or waterlogging. In Nepal, mulberry can be successfully cultivated across a wide range of elevations, from the Terai region (approximately 58-300 meters above sea level) up to the mid-hills (up to 1500-1800 meters above sea level).

Varieties

Improved varieties of mulberry cultivated in Nepal include Kanwa-2, Khopasi-1 and Khopasi-3.

Seed Rate and Spacing

The spacing for transplanting mulberry seedlings varies by plant variety, pruning type, and intercropping needs. In irrigated lowlands, short-height pruning (20 cm above ground) requires 1-meter row spacing and 60 cm plant spacing, accommodating about 800 plants per ropani (15,720 plants/ha). For non-irrigated sloping or frost-prone areas, high-density pruning (1.5 meters above the base)

uses 1.5-meter row spacing and 1-meter plant spacing, fitting around 325 plants per ropani. In high rainfall areas, medium-density pruning (30 cm above the base) requires 1.2-meter row spacing and 75 cm plant spacing, allowing about 500 plants per ropani.

Growing Saplings and Nursery Management

This crucial stage involves selecting the right mulberry variety, employing appropriate propagation methods, and carefully managing the nursery environment to produce healthy and vigorous saplings for successful field planting.

Mulberry plants can be propagated through sexual propagation (using seeds) or asexual propagation (using cuttings, grafting, or budding).

Site Selection for Nursery

The nursery should be located near mulberry farms to minimize transportation costs. The soil should be fertile, well-drained, and loamy.

Nursery Bed Preparation

Raised beds (10-15 centimeters high, 1 meter wide, and of desirable length) are prepared. 10-15 kg of well-decomposed organic manure per bed and balanced fertilizers, such as a combination of nitrogen (e.g., urea), phosphorus, and potassium, can be applied as per soil test recommendations.

Sexual Propagation

In this method, seeds are extracted from ripe mulberries, soaked in water for 24 hours, and then dried in the shade for 1-2 days before sowing. A seedbed is prepared with a width of 1meter, desired length, and a height of 15 centimeters. Seeds are sown in rows with a spacing of 6 inches between rows and 4 inches between seeds, and buried 1 inch deep. Seedlings emerge within 10-15 days after sowing. This method does not guarantee consistent quality of seedlings due to cross-pollination during seed development. Therefore, it is not widely used for direct propagation. However, seedlings produced from this method are used as rootstocks for grafting with superior mulberry varieties.

Asexual Propagation

Asexual propagation methods, such as cuttings, grafting, and budding, are applied to healthy, disease-free mulberry plants to ensure the production of high-quality saplings with desirable traits, maintaining genetic uniformity and maximizing yield potential.

Cuttings

It is the most popular method of propagation in Nepal. It is carried out generally October last to December (15^{th} Kartik to 15^{th} Poush). Healthy stems of 6-8 months old with 3-5 active buds are cut into 15-20 cm pieces. These are treated with rooting hormones like IBA or NAA to improve rooting, then planted at a distance of 10-15 cm. After 8 months, cuttings are transplanted to the main field.

Grafting and Budding in Mulberry Plants

Grafting and budding in Mulberry plants are carried out in both young and matured plants. These techniques are easier and more successful on young saplings due to their smaller size and higher cambium activity. In mature trees Grafting and Budding helps to introduce new varieties, improve yield, and enhance disease resistance.

Grafting

A scion from a desired variety is grafted onto a rootstock to combine desirable traits. This includes shoot, root, or bud grafting, making it possible to propagate varieties unsuitable for other methods. Successful graft union typically occurs within 3-4 weeks, depending on environmental conditions and the specific grafting technique used. Once the graft union is established and the scion starts to grow vigorously, the grafted plants are ready for transplanting to the field.

Budding

A bud is removed from one plant and inserted into another. Techniques include patch, T-budding, and ring budding. Successful bud union usually takes 2-3 weeks. Once the bud has taken and starts to grow, the stock is carefully cut back above the bud to encourage the growth of the scion. Once the scion has

developed a strong shoot, the grafted plants are ready for transplanting to the field.

Transplanting

The best time to transplant mulberry seedlings depends on the season and the availability of water. For irrigated areas, the months of Magh and Falgun (January to February) are ideal, while for non-irrigated areas, Ashadh and Shrawan (June to July) work better. To ensure the seedlings grow well, dig a pit 30-40 cm wide and deep, as mulberry roots grow deeply into the soil. It's best to prepare the pit a month in advance, separating the topsoil from the subsoil. At the bottom of the pit, mix 1 kg of compost, 50 grams of wood ash or mustard cake, and 10 grams of malathion dust with the topsoil. Place the seedling carefully in the pit, firm the soil around its base with feet. Finally, water the plant thoroughly to help it settle and grow quickly. In sloppy areas, use contour planting to prevent soil erosion.

Mulching

Mulching around mulberry trees with organic materials like straw, wood chips and other locally available organic matters helps to conserve soil moisture, suppress weeds, regulate soil temperature, and improve soil health, ultimately leading to better tree growth, higher leaf yields, and reduced maintenance needs.

Manures and Fertilizers

Apply 15-20 tons of well-decomposed FYM per hectare. Supplement with 100 kg of Nitrogen (N), 40 kg of Phosphorus (P), and 60 kg of Potassium (K) per hectare annually. It is recommended to adjust the fertilizer application based on soil test results and plant requirements.

Irrigation

Mulberry plants require consistent moisture for optimal growth. In irrigated areas, water every 7-10 days during dry seasons and reduce frequency during monsoons. Drip irrigation is ideal for efficient water use, while furrow irrigation works well in flat lands. Avoid overwatering to prevent root rot. In non-irrigated areas, mulch the soil to retain moisture.

Training and Pruning

Training and Pruning is essential for maintaining healthy mulberry trees, helping them grow strong and produce high-quality leaves. Winter is the best time for pruning, as the trees naturally shed their leaves during this season. The method of pruning depends on the location and the frequency of silkworm rearing.

In the Terai plains, pruning is typically done twice a year, once in winter and again during the rainy season. In hilly areas, pruning is done in winter, followed by light trimming of the tips after spring silkworm rearing. Branch feeding can also be done to reduce intensive labor. In this method, silkworms are fed entire branches instead of plucked leaves. In this method the harvested branches work as moderate pruning which can encourage new growth.

If silkworms are reared four times a year, the mulberry garden can be divided into two sections, with each section pruned at different times. Pruning not only ensures a steady supply of nutritious leaves but also keeps the trees healthy and productive year-round.

Harvesting and Yield

Mulberry leaf harvesting typically begins 3-4 months after transplanting, coinciding with the silkworms' rearing cycle. Fresh, tender leaves are harvested, either by plucking individual leaves or by cutting entire branches. Harvesting should be done carefully to avoid excessive leaf removal, which can weaken the plants. Leaf yield varies significantly depending on factors like mulberry variety, tree health, soil fertility, climate, and proper cultivation practices. While average yields in Nepal range from 15-30 tons per hectare per year, high-yielding varieties and optimal management practices can significantly increase leaf production.

2.4 Silkworm Rearing

Silkworm rearing involves several carefully managed steps, from nurturing the silkworms at each stage of their lifecycle to ensuring the production of high-quality silk. To understand silkworm rearing, it is essential to know the lifecycle of the silkworm, which consists of four main stages i.e. egg, larva, pupa, and

adult those are described below:

Egg Stage

The lifecycle begins with eggs laid by adult moths. A single female moth can lay around 300-500 eggs, which are tiny, oval, and yellowish-white. These eggs are incubated under controlled conditions at an optimal temperature of 18-25°C. After 10-12 days, the eggs hatch into larvae.

Larva Stage

The larva, commonly known as the silkworm, is the most crucial stage for silk production. It goes through five growth stages called instars. During this time, the silkworm feeds exclusively on mulberry leaves, growing rapidly and shedding its skin four times (molting). This stage lasts for 25-30 days. Toward the end of the larval stage, the silkworm stops feeding and begins to spin its cocoon.

Pupa Stage (Cocoon Formation)

The silkworm secretes a protein-based liquid through its salivary glands, which solidifies upon exposure to air, forming a silk thread. The larva spins this silk in continuous figure-eight movements, creating a cocoon around itself for protection as it transitions to the pupal stage. A single cocoon can produce up to 1,000 meters of silk thread. This stage lasts 10-14 days. In sericulture, the cocoons are harvested before the moth emerges to preserve the silk thread's continuity.

Adult Stage

If allowed to complete its lifecycle, the pupa transforms into an adult moth inside the cocoon. The adult moth breaks out of the cocoon using a specialized enzyme. However, in commercial silk production, the pupae are typically killed by steaming or drying the cocoons to prevent the moth from breaking the silk thread. The purpose of adult moth is reproduction. After mating, female moths lay eggs, and the lifecycle begins again. Adult moths do not feed and have a short lifespan of 5-10 days

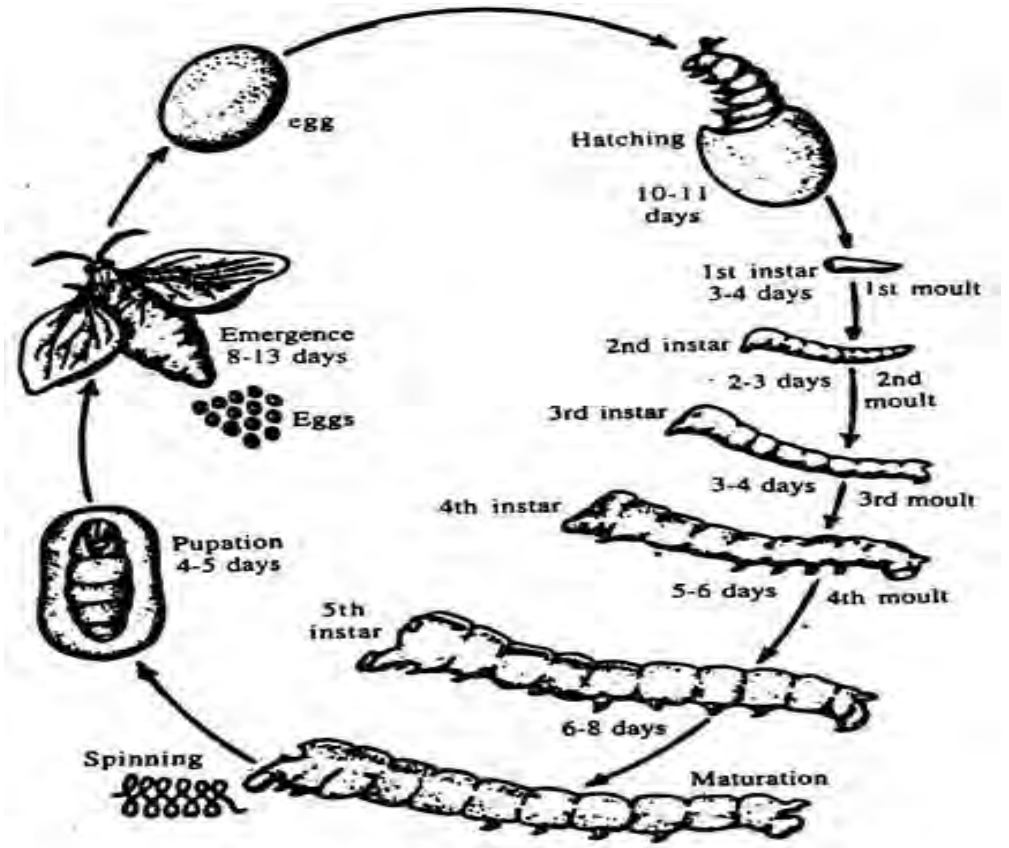


Fig. 47.4. Bombyx sp. Life Cycle

Picture Source: https://www.notesonzoology.com

2.5 Young Age Silkworm Rearing

The hatching room plays a crucial role in ensuring the successful incubation of silkworm eggs. It must be clean, well-ventilated, and free from dust, pests, and other contaminants to create a healthy environment. Temperature and humidity are critical factors that require precise control, with an ideal range of 25–27°C and a relative humidity of 75–80%. Adequate lighting is equally important to ensure uniform hatching across the batch.

To select disease-free silkworm eggs, ensure they are uniform in size, color, and texture, sourced from reputable breeders, and free from visible defects or cracks. Conduct serological tests if available to confirm the absence of pathogens. For

disinfection, immerse the eggs in a 2% formalin or 0.5% sodium hypochlorite solution for 5–10 minutes, rinse thoroughly with sterile water, and dry in a clean, ventilated area. Handle with sterilized tools and gloves to prevent re-contamination, ensuring optimal conditions for healthy incubation.

The first, second and third instars of silkworm larvae are referred to as Chawki. These stages require attentive care for optimal growth and development before transitioning to later instars. After hatching, the tiny larvae are gently removed from the egg sheets using a soft brush, a process called brushing. They are fed tender, finely chopped mulberry leaves (1^{st} or 2^{nd} leaf) 4-5 times a day. During the first and second instars (Chawki stage), silkworms have very small appetites. The amount of leaves they consume is minimal, typically requiring only a few grams of finely chopped, tender mulberry leaves per larva per day. The feeding frequency increasing as they grow. The rearing room should be kept at a temperature of 26-28°C and a relative humidity of 85-90% to ensure optimal growth. Cleanliness is crucial, so rearing trays and equipment must be kept clean to prevent the spread of diseases. Regular monitoring for signs of illness, combined with timely preventive measures, is essential for safeguarding the health of larvae during this vulnerable stage.

2.6 Late Age Silkworm Rearing

Late-age silkworm rearing encompasses the fourth, and fifth instars of the silkworm's larval life. This is a crucial period as the silkworms significantly increase in size and consume a large amount of mulberry leaves. Proper management during this stage is essential for achieving high cocoon yield and quality.

Late-age silkworms 4^{th} and 5^{th} instars are the stages of rapid growth and preparation for cocoon spinning. The 4th instar lasts for 4-5 days, while the 5th instar lasts for 6-8 days. During these stages, silkworms require proper temperature and humidity for optimal growth: 24°C-26°C and 75%-80% humidity for the 4th instar, and 23°C-25°C and 70%-75% humidity for the 5th instar. Fresh, high-quality mulberry leaves are fed to the silkworms, with chopped leaves (1-2 cm)

used in the 4th instar and whole or slightly chopped leaves in the 5th instar. Feeding occurs four times a day (morning, midday, evening, and night), with amounts increasing as the silkworms grow starting with 1 kg per 100 worms in the 4th instar and reaching up to 10-12 kg per 100 worms by the end of the 5th instar. Space is crucial to avoid overcrowding, with silkworms needing 400-500 square cm per 100 worms in the 4th instar and 800-1,000 square cm per 100 worms in the 5th instar. Characteristics of the 4th instar include pale white, growing larvae with increased feeding, while in the 5th instar, silkworms become fully grown, translucent, and highly active, consuming large amounts of leaves. Toward the end of the 5th instar, silkworms stop eating and start wandering, indicating readiness for mounting, where they spin their cocoons. Mounting involves providing structures such as Chandrika frames, cardboard nets, or dry twigs, ensuring a clean and organized space for cocoon formation. Proper mounting is essential for producing uniform and high-quality silk. Throughout the late-age stages, maintaining a clean environment, proper ventilation, and monitoring for diseases are crucial for healthy growth and successful cocoon spinning.

2.7 Introduction of Cocoon, Cocoon Quality, Characteristics and Classification

Silk cocoons are protective coverings spun by silkworms, especially the *Bombyx mori* species, which feed only on mulberry leaves and produce white or yellow color cocoon. The quality of these cocoons depends on factors like their size, shape, shell thickness, and color. These features play an important role in determining the cocoon's value. In the silk industry, cocoons are sorted and priced based on their characteristics such as shape, size, color, and texture. They are also classified into different grades, such as Grade A, B, and C, to ensure proper use and fair pricing.

2.7.1 Introduction of Cocoon

Silk cocoons are protective coverings spun by silkworms. *Bombyx mori* insects feed exclusively on fresh mulberry leaves, which provide the nutrients needed to

produce silk. After completing their larval stages, silkworms spin a continuous silk thread around themselves to form oval-shaped cocoons that serve as shelters during the pupal stage. This protective cocoon ensures the silkworm's survival as it undergoes transformation into a moth.

