



Principles of Systematics

ZOO511P

PRACTICAL MANUAL

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Practical # 1

Phylum Porifera

INTRODUCTION

The poriferans are commonly known as sponges. They play a crucial role in aquatic ecosystem.

DISTINGUISHING CHARACTERS

- ♦ Simplest and primitive organisms
- ♦ First multicellular animals
- ♦ Porous body structure
- ♦ Cellular level of body organization
- ♦ Sessile and benthic organisms

GENERAL CHARACTERISTICS

1. Body Structure:

Porifera are the simplest type of multicellular animals. They are sessile and lack true tissues and organs.

2. Porous structure:

They consist of a porous body covered in tiny openings called ostia, through which water is drawn.

3. Water Canal System:

Water flows through the sponge's body, facilitated by specialized cells called choanocytes which flow out through large opening called osculum.

4. Skeleton:

Skeleton consists of spongin fibres and siliceous or calcareous spicules.

5. Nutrition:

They show holozoic nutrition which involves absorbing or ingesting solid organic food particles from water.

6. Reproduction:

They reproduce either sexually by releasing male and female gametes into the water and asexually by budding. They have also capability of regeneration

7. Classification:

This phylum contains three main classes;

- a. Class Demospongiae
- b. Class Calcarea
- c. Class Hexactinellida

Examples: *Spongia*, *Sycon* and *Grantia*.

Spongia officinalis

CLASSIFICATION

Phylum: Porifera

Class: Demospongiae

Order: Dictyoceratida

Family: Spongiidae

GENERAL CHARACTERISTICS

1. *Spongia* is commonly called as “Bath Sponge”.
2. It is light grey to black in color.
3. It grows in massive, globular lobes with fine openings which are slightly elevated and have cone-shaped voids (conules).
4. **Oscula can** either be scattered or at the tip of the lobes.
5. It has a network of canals and chambers.
6. It consists of ectosomal skeleton and choanosomal skeleton.
7. The choanocytes lining the canals create water currents that bring in food particles, which are then captured and digested.
8. Body is composed of spongin fibres and inclusions such as sand grains and spicules.

HABIT AND HABITAT

Spongia officinalis is typically found in shallow marine environments, attached to rocks or other substrates. It thrives in regions with moderate water currents, allowing it to efficiently filter water for nutrients.



Figure shows the specimen of *Spongia officinalis*

Practical # 2

Phylum Cnidaria

INTRODUCTION

Phylum Cnidaria (previously Phylum Coelenterata means hollow cavity) are named due to presence of cnidocytes in their body.

DISTINGUISHING CHARACTERS

- ♦ Radially symmetrical
- ♦ Acoelomate (Absence of body cavity)
- ♦ Cnidocytes / nematocyst or stinging cells are present
- ♦ Diploblastic and tissue level of body organization
- ♦ Polymorphic; one is polyp form and other is medusa

GENERAL CHARACTERISTICS

1. Body structure:

Cnidarians are characterized by radial symmetry, which means their bodies are organized around a central point. Some are bilateral symmetrical.

2. Body organization:

They are diploblastic and exhibit a simple body plan, with a sac-like structure known as the gastrovascular cavity in which a jelly-like mesoglea is present.

3. Predation and Defense:

They possess specialized stinging cells called cnidocytes or nematocyst, used for both predation and defense.

4. Polymorphism:

They are polymorphic, one is polyp form and other is medusa. Most of the species possess alternation of generation (means change from one form to another throughout their life cycle).

5. Nervous system:

Nervous system consists of a network of nerve cells throughout the body.

6. Reproduction:

Reproduction occurs by both asexually and sexually.

7. Habit and Habitat:

They are either solitary or colonial lives in shallow water or in benthic region.