The silk thread is produced by two special silk glands located on each side of the silkworm's lower body (abdomen). These glands secrete a liquid protein called fibroin, which forms the core of the silk thread. The fibroin is expelled through the spinneret, a nozzle-like organ near the silkworm's mouth. When the liquid fibroin comes into contact with air, it solidifies into a fine, continuous thread. In addition, the silkworm secretes a sticky substance called sericin, which acts as a natural glue, binding the silk thread into a cohesive cocoon structure.

Using rhythmic movements of its head, the silkworm weaves this thread back and forth, creating the intricate layers of the cocoon. This process takes about 2-3 days, and a single cocoon can contain up to 900-1,500 meters of silk thread. The formation of silk cocoons is vital in the production of silk. These cocoons are later processed to extract the raw silk thread, which is used to create luxurious fabrics. By understanding the natural behavior and needs of silkworms, humans have developed methods to rear them efficiently, ensuring high-quality silk production while maintaining the delicate balance of their life cycle.

2.7.2 Cocoon quality, Characteristics and Classification

Cocoons are graded based on their size, shape, weight, shell thickness, color, texture, and silk yield, which determine their quality and value in silk production. The three main grades are Grade A, Grade B, and Grade C, with each grade reflecting specific characteristics and uses. Grade A cocoons are of the highest quality, with uniform size and oval shape, thick shells, smooth texture, and bright, uniform color, often white or yellow depending on the silkworm species. These cocoons yield long, continuous, and strong silk threads of about 900 to 1500 meters, making them ideal for producing premium silk fabrics. Grade B cocoons have slightly irregular size or shape, moderate shell thickness, and less uniform texture or color and cocoon yields about 600 to 900 meters long silk but

they still provide good-quality silk suitable for medium-grade textiles. Grade C cocoons are of the lowest quality, characterized by irregular shape, thin shells, coarse texture, and often discolored or spotted appearance, resulting in lower silk yield of about less than 600 meters. It is suitable primarily for spun silk or non-premium products.

The grading procedure involves several steps. First, cocoons are inspected visually for size, shape, and color uniformity. Then, they are weighed to determine their total weight and shell thickness, which indicates potential silk yield. A reeling test is conducted on sample cocoons to assess the quality, length, and strength of the silk thread. Based on these observations, cocoons are sorted into Grade A, B, or C. To produce high-quality cocoons, it is essential to maintain optimal rearing conditions, including temperature, humidity, and feeding fresh mulberry leaves to the silkworms.

2.8 Silk Production

2.8.1 Harvesting of Cocoon

The timing of cocoon harvesting is crucial for optimal silk quality and yield. Generally, harvesting occurs 5-7 days after the larvae complete spinning. Seed cocoons, intended for breeding, may require a slightly longer harvest period, typically 8-9 days. Premature harvesting can lead to underweight cocoons and reduced silk quality, while delayed harvesting can result in pierced cocoons due to moth emergence or damage from pests like uzi maggots. Harvesting is typically done manually, although simple devices can assist with harvesting from rotary mountages.

2.8.2 Post-Harvest Activities

Disinfection of Mountages

Mountages, the structures on which silkworms spin their cocoons, can harbor diseases. Disinfection is essential to prevent pupal mortality and maintain cocoon quality. Methods include spraying with solutions like slaked lime, formalin, or bleaching powder, flame treatment for bamboo mountages, and submersion for

plastic mountages.

Floss Removal

Excess silk floss is removed to improve cocoon appearance and facilitate handling. This is typically done manually or with mechanical devices. However, floss removal is generally avoided for seed cocoons as it can damage the pupae.

Sorting and Grading: Cocoons are sorted based on size, color, shape, and quality. Low-quality cocoons are separated and disposed of properly to prevent disease spread.

Packing and Storage: Good quality cocoons are packed loosely in perforated bags to allow for air circulation and stored in cool, dry, and well-ventilated areas to prevent overheating and moisture buildup. Transportation should be done during cooler parts of the day to minimize temperature fluctuations.

2.8.3 Silk Extraction

I. Traditional Method of Silk Extraction: Silk extraction through traditional methods is a slow and detailed process, commonly used in regions with a rich history of silk production, such as India, China, and Japan. This method is highly effective in producing high-quality silk with a natural luster and softness, making it ideal for crafting premium silk fabrics.

Cocoon Selection: In this step, cocoons are chosen carefully based on their size, color, and overall quality. Workers inspect each cocoon by hand, looking for uniformity and making sure there are no defects like holes or damage. Special trays are used to organize and sort the cocoons during this process. Only the best cocoons are selected to ensure high-quality silk.

Boiling Cocoon/Killing Pupa: To make it easier to extract silk threads, the pupae inside the cocoons must be killed. This is done by placing the cocoons in boiling water, which softens the sericin, a natural substance that holds the silk fibers together. The boiling process typically lasts 5-10 minutes. Large pots or vats and wooden stirrers are used for this step. This process ensures the silk threads

remain intact and are easier to unwind.

Reeling

After boiling, the softened cocoons are placed on a reeling device. Skilled workers gently pull out the silk threads using brushes and guide them onto a spinning wheel, such as a charkha. They combine threads from multiple cocoons to create one continuous silk strand. This step requires a lot of patience and skill to avoid breaking the delicate threads.

Degumming

The silk threads still contain sericin, which needs to be removed to make the silk soft and shiny. This is done by soaking the threads in a hot soap (2–3% of the total weight of the silk) and soda (1–2% of the total weight of the silk) solution. The threads are then thoroughly rinsed with water to remove any residue. Large basins or vats are used for this process, and it gives the silk its smooth texture and natural shine.

Drying

Once the sericin is removed, the silk threads are stretched out and dried. This can be done in the sunlight or in well-ventilated rooms. Drying racks or open spaces are commonly used for this step. Proper drying ensures the silk threads retain their quality and are ready for the next stages.

Dyeing

The dried silk threads are then dyed to give them beautiful colors. Workers immerse the silk in dye baths that contain either natural dyes, like indigo or turmeric, or synthetic dyes. Mordants, such as alum or iron, are added to fix the colors and make them long-lasting. This step adds vibrant and attractive hues to the silk.

Weaving

In the final step, the dyed silk threads are woven into fabric using traditional handlooms or power looms. Skilled artisans carefully weave the threads to create

intricate patterns and designs. This step transforms the silk threads into luxurious fabric that can be used for clothing and other products.

II. Modern Silk Extraction Method

The modern method of silk extraction utilizes advanced technology and equipment to improve efficiency, consistency, and quality. This process is particularly effective in industrial-scale production and ensures high precision and reduced labor intensity.

Sorting

Sorting of cocoons is carried out using automated systems. Automated sorting machines equipped with conveyor belts, sensors, and cameras sort cocoons based on size, color, and quality. These systems ensure uniformity by detecting and separating cocoons automatically, significantly reducing manual labor and improving the consistency of the raw materials used.

Softening

After sorting, the cocoons undergo softening to prepare them for the reeling process. This is achieved by immersing the cocoons in hot water within automated boiling vats equipped with temperature control systems. The temperature is precisely maintained, typically around 90-100°C, to soften the sericin without damaging the delicate silk fibers. This controlled process ensures that the cocoons are uniformly softened, allowing for smoother reeling in the subsequent steps.

Reeling

This is the core process where the silk filaments are extracted from the cocoons. Once softened, the silk filaments are extracted through reeling, which is performed using automated reeling machines. These machines are equipped with multiple spindles, sensors, and controls to ensure an efficient process. The machines unwind filaments from multiple cocoons simultaneously, combining them into a single continuous thread. Sensors continuously monitor the thread's quality and make adjustments to maintain consistency, resulting in high-quality silk threads suitable for further processing.

Degumming

This step involves removing the remaining sericin from the silk thread. Degumming, which removes the sericin from the silk threads to leave them soft and shiny. Large vats with automated temperature control systems are used for this process. Enzymatic degumming is a popular choice due to its efficiency and environmental benefits. A solution containing around 0.5-1% proteolytic enzymes and a small amount of detergents is used to break down and remove the sericin at a controlled temperature (usually between 40-60°C) for a specific duration (typically 30-60 minutes).

Drying

After degumming, the silk threads are dried under controlled conditions to preserve their quality. Automated drying chambers with precise temperature and humidity control are employed for this purpose. The silk is carefully stretched and dried in these chambers, ensuring uniformity and preventing any damage to the threads during the drying process. The moisture content of the dried silk should be low to prevent mildew and maintain its quality. The ideal moisture content of dried silk should be between 8-11%. A moisture content that is too high can lead to the growth of mold and mildew, which can damage the silk and reduce its quality. On the other hand, if the moisture content is too low, the silk can become brittle and prone to breakage.

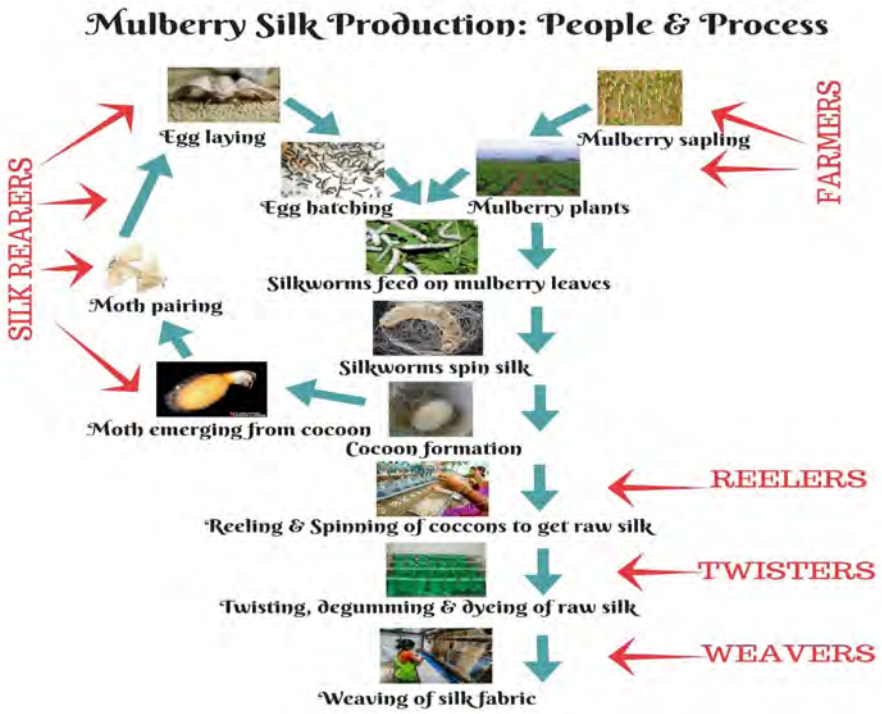
Dyeing

The dried silk is then dyed to achieve vibrant and consistent colors. Automated dyeing machines with temperature control systems are used, allowing for precise regulation of dye concentration and temperature. Synthetic dyes and mordants, such as alum, are commonly used to fix the colors. The silk is immersed in dye baths, and the automated machines ensure uniform coloring and vibrant hues throughout the batch.

Weaving

Finally, the dyed silk threads are woven into fabric using high-speed power

looms. These looms enable the production of intricate designs and patterns at a faster rate compared to traditional methods. The advanced weaving techniques ensure consistent quality and make it possible to produce large volumes of fabric efficiently.



Pic source: https://www.parinita.co.in/blogs/articles/mulberry-silk-production-people-processes.

Exercise

Choose the correct answer from the given alternatives.

1. Sericulture is the cultivation of **……..** to produce silk.

   a. Bees b. Silkworms c. Caterpillars d. Worms

2. The word "sericulture" is derived from the Latin words "*sericus*" (silk) and "**……..**" (cultivation or culture).

   a. Agriculture b. Culture c. Cultivation d. Farming

3. Nepal's first major effort in silk farming began in **…….**

   a. 1957 b. 1967 c. 1977 d. 1987

4. The **……** was established in 1975.

   a. Kathmandu Sericulture Center b. Khopasi Sericulture Center

   c. Pokhara Sericulture Center d. Bhaktapur Sericulture Center

5. **……..** plants provide food for silkworms.

   a. Bamboo b. Oak c. Mulberry d. Pine

6. The larva, commonly known as the **……**, is the most crucial stage for silk production.

   a. Caterpillar b. Pupa c. Moth d. Silkworm

7. Silkworms spin cocoons made of **…….**

   a. Cotton b. Wool c. Silk d. Nylon

8. The **…….** stage is when the silkworm transforms inside the cocoon.

   a. Larva b. Pupa c. Moth d. Egg

9. **……** is the process of unwinding silk threads from cocoons.

   a. Spinning b. Weaving c. Dyeing d. Reeling

Write short answer to the following questions.

1. What is the primary role of the Khopasi Sericulture Center in Nepal?
2. What are the key factors considered when selecting a suitable site for mulberry cultivation?
3. List the four main stages in the lifecycle of a silkworm.
4. Why is proper mounting crucial for successful cocoon formation?
5. Mention two factors that significantly influence the quality of a silk cocoon.

Write long answer to the following questions.

1. Discuss the economic, social, environmental, and cultural importance of sericulture in Nepal. Elaborate on how these aspects contribute to the overall development of the country.
2. Describe the various methods of mulberry propagation (sexual and asexual). Explain the advantages and disadvantages of each method and discuss the factors that influence the success of these methods.
3. Explain the significance of proper rearing practices during the early and late stages of silkworm development. Discuss the factors that influence silkworm growth and health, and how these factors can be managed effectively.
4. Describe the process of silk extraction from cocoons, including the traditional methods. Discuss the importance of cocoon quality in the silk extraction process and explain how different grades of cocoons are utilized.
5. Analyze the challenges facing the sericulture industry in Nepal and suggest potential solutions to overcome these challenges. Consider factors such as competition, market access, and technological advancements.
6. Discuss the cultivation practices of Mulberry plant.

Project Work

1. Conduct a local investigation into sericulture practices. Your project should

include interviews with local silk producers, observations of mulberry cultivation and silkworm rearing techniques, research on the history of silk production in your region, and documentation of your findings through photographs, videos, or sketches. Finally, prepare a presentation that showcases your findings, addresses the challenges faced by local sericulture practitioners, and proposes potential solutions to improve their livelihoods.

Introduction

Unit 3

3. Introduction

3.1 Definition, Importance and Scope of Fish Culture in Nepal

3.1.1 Definition of Aquaculture, Fish culture and History and Origin of fish culture:

Aquaculture is the practice of raising fish and other aquatic animals in controlled environments for food and other products. The term "aquaculture" derived from the Latin words "aqua" (water) and "culture" (cultivation).

Fish culture is a branch of aquaculture, which deals about the practice of growing and taking care of fish in controlled environments like ponds, lakes, tanks, cages etc. It involves providing the right conditions for fish to live and grow, such as maintaining clean water, giving them proper food, ensuring they stay healthy, and helping them breed. The main goal of fish culture is to produce more fish for food, income, and other uses, while protecting natural fish populations in rivers and lakes has a long history worldwide, originating thousands of years ago in places like China and Egypt. However, in Nepal, aquaculture as an organized activity began more recently, in 2003 BS (1946 AD), when a fisheries unit was established under the Agricultural Council.

Fish culture is the fastest-growing agricultural sectors in the country. According to statistical information on Nepalese agriculrure 2079/80 (2022/23), the total fish production of Nepal is 113,736 metric tons (Mt). Among 20% comes from capture fisheries (natural rivers and lakes), and 80% comes from aquaculture (fish farming). Despite this growth, the average fish consumption in Nepal is only 3.9 kg per person per year, much lower than the 11 kg average in other least-developed countries.

Fish is a protein-rich food that is popular across all social levels in Nepal. Most of the fish produced domestically comes from traditional capture fisheries in rivers and lakes (21,000 Mt) and from fish farming in private and government sectors (92,736 Mt). However, Nepal's fish production is still very low despite its abundant water resources, such as rivers, lakes, and reservoirs.

3.1.2 Importance and Scope of Fish Culture in Nepal

Importance of Fish Culture in Nepal

Food Security

Fish provides a valuable source of protein and essential nutrients, contributing to food security and a balanced diet for the growing population.

Income Generation

Aquaculture offers employment opportunities, both directly in fish farming and indirectly in related industries like feed production, processing, and distribution.

Foreign Exchange Earnings

Nepal can potentially export surplus fish and fish products, generating foreign exchange and boosting the economy.

Poverty Reduction

Fish farming can be a viable income source for small-scale farmers and marginalized communities, helping to alleviate poverty and improve livelihoods.

Rural Development

Aquaculture can contribute to rural development by promoting economic diversification and creating sustainable income streams in rural areas.

Scope of Fish Culture in Nepal

Abundant Water Resources

Nepal is blessed with abundant water resources, including rivers, lakes, and ponds, providing ample opportunities for both freshwater and coldwater aquaculture.

Diverse Climate Zones

The diverse climatic zones across Nepal allow for the cultivation of a wide variety of fish species, from tropical carps to coldwater trout.

Growing Domestic Demand

The increasing population and rising demand for protein-rich food create a strong domestic market for fish products.

Potential for Export

With improved quality and production, Nepal can explore export opportunities for high-value fish species to regional and international markets.

Employment Generation

The aquaculture sector can create employment opportunities, particularly in rural areas, contributing to poverty reduction and economic development.

3.2 Indigenous and exotic fish species, their identification

3.2.1 Indigenous fish

Indigenous fish are species naturally found in a specific geographic region or ecosystem, where they have evolved over time without human intervention. These fish are adapted to local environmental conditions and play a vital role in maintaining the ecological balance of their habitats.

Nepal is home to a diverse range of indigenous fish species due to its varied aquatic ecosystems, including rivers, lakes, and wetlands. Many of these fish species are highly valued for their ecological, cultural, and economic importance. Some of the popular indigenous fish species of Nepal include:

Mahseer (*Tor* species):

Mahseer (*Tor* species) are iconic freshwater fish of Nepal, prized for their ecological, cultural, and recreational value. The Golden Mahseer (*Tor putitora*) is renowned for its striking golden hue, while the Chocolate Mahseer (*Neolissochilus hexagonolepis*), locally known as "Katle," holds cultural significance and is a popular food fish.

Source: https://www.researchgate.net/figure/Chocolate-mahseer

Asla (*Schizothoraichthys* species): Often found in mid-altitude streams and rivers. This fish is adapted to cold water and is an important resource for local communities.

Source: https://en.wikipedia.org/wiki/Common_snowtrout

Rita (*Rita rita*): A type of freshwater catfish commonly found in warmer rivers of the Terai region.

Source: https://www.researchgate.net/profile/Sandipan-Gupta

Buduna (*Labeo dero*): A popular fish in Nepal's rivers, it is appreciated for its taste and role in traditional diets.

Source: https://www.researchgate.net/publication/369138885

Gonius (*Labeo gonius*): Found in the plains and lowlands, especially in rivers and oxbow lakes.

Source: https://freshwaterbiodiversity.org.bd/species/labeo-gonius/

Chitala (*Chitala chitala*): Also known as the "Clown Knifefish," it is a native species found in the Terai's larger rivers and wetlands.

Source: https://en.wikipedia.org/wiki/Chitala_chitala

Raj Bam (*Anguilla bengalensis*): It is found in the mid- and low-altitude regions of Nepal. It is valued for its unique texture and taste.

Source: https://nefis.org.np/wp-content/uploads/2018

Pothi (*Puntius* species): Small cyprinid fish commonly found in rivers, streams, and ponds.

Source: https://www.researchgate.net/figure/Puntius-sophore

Sahar/Mahseer (*Tor putitora*): The Sahar, or Mahseer (*Tor putitora*), is a prized game fish renowned for its powerful fighting ability and impressive size, making it a favorite among anglers. Indigenous to Nepal, it inhabits the pristine rivers and streams of the Himalayan region, particularly the Karnali, Gandaki, and Kosi river basins. Despite its prominence, the Mahseer faces threats from overfishing, habitat loss, and pollution, leading to a decline in its population. Beyond its ecological value, this majestic fish holds deep cultural and religious significance in Nepal, with some communities revering it as a sacred species.

Source: https://en.wikipedia.org/wiki/Tor_putitora

Similarly, widely grown indigenous fish in Nepal are: Rohu (*Labeo rohita*), Mrigal/Naini (*Cirrhinus mrigala*), Catla/Bhakur (*Labeo catla*) which are describes below in detail:

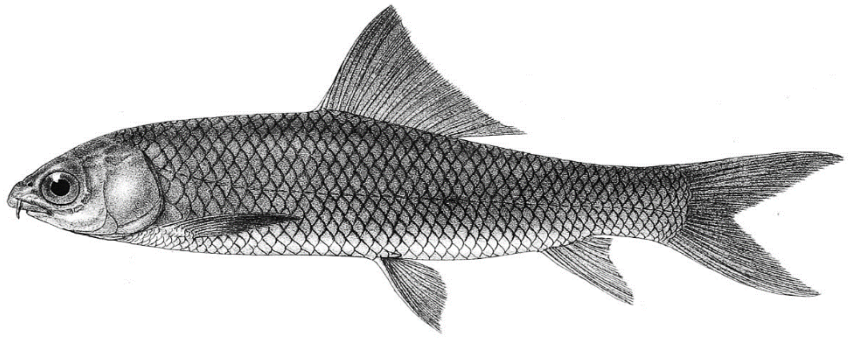
Rohu (*Labeo rohita*): Rohu (Labeo rohita) is one of the fastest-growing indigenous fish of Nepal. It is known for its delicious taste and highly valued in fish farming due to its adaptability and nutritional value**.**

Source: https://www.researchgate.net/figure/Labeo-rohita

Characteristics

- The Rohu fish has an elongated, cylindrical body adorned with prominent, large silvery scales that exhibit a reddish tinge.
- It has small, pointed head features a sub-terminal mouth that is smooth and devoid of scales.
- A single pair of maxillary barbels adds a distinctive characteristic to its appearance.
- The thick, fringed lips of the Rohu enhance its ability to feed efficiently.
- Body is marked by a dull reddish hue on the sides, which gradually transitions to a whitish tone on the belly.
- The rounded abdomen is complemented by a clearly visible lateral line, aiding in identification.
- The bi-forked caudal fin facilitates swift and agile movement in water.
- As an omnivorous species, the Rohu consumes a varied diet of plankton, plant matter, and detritus.
- With its rapid growth in warm waters, the Rohu is exceptionally well-suited for aquaculture practices.

Mrigal/Naini (*Cirrhinus mrigala*): Mrigal (Cirrhinus mrigala), locally known as Naini in Nepal, is one of the most important indigenous fish species after Rohu and Catla for aquaculture due to its adaptability and ecological significance.



Source: https://en.wikipedia.org/wiki/Cirrhinus_mrigala

Characteristics

- The body is elongated, cylindrical, and covered with prominent silvery scales, providing a streamlined appearance.
- It has a small head with a sub-terminal mouth that lacks scales, contributing to its sleek profile.
- Thin, non-fringed lips and a pair of small rostral barbels enhance its identification.
- The upper jaw is slightly longer than the lower jaw, a distinct feature of this species.
- The body coloration is grayish on the dorsal side, transitioning to a whitish tone on the belly.
- A visible lateral line runs along the body, aiding in sensory perception.
- The bi-forked caudal fin enables smooth and efficient swimming.
- As a bottom feeder, it consumes detritus and organic matter, playing an essential role in maintaining pond ecosystems.
- While its growth rate is moderate, its adaptability and feeding habits make it well-suited for aquaculture.

Catla (*Catla catla*): This fish is locally known as Bhakur in Nepal, is a fast-growing indigenous carp species highly valued in aquaculture for its rapid growth and significant contribution to freshwater fish farming.

Source: https://www.researchgate.net/figure/Catla-Catla

Characteristics

- The body is laterally compressed and deep, covered with prominent, large scales that aid in identification.
- It has a large head with an upturned mouth that lacks scales.
- Barbels are absent, and the lips are smooth and non-fringed.
- The body color transitions from grayish to silvery on the upper sides to whitish on the belly.
- A visible lateral line extends along the body, aiding in environmental sensing.
- The bi-forked caudal fin enhances swimming efficiency and agility.
- As a surface feeder, it primarily consumes phytoplankton and zooplankton, making it ecologically important.
- Known for its rapid growth, Catla can reach impressive sizes of 20–30 kg, making it ideal for commercial aquaculture.

3.2.2 Exotic fish in Nepal

Exotic fish in Nepal are species introduced from other countries, either

intentionally for farming and decoration or accidentally through escapes. While some of these fish have become important for aquaculture, providing food and income, others have caused serious challenges to aquatic ecosystems. They often compete with native fish for food and habitat, sometimes even driving them away or reducing their numbers. This disrupts the natural balance of Nepal's rivers and lakes, threatening the health of aquatic ecosystems and the survival of local species. There are different exotic fish cultivated in Nepal which are described below:

Common Carp (*Cyprinus carpio*): The common carp is one of the most widely cultivated and economically significant fish species in the world. It was introduced to Nepal in 1956 from India and later in 1960 from Israel, marking a turning point in the development of aquaculture in the country. It is known for its adaptability to a wide range of environments, the common carp has become a cornerstone of fish farming due to its high growth rate, efficient feed conversion, and resilience to varying water conditions.

Source: https://en.wikipedia.org/wiki/Common_carp

Characteristics

- The body is flat, deep, and robust, making it well-suited for swimming in various aquatic environments.
- It has a short, small head that lacks scales, contributing to its streamlined appearance.

- The mouth is protractile, allowing it to extend outward while feeding, and it features two pairs of maxillary barbels for detecting food.
- The dorsal fin is long and prominent, with a sharp spine providing protection against predators.
- The body is covered with large, shiny, yellowish scales that aid in identification and offer protection.
- A well-defined lateral line runs along the body, enhancing its ability to sense movements and vibrations in the water.
- The caudal fin is bi-forked, contributing to its efficient swimming and maneuverability.
- Common carp are omnivorous, feeding on a variety of plant material, insects, and detritus, which makes them highly adaptable to different environments.
- The species can thrive in a wide range of aquatic conditions, including ponds, lakes, and rice fields, showcasing its resilience and versatility.
- Its ability to grow quickly and efficiently makes it an essential species in aquaculture worldwide.

Grass Carp (*Ctenopharyngodon idella*): The Grass Carp is an exotic fish species introduced to Nepal from India in 1967 and Japan in 1968. Known for its rapid growth and herbivorous diet, it is widely used in aquaculture for weed control and fish farming, playing a vital role in sustainable aquatic management.

Characteristics

- The body is elongated, cylindrical, and covered with large, greenish scales, giving it a distinct appearance.
- It has a broad head that lacks scales, making it easily recognizable.
- The species is devoid of barbels, unlike many other carp species.
- The mouth is sub-terminal, with the upper jaw slightly extending beyond the lower jaw.

- A prominent lateral line runs along the body, aiding in detecting water movements and maintaining balance.
- The caudal fin is bi-forked, providing efficient swimming capabilities.
- Grass Carp are primarily herbivorous, feeding on aquatic plants, making them effective for controlling excessive vegetation in water bodies.
- They grow rapidly in favorable conditions, making them an essential species for enhancing fish production in aquaculture systems.
- Their adaptability to different aquatic environments and their ability to coexist with other species make them a valuable addition to Nepal's aquaculture practices.

Silver Carp (*Hypophthalmichthys molitrix*): The silver carp is an exotic fish species introduced to Nepal from India and Japan in 1967 and 1968, respectively. This species is highly valued for its rapid growth and ability to thrive in freshwater aquaculture, making it a significant addition to the fish farming industry in Nepal.

Characteristics

- The body is flat, laterally compressed, and covered with small, shiny silvery scales.
- It has a small head that lacks scales and barbels, giving it a smooth and streamlined appearance.
- The mouth is distinctly upturned, with the lower jaw longer than the upper jaw, aiding in its feeding habits.
- A complete abdominal keel runs along the body, which is a distinguishing feature of this species.
- The posterior margin of the pectoral fin does not extend beyond the base of the pelvic fin, a key identification trait.
- A well-defined lateral line is present, aiding in movement and environmental sensing.

- The caudal fin is bi-forked, enabling swift and efficient swimming.
- Silver carp are filter feeders, consuming plankton and organic matter, which helps maintain water quality in aquaculture systems.
- Known for their fast growth rate, they are an excellent choice for increasing fish production in both ponds and large reservoirs.
- Their adaptability to different water temperatures and environments makes them a versatile species for fish farming.

Bighead Carp (*Hypophthalmichthys nobilis*): The Bighead carp is an exotic fish species introduced to Nepal from America in 1969 and Hungary in 1972. It is a highly productive fish, valued for its fast growth and adaptability to various freshwater environments, making it a significant species in aquaculture practices.

Characteristics

- The body is flat, laterally compressed, and covered with small silvery scales, with a brownish tinge on the upper side.
- It has a long and massive head that lacks scales, giving it a distinctive appearance.
- The mouth is large and upturned, with the lower jaw extending beyond the upper jaw.
- The abdominal keel is incomplete, setting it apart from other related species.
- A prominent lateral line is present, aiding in detecting water movements and vibrations.
- The caudal fin is bi-forked, providing efficient propulsion in water.
- The posterior margin of the pectoral fin extends beyond the base of the pelvic fin, which is a unique identifying feature.
- Bighead carp lack barbels, further distinguishing them from other carp species.
- As filter feeders, they primarily consume phytoplankton and zooplankton, contributing to the ecological balance in aquaculture systems.

- Their rapid growth and ability to thrive in diverse environments make them a valuable species for enhancing fish production in Nepal.

Nile Tilapia (*Oreochromis niloticus*): Nile Tilapia is an exotic fish species native to the Nile River in Africa and has been widely distributed across the world due to its adaptability and economic importance. It was introduced to Nepal from Thailand in 1985 and has since become a valuable species for aquaculture, known for its fast growth, high reproduction rate, and ability to thrive in diverse water conditions.

Characteristics

- The body is laterally compressed and covered with large, prominent scales, aiding in easy identification.
- The head is scaled, with relatively large eyes, providing enhanced vision.
- The mouth is terminal, with a folded and thick upper lip, suitable for its diverse feeding habits.
- The dorsal fin is long and spiny, providing protection against predators.
- Both pelvic and anal fins are spiny, contributing to the fish's defensive mechanisms.
- The lateral line is interrupted, and distinct black stripes are present on the body and tail, adding to its recognizable appearance.
- The caudal fin is single-lobed, enabling efficient swimming.
- Adult males have a reddish underside and a red coloration at the tip of the caudal fin, making them visually distinct.
- Adult females display a yellowish underside and a brownish dorsal surface with stripes.
- Nile Tilapia is an omnivorous species, feeding on plankton, aquatic vegetation, and detritus, making it ecologically adaptable and economically significant.

Pangas/Baikhi (*Pangasiodon hypophthalmus*): Pangas, also known as Baikhi, is an exotic catfish species native to the rivers of South Asia. It was introduced to Nepal from India and has recently gained popularity among farmers for aquaculture. This species is highly valued for its rapid growth, adaptability to various aquatic environments, and its role in providing a reliable source of protein for local communities.

Characteristics

- The body is long, laterally flattened, and lacks scales, giving it a smooth appearance.
- It has a flat, bony head with relatively large eyes for enhanced vision in murky waters.
- The mouth is broad and terminal, equipped with small sharp teeth on the jaw for efficient feeding.
- Two pairs of small barbels are present, with the upper pair being shorter than the lower, aiding in sensory perception.
- The fins are dark grey or black, adding to its distinctive appearance.
- A prominent lateral line runs along the body, helping the fish detect movement and vibrations in the water.
- Adult Pangas are uniformly grey on the upper body, silvery on the sides, and white on the abdomen, creating a striking color pattern.
- The caudal fin is bi-forked, allowing for efficient swimming and quick movement.
- Pangas catfish are omnivorous, feeding on a variety of food sources, making them highly adaptable to different aquaculture systems.
- Their rapid growth and resilience to environmental changes make them an essential species for enhancing fish production in Nepal.

Rainbow Trout (*Oncorhynchus mykiss*): The Rainbow trout is an exotic fish species native to the United States but was introduced to Nepal in 1988 from Japan. Known for its vibrant colors and excellent taste, the Rainbow trout has

become a popular choice for aquaculture in Nepal. It is farmed globally and thrives in cooler fresh running waters, making it suitable for high-altitude regions like Nepal.

Characteristics

- The body is elongated and laterally compressed, with a rounded snout that gives it a sleek appearance.
- The upper side of the head is blue-green, yellow-green, or almost brown, offering camouflage in natural environments.
- The sides of the body are silvery, marked by a bright pink, bluish, or red band, complemented by many small black spots that are characteristic of the species.
- The underside of the body (belly) is silvery, white, grey, or yellowish, providing a striking contrast to the upper coloration.
- The dorsal and caudal fins feature radiating rows of black spots, adding to the fish's distinctive beauty.
- A well-defined lateral line runs along the body, assisting in movement and environmental sensing.
- The caudal fin is not distinctly bi-forked, but its shape enables efficient swimming.
- Rainbow trout are carnivorous and primarily feed on smaller fish, insects, and aquatic invertebrates, making them well-suited for higher-altitude aquaculture systems.
- Their vibrant coloration, delicious flesh, and high market demand have made them an important species for fish farming in Nepal.

African Catfish (*Clarias gariepinus*): The African catfish, known locally as *Mangur* in Nepal, is an exotic species that was introduced to the country in the mid-1990s from India. This species has quickly become popular among fish farmers due to its fast growth rate, hardiness, and ability to thrive in diverse environments, making it an important species for aquaculture in Nepal.

Characteristics

- The body is long and cylindrical, with smooth, scale-less skin that contributes to its sleek appearance.
- The head is flat and bony, providing strength and structure to the fish.
- The mouth is broad and terminal, equipped with four pairs of barbels, which help the fish detect food in murky waters.
- The body color is dark grey or black on the dorsal side, transitioning to a white belly, offering camouflage in natural environments.
- Both the dorsal and anal fins are long and lack spines, contributing to the fish's streamlined shape.
- The pectoral fins are equipped with spines, providing defense mechanisms against predators.
- The caudal fin is rounded, allowing for powerful swimming movements.
- African catfish are omnivorous, feeding on a variety of plant and animal matter, making them adaptable to different farming conditions.
- Their resilience to environmental changes, along with their rapid growth and high reproductive rate, makes them an ideal species for aquaculture in Nepal.

Aquarium fish: Aquarium fish are species of fish that are specifically bred or adapted to live in the controlled environment of aquariums. These fish come in a wide variety of shapes, sizes, and colors, making them popular choices for both beginner and experienced fish keepers. Aquarium fish can be found in freshwater or saltwater aquariums, and they are often selected for their beauty, ease of care, or interesting behaviors. Keeping aquarium fish provides a unique opportunity to create and maintain miniature ecosystems, offering enjoyment, relaxation, and education to people of all ages. These fish are not only a source of aesthetic appeal but also contribute to understanding aquatic biology and conservation. Some of the popular aquarium fish are listed below:

- **Goldfish** (*Carassius auratus*): Small, colorful fish, popular for

ornamental use.

- **Koi Carp:** Decorative variety of *Cyprinus carpio*, bred for aesthetic appeal.
- **Guppy** (*Poecilia reticulata*): Small, vibrant fish used for mosquito control and aquariums.

Exercise

Choose the correct answer from the given alternatives.

1. ..... is the practice of raising fish and other aquatic animals.
   a. Aquaculture b. Fish culture
   c. Horticulture d. Floriculture

2. Fish culture is a branch of .....
   a. Agriculture b. Forestry c. Horticulture d. Ssericulture

3. The term "aquaculture" is derived from the Latin words "aqua" meaning ..... and "culture" meaning cultivation.
   a. Air b. Earth c. Water d. Fire

4. One of the main goals of fish culture is to .....
   a. Reduce air pollution b. Protect natural fish populations
   c. Increase soil fertility d. Control pests

5. ..... is a fast-growing agricultural sector in Nepal.
   a. Dairy farming b. Crop production
   c. Fish culture d. Poultry farming

6. ..... is a popular indigenous fish species in Nepal.
   a. Nile Tilapia b. Common Carp
   c. Rohu d. Grass Carp

7. ..... is an exotic fish species introduced to Nepal.
   a. Mahseer b. Rohu
   c. Common Carp d. Asla

8. The ..... is an important indigenous fish species known for its rapid growth.

a. Mahseer
b. Catla
c. Rainbow Trout
d. African Catfish

9. ..... is a major concern regarding the introduction of exotic fish species.
   a. Increased fish diversity
   b. Improved water quality
   c. Competition with native species
   d. Enhanced aquaculture productivity

Write short answer to the following questions.

1. What are the two main sources of fish production in Nepal?
2. Mention two important indigenous fish species of Nepal.
3. What are the main goals of fish culture?
4. How can fish culture contribute to rural development?
5. What are the potential ecological impacts of exotic fish species?

Write long answer to the following questions.

1. Describe the importance and scope of fish culture in Nepal.
2. Explain the characteristics of Rohu, Mrigal, and Catla.
3. Discuss the challenges faced by the aquaculture sector in Nepal.
4. How can the introduction of exotic fish species impact native fish populations?
5. What are the benefits and risks of aquaculture in Nepal?

Project Work

1. If you have access to a fish pond (home-based or community), observe the fish species present (if possible, identify them), their feeding habits, and the overall condition of the pond. Present your observations in class with pictures or drawings.

Fish-Pond

Unit 4

4. Fish-pond

4.1 Fish-pond Construction

Constructing a fish pond is essential for fish farming, providing a controlled environment for raising species like carp. A well-planned pond ensures healthy fish growth and sustainable production. Below are the steps involved in fish pond construction explained in detail:

Site Selection

The first step is site selection, which involves choosing a location with a reliable water source such as a river, stream, or groundwater. The soil should be clayey as it retains water better, while sandy soil is unsuitable. The site must receive sunlight for 6-8 hours daily to promote the growth of plankton, a natural food source for carp. Additionally, accessibility is crucial for maintenance and transportation of fish or feed, and proximity to markets can make fish distribution easier.

Pond Design

The pond design is equally important. Most carp ponds are rectangular or square because these shapes are easier to manage. The size of a typical pond ranges between 1000–2000 square meters (0.1–0.2 hectares), which is suitable for small-scale fish farming. The depth of the pond should be between 1.5 and 2 meters, providing adequate space for fish movement and maintaining favorable water temperatures for carp growth.

Land Preparation

Land preparation involves clearing vegetation and removing debris such as roots, rocks, and waste. The ground must be leveled to prevent uneven water

distribution, and a slight slope (1–2%) should be created towards the center or an outlet for proper drainage and waste management.

Excavation

Excavation is the next step, where the pond is dug to the required depth. The bottom should slope gently towards the center to facilitate water drainage. During excavation, care must be taken to remove sharp objects like rocks or roots that could harm the fish or damage any lining materials used in the pond.

Pond Lining

In areas where soil cannot retain water effectively, pond lining is essential. Suitable materials for lining include clay, plastic sheets, or specialized pond liners. These materials prevent water seepage and help maintain a stable water level.

Building Dikes

Building dikes around the pond is necessary to keep the water contained. Dikes should be sturdy, with a width of about 1 meter at the top and 2–3 meters at the base, depending on the pond size. Planting grass on the dikes helps to prevent soil erosion and adds stability.

Construction of In-let and Out-let System

The installation of water inlet and outlet systems ensures proper water management. The inlet pipe is used to bring fresh water into the pond, positioned at a height to avoid sediment entering the water. The outlet pipe helps regulate water levels and drain the pond when necessary. Both pipes should have screens to prevent fish from escaping or unwanted species from entering.

Aeration

In heavily stocked ponds, aeration is crucial to maintain adequate oxygen levels for the fish. Aerators, such as paddle wheels or air pumps, can be installed to oxygenate the water, which is vital for fish health and growth, especially during warm weather or in densely stocked systems.

Pond Filling

Once the pond is ready, it is time for pond filling. The pond is gradually filled with water while checking for leaks. The water should be left to settle for a few days to ensure it is safe for the fish.

Stocking

The final step is stocking the pond with fish. Carps can be reared for a 1000 square meter pond, about 2000–3000 fingerlings (young fish) can be stocked. It is essential to use healthy fingerlings free from diseases to ensure successful farming.

4.2 Management of Fish Pond

Fish pond management is the process of maintaining a pond to ensure healthy fish growth and sustainable production. Good management practices help create a balanced environment for the fish, control water quality, and improve productivity. Proper care of the pond not only ensures the fish remain healthy but also increases the efficiency of fish farming. The different management practices of fish pond are described below:

Water Quality Management

One of the most important practices in fish pond management is water quality management. The water should be clean and free from harmful chemicals. Regularly check the water's pH level, which should be between 6.5 and 8, and ensure there is enough oxygen for the fish. Aeration devices can be used to add oxygen to the water, especially in heavily stocked ponds.

Feed Management

Fish need a balanced diet to grow properly. In addition to natural food like plankton, provide supplementary feed such as rice bran, oil cakes, or commercial fish feed. Feed should be given in small amounts at regular intervals to prevent wastage and water pollution.

Stocking Density Management

Another important practice is stocking density management. Overcrowding can lead to stress, disease, and slower growth. Follow the recommended stocking density based on the pond size and fish species. For example, in a 1000 square meter pond, around 2000–3000 fingerlings are ideal.

Waste and Weed Control

Waste and weed control is necessary to maintain a healthy pond environment. Remove excess weeds, algae, and debris regularly to prevent water pollution and ensure proper circulation of water. Managing pond waste also helps reduce the risk of fish diseases.

Predator and Disease Control

Use nets or fences to keep predators like birds and animals away from the pond. Monitor the fish for signs of disease, such as unusual swimming behavior or loss of appetite, and take prompt action if any problems are noticed.

Harvesting and Restocking

Harvest fish when they reach the desired size, ensuring minimal stress during the process. After harvesting, prepare the pond by cleaning it thoroughly and restock it with new fingerlings to continue production.

4.3 Aquatic Weeds and the Control Method

Aquatic weeds are unwanted plants that grow in water bodies, such as ponds, lakes, and rivers. They can significantly impact the ecosystem by disrupting water flow, reducing oxygen levels, and competing with native plants and animals for resources. There are different types of aquatic weeds which are described below with their control methods:

Free-Floating Weeds

These weeds float freely on the water surface, with their roots not anchored to the bottom. They can spread rapidly, forming dense mats that block sunlight and hinder oxygen exchange. Examples: Water Hyacinth (*Eichhornia crassipes*),

Water Lettuce (*Pistia stratiotes*), Duckweed (*Lemna minor*) etc.

Submerged Weeds

These weeds grow entirely underwater, rooted to the bottom or floating freely. They can form dense underwater masses, hindering fish movement and reducing water clarity. Examples: Hydrilla (*Hydrilla verticillata*), Eurasian Watermilfoil (*Myriophyllum spicatum*), Elodea (*Elodea canadensis*) etc.

Emergent Weeds

These weeds are rooted in the bottom of the water body but have leaves and stems that extend above the water surface. They can form dense stands along shorelines, reducing water depth and affecting water flow. Examples:Cattails (*Typha latifolia*), Reeds (*Phragmites australis*), Water Lilies (*Nymphaea spp.*) etc.

Controlling aquatic weeds is crucial for maintaining healthy water bodies. Various methods can be used, including:

Mechanical Control

Mechanical control involves physically removing aquatic weeds from the water body. For small infestations of free-floating weeds, manual removal using rakes, nets, or by hand can be effective. Submerged weeds can be controlled by cutting them underwater using specialized tools such as weed harvesters or weed cutters. These methods are generally labor-intensive but can be effective for controlling smaller infestations or in situations where chemical or biological control methods are not feasible.

Biological Control

Biological control involves utilizing natural enemies of weeds to suppress their populations. This can include introducing herbivorous fish species like grass carp and tilapia, which can consume certain types of aquatic weeds. However, it's crucial to ensure these introduced species are compatible with the existing ecosystem and do not harm native fish or other aquatic organisms. Additionally, specific insects and other organisms can be employed for weed control. For

instance, the weevil *Neochetina eichhorniae* has proven effective in controlling the invasive water hyacinth.

Chemical Control

Chemical control involves the use of herbicides to kill aquatic weeds. While effective, it's crucial to exercise extreme caution to prevent harm to other aquatic organisms and the environment. Only herbicides specifically formulated for aquatic use should be employed, and adhering strictly to label instructions is paramount. Examples of herbicides used in aquatic weed control include Fluridone and Endothall, which are effective against submerged weeds like hydrilla and Eurasian watermilfoil. Diquat, on the other hand, is commonly used to control free-floating weeds such as water hyacinth and water lettuce.

Integrated Weed Management (IWM)

Integrated Weed Management (IWM) recognizes that no single method of weed control is universally effective. The most successful approach often lies in a carefully orchestrated combination of mechanical, biological, and chemical control methods. This tailored approach considers the specific characteristics of the target weed, the unique conditions of the water body, and the broader ecological implications. IWM aims to achieve sustainable and effective weed control while minimizing environmental impact and preserving the overall health of the aquatic ecosystem.

4.4 Fish Predators and Control Methods

Fish predators pose a significant threat to aquaculture operations, causing economic losses and disrupting the delicate balance of the aquatic ecosystem. These predators can be from various groups, including birds, mammals, reptiles, amphibians, and other fish species. They can directly consume cultured fish, compete for food and oxygen, and introduce diseases or parasites. The various fish predators are described below in detail with their control methods:

Birds

Birds, such as kingfishers, herons, egrets, and cormorants, are common predators

that pose a threat to fish ponds, especially targeting fingerlings and smaller fish. Their predation can lead to significant fish losses, impacting the productivity of the pond. To manage this, farmers can employ effective control methods like installing bird netting, setting up scarecrows, using visual deterrents such as reflective tapes, and modifying the pond environment to eliminate perching spots. These measures help protect the fish and ensure a more productive aquaculture system.

Mammals

Mammals such as otters, raccoons, and stray dogs can pose significant challenges to fish ponds by preying on fish and causing damage to pond infrastructure. Their activities not only result in direct fish losses but can also disrupt the overall structure and functionality of the pond. To counter these threats, effective control measures include installing sturdy fencing around the pond, using humane trapping methods, and modifying the pond environment to eliminate hiding spots for these animals. These steps help safeguard the pond and ensure a more secure and productive aquaculture system.

Reptiles

Reptiles such as snakes, turtles and crocodiles can become predators in fish ponds, preying on smaller fish and eggs. Their presence can lead to significant losses, particularly during the early stages of fish development. To manage these threats, farmers can implement physical barriers like fencing, use traps to capture intruders, and modify the pond environment to eliminate hiding spots. These measures help protect the fish population and maintain a safe and productive pond ecosystem.

Amphibians

Amphibians, such as frogs and toads, can pose challenges in fish ponds by preying on fish fry and small fish, particularly affecting the early stages of fish development. Their presence can hinder fish growth and reduce productivity. To mitigate their impact, practices like drying the pond periodically and modifying

the environment to eliminate hiding spots can be effective. These measures help create a safer habitat for the fish, ensuring better survival rates and overall pond health.

Fish

Large and carnivorous fish, such as Bhoti and Mungri, can pose a significant threat within fish ponds by preying on smaller fish species. These predators not only cause direct fish losses but also create competition for food and space, disrupting the balance of the pond ecosystem. To mitigate their impact, selective fishing can be used to remove these predatory species, ensuring a safer environment that supports the growth and productivity of the desired fish populations.

Insects

Insects such as dragonfly larvae, diving beetles, and other aquatic pests can pose a threat to fish ponds by preying on fish fry and eggs, particularly during the early stages of fish development. This predation can significantly reduce the survival rates of young fish, impacting overall pond productivity. To control these insect predators, introducing predator-eating fish, like certain types of tilapia, can be an effective solution. Additionally, modifying the pond environment by removing excessive aquatic vegetation helps reduce hiding spots for these insects, creating a safer and more conducive environment for the fish to thrive.

Exercise

Choose the correct answer from the given alternatives.

1. ..... is the first step in fish pond construction.

   a. Excavation b. Site selection c. Pond lining d. Building dikes

2. The ideal depth of a fish pond for carp farming ranges between ..... meters.

   a. 0.5-1 b. 1-1.5 c. 1.5-2 d. 2-2.5

3. ..... is essential for maintaining adequate oxygen levels in heavily stocked ponds.

   a. Aeration b. Pond lining c. Excavation d. Land preparation

4. ..... is a common method for controlling free-floating weeds.

   a. Herbicides b.Biological control

   c. Manual removal d. All of the above

5. ..... can be used to control submerged weeds.

   a. Weed harvesters b. Bird netting

   c. Scarecrows d. Aerators

6. ..... are common predators of fish in ponds.

   a. Birds b. Mammals c. Reptiles d. All of the above

7. ..... can be used to control bird predation in fish ponds.

   a. Bird netting b. Herbicides

   c. Weed harvesters d. Aeration

8. ..... is crucial for maintaining a healthy pond environment.

   a. Water quality management b. Pond construction

   c. Fish feeding d. Harvesting

9. Integrated Weed Management (IWM) emphasizes ..... for effective weed control.
   a. Using only chemical methods
   b. A combination of control methods
   c. Relying solely on biological control
   d. Avoiding any form of weed control

Write short answer to the following questions.

1. What are the key factors to consider when selecting a site for fish pond construction?
2. Explain the importance of pond lining in fish pond construction.
3. What are the different types of aquatic weeds?
4. How can fish farmers control bird predation in their ponds?
5. What are the benefits of Integrated Weed Management (IWM)?

Write long answer to the following questions.

1. Describe the step-by-step process of fish pond construction.
2. Discuss the importance of water quality management in fish pond management.
3. Explain the various methods of controlling aquatic weeds.
4. Analyze the different types of fish predators and their impact on aquaculture.
5. Discuss the importance of sustainable fish farming practices in Nepal.

Project Work

1. Design a small-scale fish pond for school backyard or a suitable location. Consider factors like size, depth, water source, and drainage. Create a scale model in a drawing paper with a detailed plan of your design.
2. Conduct a survey of common aquatic weeds found in your local area. Collect samples and try to identify them using available resources (books, online databases). Present your findings with pictures or drawings in classroom.

Fish Culture System

Unit 5

5.1 Mono Culture (Tilapia, Pangasius, Common carp and Mangur)

Monoculture in fish farming refers to the practice of cultivating only a single species of fish within a specific aquaculture system, such as a pond or cage. This allows farmers to combine everything like feeding, maintaining water quality, and disease control for single fish species which helps them grow faster and healthier.

Advantages of Monoculture

- By focusing on a single species, farmers can optimize feeding, water quality management, and other factors to maximize the growth and yield of that specific fish.
- Easy to manage, tasks like feeding, monitoring health, and harvesting become more straightforward and efficient.
- Monoculture often produces larger, more uniform fish, which can fetch higher prices in the market.
- By isolating a single species, the risk of disease outbreaks spreading to other species is minimized.
- Farmers can develop in-depth knowledge and expertise in managing a single species, leading to improved practices and higher success rates.

Disadvantages of Monoculture

- High stocking densities of a single species can create ideal conditions for the rapid spread of diseases and parasites, leading to significant economic losses.
- Monoculture systems can be more susceptible to changes in water

quality, temperature, or oxygen levels, as all fish have similar requirements.

- Overreliance on a single species can make farmers vulnerable to market fluctuations in price and demand.
- Monoculture practices can disrupt the natural ecological balance of the pond ecosystem, potentially leading to nutrient imbalances and reduced biodiversity.

5.1.1 Tilapia

Tilapia is one of the most important fish in aquaculture. It is known to be the second most widely farmed fish in the world. Among the different types of tilapia, the Nile tilapia (Oreochromis niloticus) is popular because it grows quickly, reaches good sizes for the market, and can live in many different environments.

Source: https://www.hatcheryinternational.com

Advantages

- Tilapia grow quickly, making them a relatively fast and efficient source of protein.
- They are generally more resistant to certain diseases compared to some other fish species.
- Tilapia are omnivores and can adapt to various diets, including plant-based and animal-based feeds.
- Tilapia is a good source of essential nutrients like vitamin B12, selenium, and phosphorus, which play vital roles in various bodily functions.

Disadvantages

- Waste from tilapia farming can contribute to water pollution if not managed properly.
- While tilapia is low in fat, it has a higher ratio of omega-6 to omega-3 fatty acids, which may contribute to inflammation in some individuals.
- In some cases, escaped tilapia can compete with native fish species for resources and habitat.
- High-density farming practices can increase the risk of disease outbreaks, potentially leading to economic losses.

5.1.2 Pangasius

Pangasius is a group of freshwater fish native to Southeast Asia. It is widely recognized for its role in global aquaculture. Among the species, the most commonly farmed is *Pangasius hypophthalmus.* It is also known as the striped catfish or tra fish. Pangasius is highly valued for its mild flavor, tender texture, and white boneless fillets. This character makes it a popular choice in national and international markets.

Source: https://www.fao.org/fishery/affris/species

Advantages

- Pangasius grows quickly, reaching a marketable size of 1 to 1.5 kg within a year, which allows for high turnover rates in production.
- The size and quality of Pangasius fillets make them highly appealing to global markets.
- Pangasius requires relatively low investment in feed and maintenance

compared to other species, making it a profitable choice for farmers.

- Pangasius is resilient and can thrive in various water conditions, including low-oxygen environments, reducing the risk of total failure.
- Pangasius has a good feed conversion ratio, reducing feed costs and enhancing profitability.
- It can be farmed intensively in small areas, making it suitable for large-scale commercial operations

Disadvantages

- Intensive farming can lead to water pollution and degradation due to effluents, uneaten feed, and fish waste, impacting surrounding ecosystems.
- Dense stocking and monoculture practices increase the risk of disease outbreaks, which can result in significant losses.
- While Pangasius is affordable and versatile, it has a lower omega-3 fatty acid content compared to some other fish species, which may limit its appeal to health-conscious consumers.

5.1.3 Common carp

The common carp (*Cyprinus carpio*) is a freshwater fish species of the Cyprinidae family. It is a bottom-feeding fish with a long body covered in large scales. Common carp are native to Europe and Asia but have been introduced to many other parts of the world. They are widely cultured globally due to their hardiness, fast growth rate, and ability to thrive in various water conditions.

Source: https://en.wikipedia.org/wiki/Common_carp

Advantages

- Common carp are known for their resilience, tolerating a wide range of water conditions, temperatures, and oxygen levels.
- They are omnivorous feeders, consuming a variety of food sources including plants, invertebrates, and detritus, making them efficient converters of available resources.
- Common carp exhibit rapid growth rates, allowing for relatively quick returns on investment in aquaculture operations.
- Their robust nature makes them relatively easy to handle, transport, and stock in different water bodies.

Disadvantages

- Their voracious appetite and bottom-feeding habits can lead to competition with other fish species for food resources, potentially impacting native biodiversity.
- Common carp are prolific breeders, producing large numbers of offspring, which can contribute to overpopulation and potential ecological imbalances.
- Their feeding activities can stir up sediments, leading to increased turbidity and potential oxygen depletion in water bodies.

5.1.4 Mangur

Mangur, also known as African catfish (Clarias gariepinus), is a species of catfish native to Africa. It is a popular choice for aquaculture due to its fast growth rate, adaptability to various environments, and high tolerance for varying water quality conditions. Mangur is also a good source of protein and omega-3 fatty acids, making it a valuable food source for many people around the world.

Advantages

- African catfish exhibit rapid growth rates, allowing for quick production cycles and faster returns on investment.

- They can survive and thrive in a wide range of water conditions, including low oxygen levels and high temperatures, making them suitable for aquaculture in challenging environments.
- They efficiently convert feed into biomass, minimizing feed costs and maximizing production output.
- African catfish are generally robust and resistant to many common fish diseases, reducing the need for extensive disease management practices.
- They are omnivorous and can adapt to a variety of diets, including plant-based and animal-based feeds, making them relatively easy to feed.

Disadvantages

- Their hardy nature and ability to survive in various environments make them a potential invasive species, posing a threat to native fish populations in new ecosystems.
- African catfish can exhibit cannibalistic tendencies, especially under stressful conditions or when food availability is limited, impacting production yields.
- Intensive aquaculture practices for African catfish can have potential negative impacts on the environment, such as water pollution and habitat degradation.
- Under certain conditions, African catfish can develop off-flavors, which can negatively impact their marketability and consumer appeal.

5.2 Poly culture of fish and its importance

Polyculture in fish farming is the practice of raising two or more different species of fish together in the same pond or tank. Unlike monoculture, where only one type of fish is cultivated, polyculture mimics the natural diversity of aquatic ecosystems. This method creates a balanced and sustainable environment by combining species with different feeding habits, growth rates, and habitat preferences.

In a polyculture system, each species plays a unique role. Herbivorous, carnivorous, and omnivorous fish work together to use resources efficiently, reducing competition for food. For example, one species might feed on algae, another on insects, and a third on leftover organic matter. This reduces waste and helps maintain water quality.

Importance

Polyculture offers several benefits that make it a sustainable and efficient method of fish farming.

- It allows for better use of resources as different species feed on various food sources and occupy different spaces in the pond, reducing competition.
- Natural waste recycling occurs, where one species' waste becomes nutrients for another, improving water quality.
- It helps in boosting overall production, as multiple species can be harvested together, maximizing yield.
- Polyculture often reduces the need for external inputs, such as fertilizers and feeds, since the system is more self-sustaining.
- this method mimics natural ecosystems, creating a healthier and more balanced environment for the fish.

Challenges

Despite its benefits, polyculture also has some challenges.

- Managing species compatibility can be difficult, as certain fish may compete aggressively or prey on each other.
- Disease management becomes more complicated because different species may carry or react differently to illnesses.
- Maintaining water quality requires extra attention, as the combination of species may increase the organic load.
- Feeding and monitoring the specific needs of each species can be time-consuming and require more expertise.

- Polyculture systems may have variable production rates, as some species grow faster than others, which could complicate harvesting schedules.

5.3 Common fish disease, prevention and treatment

Fish disease is a condition that makes fish unhealthy and affect the normal function of the fish body due to the germs, poor nutrition or adverse environment. Fish diseases are a big challenge in fish farming, as they can reduce production, cause financial losses, and harm the long-term success of the industry. To keep fish healthy and ensure successful farming, it is important to understand what causes these diseases, how to prevent them, and the best ways to treat them. Good management and care can help protect fish stocks and make fish farming more sustainable.

Common Signs of diseased fish: Recognizing early signs of disease in fish is crucial for their health and well-being. The following points highlight key symptoms to look out for in fish affected by stress, infection, or environmental issues. The different signs of fish diseases are listed below:

i. Fish becomes restless or exhibits abnormal behavior
ii. Loss of balance, with the fish unable to maintain its position in the water
iii. Fish lies on its side, either resting at the bottom or floating near the surface
iv. Tail and fins do not function normally or lack vigor
v. Discoloration or changes in the natural color of the body
vi. Presence of red or white spots on the body
vii. Erosion of scales, fins, gill lamellae, or parts of the skin
viii. Gills appear pale or discolored
ix. Slimy gray excretion or mucus covering the skin
x. Swelling or bloating of the abdomen
xi. Eyes appear bloody, bulging, or cloudy
xii. Reduced feeding activity or complete cessation of eating

xiii. Lethargy or reduced movement

xiv. Excessive scratching against objects or rubbing on surfaces

xv. Rapid or labored breathing, often observed near the water's surface

There are two types of fish diseases Infectious and non-infectious. The common Infectious diseases include Bacterial diseases, Protozoan diseases, Monofenean Diseases, Digenean diseases, Cestodes and helminth Diseases, Crustecean Parasitic Diseases and mycotic/Fungal Diseases. The common non-infetious diseases include Nutritional Diseases and Environmental diseases. These diseases are described briefly with their symptoms and control measures as follows:

A. Infectious diseases

Infectious diseases in fish are caused by tiny living organisms such as bacteria, viruses, fungi, or parasites. These diseases can spread easily from one fish to another, especially when the water is dirty or the fish are overcrowded. When one fish gets sick, others in the same tank or pond can also get infected.

1. Bacterial Diseases

i. Columnaris disease (Saddle back disease):

It is also called Saddle back disease. It is caused by a harmful bacteria called Flavobacterium columnare. It often attacks fish like carps and pangasius of any age. This disease can happen in any season and spreads quickly, sometimes killing many fish. It damages the fish's skin, gills, and fins, making them weak and unable to swim or eat properly.

Figure: Columnaris disease

Symptoms

- **Grayish-white patches** on the back and head, forming a "saddle-shaped" mark.
- **Damaged fins** that look torn.
- Tissue around the mouth becomes pale and starts breaking down which is called mouth rot.
- Bacteria can damage the gills which cause d**ifficulty in breathing**.

Control Measures

- Separate sick fish from healthy fish immediately.
- Improve water quality by changing part of the water and keeping it clean and well-aerated.
- Treat water with potassium permanganate ($KMnO_4$) at 2 mg per liter of water for 1 hour.
- Alternatively, use copper sulfate ($CuSO_4$) at 0.5–1 mg per liter of water for 1 hour (only if water hardness is above 50 ppm).

ii. Aeromonas septicaemia

It is a dangerous fish disease caused by bacteria like *Aeromonas hydrophila, A. sobria,* and *A. veronii*. It can affect many types of fish, such as carps, rainbow trout, catfish, tilapia, and even shrimps and prawns, no matter their age. This disease mostly appears in summer and can kill more than 80% of the stock if not treated quickly.

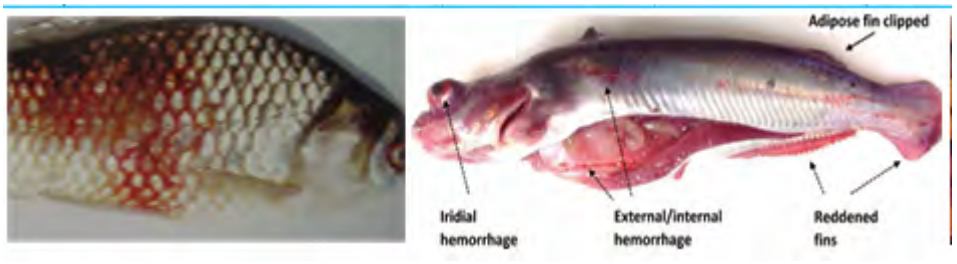


Figure: Aeromonas septicaemia disease

Symptoms

- Red patches or sores appear on the skin and fins.
- Swollen belly due to fluid build-up inside the body.
- The eyes bulge out unusually.
- Fish become weak and swim slowly or stop moving much.

Control measures

- Remove and isolate sick fish, keep the water clean, and ensure enough oxygen.
- Disinfect the pond or tank with potassium permanganate ($KMnO_4$) at 2–3 mg per liter for 1 hour.
- Treat infected fish with a bath of copper sulfate ($CuSO_4$) at 0.5–1 mg per liter for 1 hour (only if water hardness is above 50 ppm).
- Provide medicated feed containing oxytetracycline at 50-75 mg per kg of fish body weight daily for 7-10 days.

iii. Streptococcosis

It is a fish disease caused by a harmful bacteria called Streptococcus iniae. It mostly affects young fish, such as fry and fingerlings of carps, tilapia, and rainbow trout. This disease is more common in winter and can kill 30-50% of the affected fish. Infected fish may swim in circles, lose balance, or develop cloudy eyes and red spots on the body. If not treated, it spreads quickly and causes heavy losses in fish farms.

Figure: Streptococcosis disease

Symptoms

- Swollen or bulging eyes (pop-eye).
- Darkened body color and loss of natural shine.
- Swimming in circles or upside down.
- Loss of appetite and weak, slow movements.

Control Measures

- Remove sick fish and keep the water clean with good oxygen supply.
- Disinfect the pond or tank using potassium permanganate ($KMnO_4$) at 2 mg per liter for 1 hour.
- Give medicated feed containing oxytetracycline at 75 mg per kg of fish body weight daily for 10 days.
- Maintain good water quality and avoid sudden temperature changes to reduce stress.

iv. Cold water disease

It is caused by the bacteria Flavobacterium psychrophilum and usually affects young rainbow trout and salmon. It occurs mainly in winter, when the water is cold. This disease is especially dangerous for fry and fingerlings, as it can slow their growth, cause sores on their skin, and make them swim weakly. While the mortality is moderate, if not treated, it can still cause serious losses for fish farmers.

Figure: Cold water disease

Symptoms:

- White or pale patches on the skin, especially near the head, fins, or tail.

- Frayed or ragged fins that look damaged.
- Slow or weak swimming, often staying near the water surface or bottom.
- Loss of appetite and gradual weight loss

Control Measures

- Remove sick fish, keep the water clean, and maintain proper oxygen levels.
- Disinfect the pond or tank with potassium permanganate ($KMnO_4$) at 2 mg per liter of water for 1 hour.
- Feed medicated pellets containing oxytetracycline at 75 mg per kg of fish body weight daily for 10 days.
- Keep the water temperature stable and avoid sudden drops to prevent outbreaks.

v. Pseudomonas infection

It is a fish disease caused by a bacteria called *Pseudomonas anguilliseptica*. It mostly affects adult rainbow trout, especially during the summer months. The disease can lead to a moderate number of fish deaths if not treated properly. Understanding and preventing this infection is important for keeping fish healthy and safe in fish farms and natural waters.

Figure: Pseudomonas infection

Symptoms

- Red sores or ulcers on the skin and fins.
- Swollen belly caused by fluid build-up inside the body.

- Frayed fins that look torn or damaged.
- Weakness and slow swimming, often staying at the bottom.

Control Measures

- Remove sick fish, keep water clean, and ensure good oxygen supply.
- Disinfect the pond or tank with potassium permanganate ($KMnO_4$) at 2-3 mg per liter of water for 1 hour.
- Feed medicated pellets containing oxytetracycline at 75 mg per kg of fish body weight daily for 10 days.
- Maintain stable water quality and avoid overcrowding to reduce stress and spread of the disease.

2. Protozoan Diseases

i. White spot disease

It is a common fish illness caused by a tiny parasite called *Ichthyophthirius multifiliis*. It mostly affects young carps, especially the fry and fingerlings, during the cold winter months. The disease gets its name from the white spots that appear on the fish's body. While it usually doesn't cause many deaths, it can still make the fish weak and uncomfortable, so early treatment and care are important to keep them healthy.

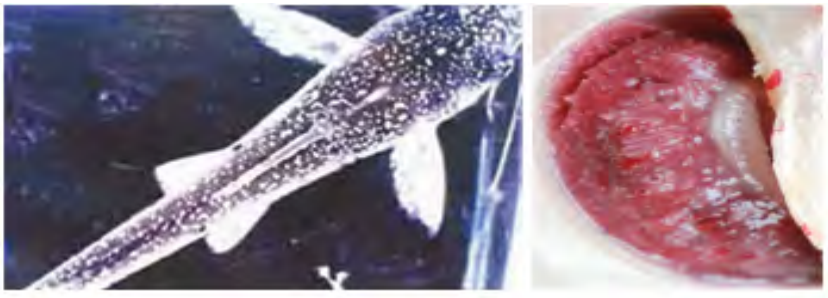


Figure: White spot disease

Symptoms

- Small white spots on the skin, fins, and gills, like grains of salt.
- Rubbing or scratching against objects due to irritation.

- Clamped fins held close to the body.
- Difficulty breathing and staying near the water surface.

Control measures

- Remove and isolate sick fish, improve water cleanliness, and maintain good oxygen levels.
- Treat the pond or tank with formalin at 25 mg per liter for 1 hour or malachite green at 0.1 mg per liter of water for 1 hour.
- Repeat treatment every other day for 3-4 times to kill all life stages of the parasite.
- Avoid sudden temperature drops and overcrowding to prevent future outbreaks.

ii. Trichodiniasis

It is a harmful fish disease caused by tiny parasites called *Trichodina* species. It mostly affects young fish like fry and fingerlings of carps, tilapia, pangas, and rainbow trout. This disease usually spreads between April and July. It can be very dangerous, especially for small fry seeds, and may cause high death rates if not treated quickly. Keeping water clean and watching the fish closely during this season helps prevent the disease.

Figure: Trichodiniasis

Symptoms

- Scratching or rubbing the body against objects due to irritation.
- Clamped fins held close to the body.

- Excess mucus on the skin, making the fish look cloudy or slimy.
- Weak swimming and loss of appetite.

Control measures

- Remove and isolate sick fish, keep water clean, and provide good oxygen levels.
- Treat the pond or tank with formalin at 25 mg per liter for 1 hour or potassium permanganate ($KMnO_4$) at 2 mg per liter of water for 1 hour.
- Repeat treatment after 3–4 days if parasites are still present.
- Avoid overcrowding and maintain good water quality to prevent re-infection.

iii. Whirling disease

It is a serious fish disease caused by a microscopic parasite called *Myxobolus cerebralis*. It mainly affects young fish from the salmonid family, such as trout and salmon. It also can be seen in carps too. Young fish are more likely to get sick, and the disease can happen in any season. Infected fish often swim in a whirling pattern, which gives the disease its name. If not controlled, it can cause high death rates in fish farms or natural waters.

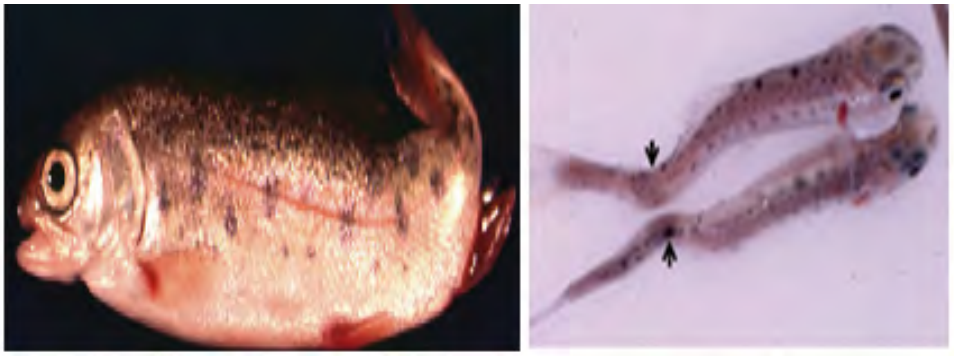


Figure: Whirling disease

Symptoms

- Fish swim in strange circles (whirling) instead of straight.
- Head or spine becomes bent or twisted.

- Tail becomes dark or black in color.
- Fish grow slowly and may become thin or weak.

Control Measures

- Remove and isolate sick fish, keep water clean, and provide good oxygen levels.
- Treat the pond or tank with formalin at 25 mg per liter for 1 hour or potassium permanganate ($KMnO_4$) at 2 mg per liter of water for 1 hour.
- Repeat treatment after 3–4 days if parasites are still present.
- Avoid overcrowding and maintain good water quality to prevent re-infection.

iv. Coccidiosis

It is a disease in fish caused by tiny parasites called *Eimeria*. These parasites can infect many types of fish, including tropical fishes and rainbow trout, and they affect fish of all ages. Outbreaks usually happen during the warmer months of May and June. Fortunately, this disease does not cause a high number of deaths, but it can still make fish weak and affect their health.

Figure: Coccidiosis disease

Symptoms

- Fish become weak and stop swimming actively.
- Fish eat less or stop eating.
- Swollen belly and body looks thin and weak.
- Diarrhea, sometimes bloody in severe cases.

Control Measures

- Remove and safely dispose of dead or heavily infected fish to stop spreading.
- Clean and dry the pond bottom or tank before restocking fish.
- Maintain clean, good-quality water and avoid overcrowding fish.
- Make formalin solution by applying 25 mg per liter of water and keep the fish in this treated water for 30–60 minutes.

3. Monogenean Diseases

i. Dactylogyrosis

It is also called gill flukes. It is a disease in fish caused by small flatworm parasites called *Dactylogyrus*. These parasites live on the gills of fish, making it hard for them to breathe. Carps, especially adult brood fish used for breeding, are more likely to get this disease. It usually appears in late autumn or early winter. Although it does not cause many fish to die, it can make them weak and less healthy.

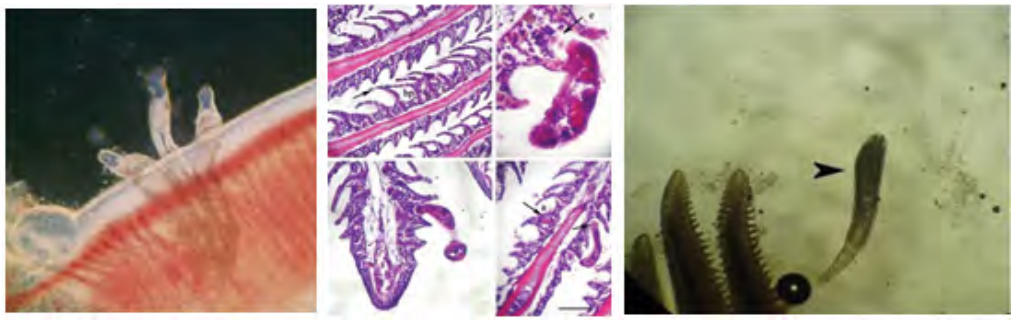


Figure: Dactylogyrosis infection

Symptoms

- Fish gasp for air at the water surface because they can't breathe well.
- Rapid movement of gills or swollen gills.
- Scratching body or gill area against objects.
- Loss of appetite and slow or weak swimming.

Control Measures

- Remove and safely dispose of dead or heavily infected fish to prevent spreading.
- Clean and dry the pond bottom or tank before restocking fish.
- Prepare formalin at 25 mg/L of water and keep fish in it for 30-60 minutes in a separate treatment tank to kill parasites.
- Keep pond water clean, maintain proper oxygen levels, and avoid overcrowding fish.

ii. Gyrodactylosis

It is also known as body flukes. It is a fish disease caused by tiny flatworm parasites called *Gyrodactylus*. They live on the skin and fins of fish, irritating them and making them less active. This disease is common in carps and sometimes affects rainbow trout, especially adult brood fish used for breeding. It usually appears in late autumn or early winter. Even though it rarely causes many deaths, it can still weaken fish and make them uncomfortable.

Figure: Gyrodactylosis infection

Symptoms

- Fish rub or scratch their body against objects.
- Red or irritated patches on the skin.
- Excess mucus on the skin, making fish look cloudy or slimy.
- Weak swimming and loss of appetite.

Control Measures

- Remove and safely dispose of dead or heavily infected fish to stop spreading.
- Clean and dry the pond bottom or tank before restocking fish.
- Prepare formalin at 25 mg/L of water and keep fish in it for 30-60 minutes in a separate treatment tank to kill parasites.
- Maintain clean water, avoid overcrowding, and keep fish stress-free.

4. Digenean Diseases

i. Metacercaria cysts

It is caused by small parasitic worms called *Diplostomum spp*. These parasites form tiny cysts inside the fish, which can affect their health and behavior. All kinds of fish can get this disease, but it is more common in adults. Outbreaks usually occur during June and July. Although it does not cause many fish to die, it can still make them weak and less active.

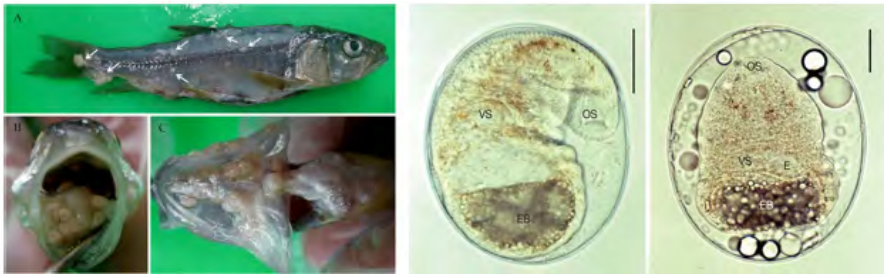


Figure: Metacercaria cysts in fish

Symptoms

- Small white cysts visible on skin, fins, or gills.
- Cloudy eyes or even blindness in severe cases.
- Fish swim slowly or lose balance.
- Weakness and loss of appetite.

Control Measures

- Remove and safely dispose of dead or heavily infected fish to stop the

disease from spreading.

- Dry and clean the pond bottom or tank before restocking fish.
- Prepare formalin at 25 mg/L of water and keep fish in it for 30-60 minutes in a separate treatment tank to kill the parasites.
- Keep pond water clean, prevent entry of infected snails or wild fish, and avoid overcrowding.

5. Cestodes and Helminth Diseases

i. Asian tapeworm

It is a fish disease caused by a long, ribbon-like parasite called *Bothriocephalus acheilognathi*. It lives inside the intestines of fish, stealing their food and causing weakness. This disease affects many fish, including common carp, bighead carp, grass carp, and goldfish, and it can infect both young fry and adult fish. Outbreaks mostly happen in summer, and because it can cause high death rates, it is considered a serious problem in fish farming.

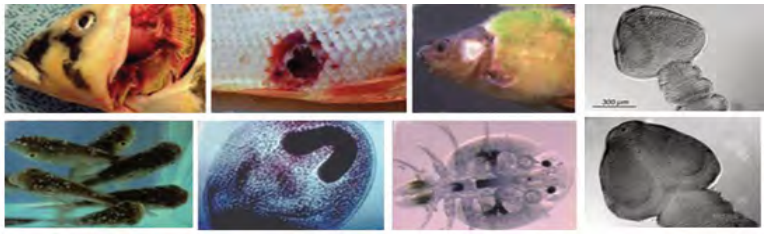


Figure: Asian tapeworm infection

Symptoms

- Fish become thin even though they are eating.
- Swollen belly in some cases.
- Weak swimming and gathering near the water surface.
- Loss of appetite and slow growth.

Control Measures

- Remove and safely dispose of dead or heavily infected fish to prevent spreading.

- Clean and dry the pond bottom or tank before restocking fish.
- Apply praziquantel at 2-10 mg/L of water in a separate treatment tank to kill the tapeworms.
- Maintain clean water, avoid overcrowding, and prevent feeding with infected live food.

ii. Piscicola infection

It is also known as fish leech disease. It is caused by a blood-sucking parasite called *Piscicola geometra*. These leeches attach to the skin or gills of fish and feed on their blood, which can make the fish weak and stressed. It affects fish like carps, trouts, and eels, mostly in adults. This disease is more common in summer. Although it rarely kills many fish, it can still cause health problems and make them more vulnerable to other diseases.

Figure: Piscicola infection

Symptoms

- Fish become weak and tired because the leeches suck their blood.
- Small dark or red spots appear on the skin or fins where leeches attach.
- Fish may scratch their bodies against stones or tank walls.
- Wounds or ulcers can form on the skin, which may get infected.

Control Measures

- Carefully remove visible leeches from fish by hand or with soft forceps, then treat the fish in a salt bath (common salt at 3% solution for 5-10 minutes).

- Move healthy fish to clean water and disinfect the pond/tank.
- Apply potassium permanganate at 2-3 mg per liter of water to kill remaining parasites in the water.
- Keep the pond water clean, and avoid overcrowding to reduce the chance of re-infection.

6. Crustacean Parasitic Diseases:

i. Argulosis

It is also called fish lice disease. It is caused by tiny crustacean parasites like *Argulus foliaceus* and *Argulus japonicum*. These parasites attach to the skin of fish and suck their blood, which can make the fish itchy, weak, and stressed. Almost all types of freshwater fish can be affected, but adult brood fish are more likely to get the disease. Outbreaks usually happen in the rainy season, and while it normally causes low death rates (about 5–10%), it can still harm fish health and growth.

Figure: Argulosis infection

Symptoms

- Fish scratch their bodies against stones, sticks, or pond walls because of irritation.
- Red spots or small wounds appear where the lice attach.
- Fish become weak, swim slowly, and lose appetite.
- Wounds may get infected, leading to more serious illness.

Control Measures

- Gently remove visible lice from infected fish with soft forceps and

immediately give them a 3% salt bath for 5–10 minutes.

- Shift treated fish to clean, fresh water to help them recover faster.
- Treat the pond or tank water with potassium permanganate at 2-3 mg per liter to kill remaining lice and their eggs.
- Keep pond water clean and avoid overcrowding fish to stop the disease from spreading again.

ii. Lerniasis

It is also called anchor worm disease. It is caused by a parasite named *Lernaea cyprinacea*. This parasite burrows into the skin and muscles of fish, causing wounds and irritation. It can affect many freshwater fish, especially those caught from the wild or raised in ponds, and is seen in both adult fish and fingerlings. Outbreaks usually occur from March to September. While the death rate is low (about 5-10%), the disease can still harm fish health, slow their growth, and make them more prone to other infections.

Figure: Lerniasis infection

Symptoms

- Long, thin, worm-like parasites sticking out from the fish's skin.
- Redness, sores, or wounds around the infected area.
- Fish rubbing or scratching themselves on objects.
- Weakness, reduced swimming activity, and loss of appetite.

Control Measures

- Carefully remove visible worms from infected fish using clean tweezers, then place the fish in clean water.

- Disinfect the pond or tank water with potassium permanganate ($KMnO_4$) at 2-3 mg per liter to kill remaining parasites and eggs.
- If infection is heavy, treat fish with a salt bath (2% salt solution for 5-10 minutes) to weaken and remove parasites.
- Regularly clean and maintain the pond/tank to prevent parasite build-up and stop re-infection.

7. Mycotic/Fungal Diseases

i. Saprolegniasis

It is a fungal disease in fish caused by water molds such as *Saprolegnia parasitica*, *Saprolegnia diclina*, and *Achlya hoferi*. It can infect all kinds of freshwater fish and even their eggs. This disease is more common in winter when the water is cold, and it usually appears as white or gray cotton-like growths on the skin, gills, or eggs. While it may not always cause high death rates, it can seriously damage fish health and reduce the survival of fish eggs.

Figure: Saprolegniasis infection

Symptoms

- Cotton-like white or gray patches on the skin, gills, or fins.
- Damaged or decaying skin and fins.
- Fish becoming weak and less active.
- Loss of appetite and slow movement.

Control Measures

- Gently remove the visible cotton-like fungus from infected areas using clean, soft tools and place the fish in clean water.

- Treat infected fish with a salt bath (2-3% salt solution for 5-10 minutes) to kill fungal spores.
- Disinfect the pond/tank water using malachite green at 0.1-0.2 mg per liter or potassium permanganate at 2-3 mg per liter of water to stop fungal growth.
- Keep the pond/tank clean, remove dead fish or decaying matter quickly, and avoid overcrowding to prevent the disease from spreading.

ii. Branchiomycosis

It is also called gill rot, is a serious fish disease caused by fungi such as *Branchiomyces demigrans* and *Branchiomyces sanguinis*. These fungi infect the gills of fish, making it hard for them to breathe. It mainly affects tilapia, common carp, and rainbow trout, especially adults. Outbreaks often happen in late summer and can be very dangerous, with death rates reaching 30–50%. This makes it an important disease to control in fish farms to prevent heavy losses.

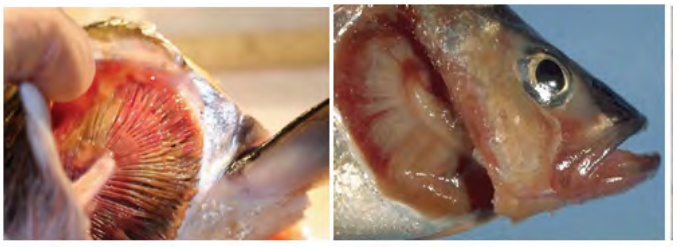


Figure: Branchiomycosis infection

Symptoms

- Gills become pale, brown, or rotten-looking.
- Fish gasp for air at the water surface due to breathing problems.
- Gills show patches of dead tissue and may have bad odor.
- Fish become weak, swim slowly, and may die suddenly.

Control Measures

- Immediately remove and isolate infected fish into clean, fresh water.
- Improve water quality by changing part of the pond/tank water and

increasing aeration to give fish more oxygen.

- Disinfect the water with copper sulfate at 0.5–1.0 mg per liter or potassium permanganate at 2-3 mg per liter of water to destroy fungal spores.
- Regularly clean the pond/tank, avoid overcrowding, and remove dead or sick fish quickly to stop the disease from spreading.

iii. Epizootic ulcerative syndrome

It is also known as mycotic granulomatosis or red spot disease, is a serious fish disease caused by water molds like *Aphanomyces invadans* and *Aphanomyces piscicida*. It affects many types of fish, including Indian major carps, catfish, brackish water fishes, and wild fish, and can occur in fish of all ages. The disease usually appears in winter and causes large red sores and ulcers on the fish's body. It is very dangerous because it has a high death rate, making it one of the most serious diseases for fish farmers.

Figure: Epizootic ulcerative syndrome infection

Symptoms

- Red patches or open ulcers (wounds) on the skin.
- Skin peeling or rotting around the sores.
- Fish becoming weak, thin, and slow in movement.
- Loss of appetite and staying near the pond/tank bottom.

Control Measures

- Remove infected fish and place them in clean, fresh water to stop the spread.
- Gently clean the wounds and improve water quality by changing part

of the water and increasing aeration.

- Disinfect pond/tank water with potassium permanganate at 2-3 mg per liter or malachite green at 0.1-0.2 mg per liter of water to kill the fungus.
- Keep the pond/tank clean, remove dead or sick fish quickly, and avoid overcrowding to prevent new infections.

iv. Aspergillosis

It is a fungal disease in fish caused by fungi like *Aspergillus fumigatus*, *A. niger*, and *A. sydowii*. It mainly affects adult fish such as Indian major carps, Puntius, and Rainbow trout. This disease usually appears in February and March. Although it does not cause many deaths, it can still weaken the fish, affect their health, and make them more vulnerable to other infections.

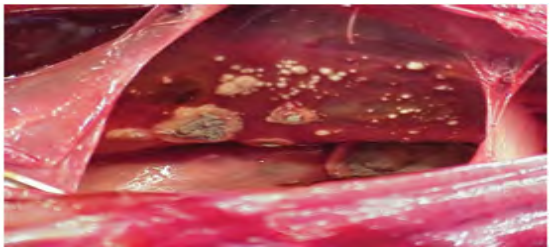


Figure: Aspergillosis infection

Symptoms

- Black, green, or gray mold-like patches on skin, gills, or fins.
- Difficulty breathing, often with gill damage.
- Weakness, reduced swimming, and staying near surface or bottom.
- Loss of appetite and gradual weight loss.

Control Measures

- Remove infected fish and place them in clean, fresh water to prevent spreading.
- Change part of the pond/tank water and increase aeration to improve water quality.

- Disinfect water with malachite green at 0.1–0.2 mg per liter or potassium permanganate at 2-3 mg per liter of water to kill fungal spores.
- Clean the pond/tank regularly, remove dead fish immediately, and never feed spoiled or moldy feed.

B. Non-Infectious diseases: Non-infectious diseases are not caused by germs, so they do not spread from one fish to another. These diseases usually happen because of bad water quality, poor nutrition, physical injuries, or sudden changes in temperature or environment.

Nutritional Disease

i. Scoliosis and lordosis

These are deformities in fish caused by a lack of protein in their diet. These conditions make the spine of fry and fingerlings bend abnormally, affecting their shape and swimming ability. All types of fish can be affected, especially those that need a high-protein diet. This problem can occur in any season, but it usually does not cause many deaths. However, it can reduce the growth and overall health of the fish.

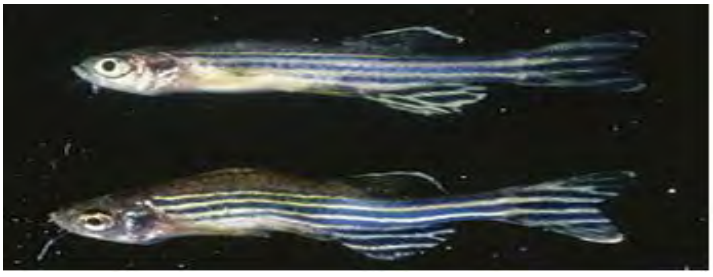


Figure: Scoliosis and lordosis

Symptoms

- Fish body bending to the side (scoliosis) or forming an upward/ downward curve (lordosis).
- Difficulty swimming in a straight line.
- Reduced growth and weaker body.
- Loss of appetite and low energy.

Control Measures

- Separate affected fish into a clean pond/tank to reduce stress and avoid competition for food.
- Improve water quality by changing part of the water and ensuring enough oxygen.
- Provide a balanced, protein-rich diet containing at least 35–40% good-quality protein to prevent and correct deficiencies.
- Keep the pond/tank clean and avoid overcrowding so fish can feed properly and grow healthy.

ii. Malnutrition

It occurs when fish do not get enough food or the right nutrients in their diet. It can affect all types of fish, at any age, and in any season. Although it usually does not cause many deaths, malnutrition can make fish weak, slow their growth, and reduce their ability to fight off other diseases. Providing a balanced diet is important to keep fish healthy and strong.

Figure: Malnutrition in fish

Symptom

- Fish grow very slowly and remain smaller than normal.
- Their body looks thin and weak, with poor muscle development.
- Fins may fray and colours look dull or faded.
- Fish become tired easily and may swim slowly or irregularly.

Control Measures

- Provide a balanced diet containing the right amount of protein, vitamins,

and minerals for that species.

- Give fresh, good-quality feed in the correct quantity, 2-3 times daily, and remove leftover feed to keep water clean.
- Improve pond conditions by maintaining good water quality (pH 6.5–8.5, dissolved oxygen above 5 mg/L).
- If vitamin or mineral deficiency is suspected, mix vitamin-mineral premix in feed at 5-10 g per kg of feed until recovery.

Environmental Disease:

i. Gas Bubble Disease

It is caused when pond water contains too many dissolved gases, like oxygen or nitrogen. These gases form bubbles inside the fish's body, especially in juveniles, which can block blood vessels and damage organs. All types of fish can be affected, and this can occur in any season. The disease causes moderate deaths, and fish may show signs like floating near the surface or struggling to swim properly. Proper pond management can help prevent this problem.

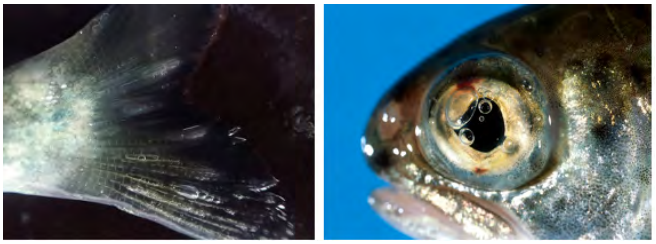


Figure: Gas bubble disease

Symptoms

- Small air bubbles appear under the fish's skin, fins, or inside the eyes.
- Fish swim in an unbalanced or zigzag way.
- Gills look swollen and fish breathe heavily.
- Fish may suddenly die without showing long sickness signs.

Control Measures

- Avoid sudden filling of pond with deep-well or cold water that contains

too much dissolved oxygen.

- Let the water stand or splash it to release extra gases before use.
- Keep water movement with aerators or splashing so gases can escape naturally.
- Maintain dissolved oxygen within safe range (5–8 mg/L).
- In emergency cases, partially replace pond water and add common salt (NaCl) at 2-3 g per litre to reduce stress on fish.

ii. Fish hypoxia

It occurs when the oxygen level in water suddenly drops, leaving fish unable to breathe properly. This can affect all types of fish at any age and can happen in any season. When oxygen is very low, fish may gasp at the water surface, become weak, and die. The mortality can be moderate to high, making it a serious problem for ponds and fish farms. Maintaining good water quality is important to prevent this disease.

Figure: Hypoxia in fish

Symptoms

- Fish gather near the water surface, gasping for air.
- Slow or weak swimming.
- Loss of appetite.
- Sudden death, especially early morning.

Control Measures

- Use aerators or splash water to quickly add oxygen.
- Avoid overfeeding and remove leftover feed to keep water clean.

- Keep oxygen level above 5 mg/L.
- In emergency, add potassium permanganate at 2-4 mg/L to reduce organic waste and improve oxygen.
- Change part of the pond water with clean, oxygen-rich water.

Exercise

Choose the correct answer from the given alternatives.

1. _____ in fish farming refers to the practice of cultivating only a single species of fish.

   a. Polyculture b. Monoculture

   c. Aquaculture d. Integrated farming

2. Tilapia is the _____ most widely farmed fish globally.

   a. first b. second c. third d. fourth

3. Pangasius is commonly known as _____.

   a. Salmon b. Trout c. Striped catfish d. Goldfish

4. _____ is a common bacterial disease that affects fish fins.

   a. Ich b. Dropsy c. Fin rot d. EUS

5. _____ is a fungal disease often characterized by white, cotton-like patches on fish.

   a. Branchiomycosis b. Saprolegniosis

   c. VHS d. Costiasis

6. _____ is a serious viral disease that can cause hemorrhages in fish.

   a. VHS b. EUS c. Ich d. Dropsy

7. In _____, two or more different species of fish are raised together in the same pond.

   a. Monoculture b. Polyculture

   c. Aquaculture d. Integrated farming

8. _____ can be used to treat some fungal infections in fish.

   a. Malachite green b. Copper sulfate

   c. Both a) and b) d. None of the above

9. _____ is a common symptom observed in fish suffering from dropsy.
   a. Pinecone-like appearance of scales
   b. White spots on the body
   c. Rapid gill movement
   d. Loss of appetite

Write short answer to the following questions.

1. What are the main advantages of monoculture in fish farming?
2. List two major disadvantages of tilapia farming.
3. What are the benefits of polyculture in fish farming?
4. Mention five common signs of fish diseases.
5. What are the main causes of bacterial diseases in fish?

Write long answer to the following questions.

1. Discuss the advantages and disadvantages of monoculture in fish farming with specific examples of different fish species.
2. Explain the concept of polyculture in fish farming and its importance in sustainable aquaculture.
3. List the common signs, causes, and control measures of tail rot and fin rot in fish.
4. Discuss the different types of parasitic diseases that can affect fish, including their symptoms and methods of control.
5. Explain the importance of biosecurity measures in preventing the spread of fish diseases.

Project Work

Survey the area with commercially cultivated fish farms, collect a list of the fish species they raise together, along with the reasons for their selection, and prepare a report to present in the classroom.

Unit 6

Fish Preservation and Marketing

6.1 Harvesting Method

Fish harvesting means catching fish from natural places like rivers, lakes, and oceans or from fish farms where they are raised. This process is very important because it gives us food to eat and supports the fishing industry. It also helps many people make a living, including fishers, farmers, and workers who process, sell, and transport fish.

Fish harvesting can be done in various ways, but two popular methods for catching wild fish are active and passive harvesting techniques which are described below:

Passive method

Passive methods of fish harvesting involve placing tools in the water and waiting for fish to get caught naturally. One common method is the use of gillnets, vertical nets designed to trap fish by their gills when they swim into them. Another is longlines, which consist of a single line with multiple baited hooks, often used to catch fish in deep-sea areas. Additionally, traps and pots are stationary structures that lure fish inside and prevent them from escaping, making them an effective and low-effort way to harvest fish.

Active method

Active methods of fish harvesting involve actively moving equipment or tools to catch fish. Trawling is a common technique where a large net is dragged through the water, capturing fish along its path. Another method is seining, which uses a large net to encircle and capture entire schools of fish efficiently. For smaller-scale or traditional fishing, handlines and rods are used, involving a single line

and hook to catch fish one at a time. These methods require more effort but are highly effective, especially for targeted fishing.

Similarly, fish farming employs specific harvesting methods, with the two main approaches being partial harvesting and complete harvesting which are described below:

Partial Harvesting

Partial Harvesting involves selectively removing a portion of the fish population, typically targeting the larger or more mature fish, while leaving the smaller ones to continue growing. This approach is especially useful for meeting market demands for fresh fish without fully depleting the pond or tank. By allowing the remaining fish to grow further, it helps maintain a steady supply and ensures better utilization of the available resources. Common tools for partial harvesting include seine nets, which sweep through the pond to catch fish, and cast nets, thrown over a targeted area to trap fish efficiently. This method is economical, sustainable, and often preferred by farmers looking to balance immediate income with long-term production.

Complete Harvesting

Complete harvesting happens when all the fish are removed from a pond or tank at the end of their growth cycle. The pond is carefully drained, making it easier to collect every fish that has been raised. This method is used when the fish have grown to the desired size and are ready for sale or consumption. To make the process faster and more efficient, farmers often use seine nets, which are large nets that sweep through the water to gather the remaining fish. Complete harvesting is an important step in fish farming, showing the farmer's hard work and the pond's ability to produce a healthy supply of fish.

6.2 Use of Ice for Fish Transport

After harvesting fish must be placed on ice immediately to prevent spoilage. Harmfull microorganisms in the fish multiply rapidly in the room temperature. This can lead to lose its flavor, texture, and safety for consumption. Proper icing

techniques are crucial for maintaining quality during transport. Fish are typically layered with crushed ice in insulated containers. The ice-to-fish ratio should be in 1:1 to keep the fish completely surrounded. For longer transport distances, block ice or gel packs may be used as they last longer and provide steady cooling. Fish stored on ice can remain fresh for 1-2 days. This depends on factors like the type of fish (fattier fish spoil faster), temperature and the amount of ice used. Insulated containers made of materials like Styrofoam or specialized plastics helps to maintain low temperatures. This helps to prevent heat from entering inside and slowing down the melting of ice which helps to increase the shelf-life the fish during transportation.

Under ideal conditions, fish stored on ice can remain fresh for 1–2 days. However, this depends on factors like the type of fish (fattier fish spoil faster), ambient temperature, and the amount of ice used. Insulated containers made of materials like Styrofoam or specialized plastics help maintain low temperatures by preventing heat from entering and slowing down the melting of ice. Proper hygiene, including clean utensils, regular handwashing, and avoiding cross-contamination, is also essential to keep fish safe for consumption. Additionally, using ice efficiently and exploring alternatives like refrigerated trucks can reduce environmental impact, ensuring a sustainable approach to fish transport.

6.3 Fish Packaging Method

Packaging fish is essential for keeping it fresh, safe, and appealing. Proper packaging helps preserve the fish by slowing spoilage caused by bacteria, mold, and oxidation. It also prevents the fish from drying out or becoming too moist. Packaging protects fish from damage during transport, keeps it at the right temperature, and ensures safe handling for consumers. Additionally, attractive packaging can enhance the product's visual appeal and build trust in the brand. Common fish packaging methods can be categorized into traditional and modern techniques which are described below:

In Nepal, traditional methods of packaging fish are designed to preserve fish for long periods without refrigeration. These methods are simple, cost-effective, and

suitable for local environments. Smoking, sun-drying, and salt curing are three traditional methods of preserving fish, each with its own packaging techniques to ensure the fish stays fresh. After smoking, the fish absorbs a distinct smoky flavor and its moisture content is reduced to about 15–20%, making it less likely to spoil. Once smoked, the fish is typically stored in paper bags, cloth bags, or sometimes hung for display. These packaging options help maintain the fish's quality while allowing for proper air circulation. The antimicrobial properties of the smoke also work to keep the fish fresh for months, making it an ideal preservation method for both local and commercial use.

Similarly, sun-drying is an easy and effective method for preserving fish, especially in sunny regions. The process involves cleaning the fish and spreading it out on drying racks or mats under the sun. The fish is regularly turned to ensure it dries evenly, reducing its moisture content to about 10–15%. Once fully dried, the fish is stored in cloth bags or woven bamboo baskets, which allow airflow to prevent mold and maintain its freshness. When kept in a cool, dry place, sun-dried fish can last for several months, offering a sustainable and long-lasting source of food.

In the same way, salt curing is another ancient method where fish is cleaned and rubbed with salt, which draws out moisture and inhibits bacterial growth. Typically, about 20–30% of the fish's weight is used in salt for effective curing. This reduces the moisture content of the fish to about 15–25%, depending on the curing time. Once cured, the fish is packed in bamboo baskets or earthenware pots, which are convenient for transport and help preserve freshness. This method allows fish to be stored for several weeks to months without refrigeration, offering both practicality and enhanced flavor. These traditional preservation techniques, alongside thoughtful packaging, have provided reliable solutions for storing fish for extended periods.

Similarly, Modern techniques of fish packaging have revolutionized the way fish is preserved and transported, ensuring it reaches consumers fresh and safe to eat. These advanced methods go beyond traditional techniques, focusing on

extending shelf life, maintaining quality, and preventing spoilage. The different modern techniques for fish packaging are described below:

Ice Packing

Ice Packing is a simple yet highly effective method for preserving fish immediately after harvesting. In this process, freshly caught fish is packed with crushed or block ice in insulated containers, such as Styrofoam boxes. These containers are designed to minimize heat exchange, ensuring that the low temperature is maintained for as long as possible. Crushed ice is often preferred because it provides maximum surface contact with the fish, allowing for rapid and uniform cooling. This is particularly important for maintaining the fish's freshness by slowing down bacterial growth and enzymatic activity. Block ice, on the other hand, melts more slowly and is often used for longer transport times or when ice supplies need to last longer.

Ice packing is especially suited for short-distance transport, keeping fish fresh for 1–2 days when maintained at temperatures close to 0°C (32°F). It helps retain the fish's natural texture, flavor, and appearance, making it a widely used method in local markets, fishing boats, and small-scale distribution networks. The effectiveness of ice packing depends on using a sufficient amount of ice to completely surround the fish, ensuring consistent cooling. The containers must be kept clean and properly sealed to prevent contamination and avoid ice melt mixing with the fish. This method is cost-effective and widely accessible, making it a popular choice in many parts of the world. However, it is best suited for short-term preservation, as the melting ice needs regular replenishment for extended transport or storage durations.

Vacuum Packaging

Vacuum Packaging is a modern and highly effective method for preserving fish. In this process, fish is placed in durable plastic bags, and the air inside the bag is completely removed using a vacuum sealer. The bag is then tightly sealed, creating a protective, oxygen-free environment around the fish. By eliminating oxygen, vacuum packaging significantly reduces the growth of bacteria and

slows down spoilage, which helps extend the fish's shelf life to 5-7 days when kept at refrigerated temperatures (0-4°C). This method also prevents freezer burn if the fish is frozen, ensuring it retains its original flavor, texture, and nutrients for longer. Vacuum packaging is convenient for both transport and storage, as the tightly sealed bags are compact and leak-proof. Additionally, this method minimizes the need for preservatives, making it a healthier and more natural option for preserving fish. Vacuum-sealed fish is also easy to label and store, making it a preferred choice for both commercial sellers and consumers.

Modified Atmosphere Packaging (MAP)

Modified Atmosphere Packaging (MAP) is an advanced method used to extend the freshness and shelf life of fish. In this process, the air inside the packaging is replaced with a carefully chosen mixture of gases, such as carbon dioxide (CO_2), nitrogen (N_2), and sometimes oxygen (O_2). Each gas serves a specific purpose in preserving the fish: Carbon Dioxide (CO_2) inhibits the growth of bacteria and molds, reducing spoilage. Nitrogen (N_2) acts as a filler gas to replace oxygen and prevent the package from collapsing, maintaining its shape and protecting the fish and Oxygen (O_2) may be included in small amounts for certain fish products to maintain a bright, natural color.

This controlled atmosphere slows down microbial activity, oxidation, and enzymatic reactions, which are the primary causes of spoilage. Fish packaged using MAP can stay fresh for 7–10 days when stored at refrigerated temperatures (0 to 4°C). MAP not only preserves the fish's flavor, texture, and appearance but also reduces the risk of contamination by creating a sealed environment. It is widely used in supermarkets and food industries for packaging. Additionally, MAP packaging is often transparent, allowing consumers to see the quality of the product while ensuring long-lasting freshness.

Canning

Canned Fish is a highly durable and convenient method for preserving fish for long periods. In this process, fish is first cleaned and often pre-cooked or partially cooked a process called retort sterilization. It is then packed into airtight metal

cans, which are usually made of tin-plated steel or aluminum. These cans are then sealed to create a completely enclosed environment that prevents the entry of air, bacteria, and contaminants.

One of the key advantages of canned fish is its extended shelf life, which can range from several months to multiple years when stored at room temperature. This makes it an ideal solution for areas without access to refrigeration and for emergency food supplies. Additionally, the canning process locks in nutrients, retaining much of the fish's protein, vitamins, and omega-3 fatty acids. Canned fish can be consumed directly from the can or used in various recipes, from salads to sandwiches and casseroles. The packaging is robust, easy to stack, and transport, making it a popular choice in both domestic and international markets.

6.4 Fish Transportation Method

Fish transportation is an important process that ensures fish stays fresh as it moves from the place where it is caught to where it is sold. The journey from the fishing grounds to the markets needs careful attention to keep the fish in good condition. It's important to keep the fish at the right temperature, reduce stress on the fish, and stop it from spoiling. Over time, different methods, like using ice or special refrigerated trucks, have been used to make sure the fish stays fresh. This process is important not only for providing a healthy food source but also for supporting the jobs of people in related on fishing or fish farming.

In Nepal, there are several traditional methods of transporting fish, which have been used for many years, especially in rural and remote areas. These methods are adapted to the local environment and help transport fish to markets or other places for consumption. Some of the popular traditional methods of fish transportation are described below:

Human Porterage

In remote mountain areas, people carry fish in baskets or bamboo containers on foot or by bicycle. This method is common in places where there are no roads, and it helps get fish to places that are difficult to reach by other means.

Animal Transport

In areas with tough terrain, animals like donkeys, mules, or yaks are used to carry fish. These animals help transport fish over mountains and rough paths, where vehicles cannot reach.

River Transport

In some regions, fish are transported using traditional boats or rafts on rivers and streams. This is especially useful in areas where rivers serve as the main route for moving goods, including fish.

As technology has advanced, Nepal and other countries have started using modern methods for fish transportation. These methods help preserve the freshness of the fish and ensure that it reaches the market in the best condition. The different modern methods of fish transportation are described below:

Refrigerated Trucks

In modern fish transportation, refrigerated trucks are commonly used. These trucks are equipped with cooling systems that keep the fish at the right temperature, preventing spoilage. This method allows fish to be transported over long distances without losing quality.

Ice Packaging

Another modern technique is the use of ice to pack fish. Crushed ice or block ice is used to keep the fish cold during transportation. This is a simple but effective way to maintain the freshness of the fish, especially during short-distance travel.

Air Transport

For fish that need to be transported over very long distances or internationally, air transport is often used. Special cool storage units are used in airplanes to keep fish fresh while it is being transported to other countries or faraway places.

Refrigerated Shipping Containers

On a global scale, refrigerated shipping containers (also known as "reefers") are used for transporting large quantities of fish across oceans. These containers are

equipped with cooling systems and ensure that fish remains fresh during the long journey.

6.4.1 Live Fish Transportation in Nepal

In recent years, live fish markets have started gaining popularity in major urban areas of Nepal. Live fish are kept for sale in large aquariums or cemented tanks equipped with oxygenation systems to ensure their health and freshness. This method appeals to consumers who prefer fresh fish and are willing to pay higher prices for quality products.

Transporting live fish to markets, especially over long distances, is a meticulous process that requires specialized equipment and careful handling to ensure the fish remain healthy and fresh. Live fish are transported in plastic tanks with a water capacity of 200-1000 liters, depending on the vehicle size, with holding up to 75 kilograms of fish. These tanks are equipped with oxygen supply systems, either using cylinders and diffusers or battery-powered aerators, to maintain adequate oxygen levels. Before transport, fish are conditioned for approximately six hours, which helps minimize stress and reduce the risk of physical injury during the journey. Additionally, specially designed trucks or vans are utilized, featuring fish-holding tanks, water circulation pumps, and aeration devices to maintain optimal conditions throughout the trip. This careful process ensures the delivery of high-quality live fish to markets, meeting consumer demands for freshness.

Transporting live fish comes with significant challenges and costs. The process is expensive due to the need for specialized equipment, such as oxygenation systems, aerators, and water tanks. Infrastructure issues, like poor road conditions and unreliable transport, especially during certain seasons, add to the complexity. Economically, live fish transport is often feasible only in urban areas where consumers value and can afford to pay higher prices for fresh fish. In rural markets, this method becomes less practical unless large volumes of fish are transported to offset the high costs and make the process more efficient.

Besides various challenges, live fish markets have gained significant popularity in Nepal over the past decade, driven by growing awareness of the health and nutritional benefits of fresh fish. These markets allow consumers to see and select live fish, ensuring superior quality and freshness. By embracing modern methods of live fish transportation and sales, Nepal is transforming its fish marketing system to meet the increasing demand for fresh fish, especially in urban centers. This innovative approach not only enhances consumer satisfaction but also supports fish farmers, fostering the growth of the aquaculture sector and contributing to the country's food security and economic development.

Exercise

Choose the correct answer from the given alternatives.

1. _____ harvesting involves actively moving equipment or tools to catch fish.

   a. Passive b. Active c. Selective d. Partial

2. Partial harvesting involves _____ removing a portion of the fish population.

   a. Complete b. Selectively c. Active d. Passive

3. _____ is crucial for maintaining fish freshness during transport by slowing down bacterial growth.

   a. Drying b. Freezing c. Icing d. Smoking

4. Vacuum packaging involves _____ air from the package, significantly reducing bacterial growth.

   a. Removing b. Adding c. Heating d. Cooling

5. _____ packaging involves replacing air with a mixture of gases like carbon dioxide and nitrogen.

   a. Vacuum b. Modified Atmosphere

   c. Ice d. Canning

6. Refrigerated trucks are equipped with cooling systems to maintain the _____ temperature for fish during transport.

   a. High b. Low c. Room d. Variable

7. _____ transport is used for long-distance transportation of fish, especially internationally.

   a. Road b. Rail c. Air d. Sea

8. _____ systems are essential for maintaining adequate oxygen levels for live fish during transport.

a. Heating b. Cooling

c. Oxygenation d. Filtration

9. Conditioning fish _____ transport helps minimize stress and reduce the risk of injury.

a. After b. Before

c. During d. Between

Write short answer to the following questions.

1. What are the two main methods of fish harvesting? Briefly explain each.
2. What are the advantages of using ice for fish transport?
3. Mention two traditional methods of fish packaging in Nepal.
4. What is the significance of modified atmosphere packaging (MAP) for fish?
5. What are the challenges of transporting live fish in Nepal?

Write long answer to the following questions.

1. Discuss the different methods of fish harvesting, highlighting the advantages and disadvantages of each.
2. Explain the importance of proper fish packaging in maintaining quality and safety. Elaborate on different modern packaging techniques.
3. Describe the various methods of fish transportation in Nepal, both traditional and modern. Analyze the impact of modern transportation methods on the fish industry.
4. Discuss the challenges and opportunities associated with the growing popularity of live fish markets in Nepal.
5. How does fish transportation contribute to the economic and social development of a region?

Project Work

1. Design a simple and effective method for transporting fish from a local pond to a nearby market using readily available materials at home. You can either build a physical model by creating a small prototype using household items such as bottles, buckets, or cardboard, or develop a visual design by drawing or sketching your method, complete with labeled parts and explanations of how it works.
2. Explore your community to learn about the traditional methods of transporting fish. Collect information, write a report, and present your findings in class.

Reference