8. Classification:

They are classified into three classes;

- a. Class Hydrozoa
- b. Class Scyphozoa
- c. Class Anthozoa

Examples: *Hydra, Physalia, Alcyonium, Aurelia, Fungia and Porpita.*

Chrysaora fuscescens

CLASSIFICATION

Phylum: Cnidaria

Class: Scyphozoa

Order: Semaestomeae

Family: Pelagiidae

GENERAL CHARACTERISTICS

1. *Chrysaora fuscescens* is commonly called as “Pacific Sea Nettle”.
2. The Pacific Sea Nettle boasts a bell-shaped body with long, flowing tentacles.
3. Medusa is plate-like structure in which eight (8) lobes are present. Each lobe consists of a tentaculocyst.
4. Mouth is present in the center which opens into gullet.
5. The tentacles are lined with stinging cells.
6. The stinging cells, or cnidocytes are equipped with tiny harpoon-like structures that inject venom into prey or potential threats.

HABIT AND HABITAT

Chrysaora fuscescens is often found in the Pacific Ocean, particularly along the western coast of North America. It inhabits both coastal and open waters, displaying its elegant tentacles and bell.

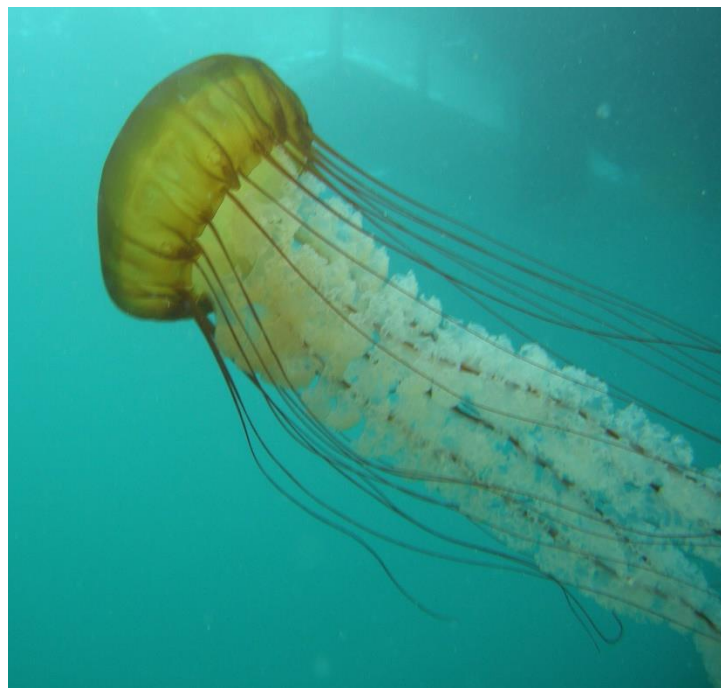


Figure shows the specimen of *Chrysaora fuscescens*

Practical # 3

Phylum Platyhelminthes

INTRODUCTION

The members/animals of Phylum Platyhelminthes are commonly known as flatworms due to the presence of flattened body plan. This Phylum contains free-living and parasitic species.

DISTINGUISHING CHARACTERS

- ◆ Flat and thin bodies
- ◆ Acoelomate (Absence of body cavity)
- ◆ Diffusion occurs as Respiratory and Circulatory system is absent
- ◆ Presence of Eyespot
- ◆ Presence of Flame Cells and protonephridia (bundles of flame cells) for Excretion.
- ◆ Mostly Flatworms are parasitic in nature

GENERAL CHARACTERISTICS

1. Body structure:

Their Bodies are flat and thin so commonly known as flatworms. They are dorsoventrally smoothed and flattened. They have a definite posterior end and anterior end.

2. Coelom or Body cavity:

The body cavity or coelom is absent in the members of Phylum Platyhelminthes. Therefore, they belong to the Group Acoelomates.

3. Symmetry:

Flatworms are Symmetrical Animals having Bilateral Symmetry so belong to Grade Bilateria under Sub-Kingdom Eumetazoa.

4. Cellular organization:

These are multicellular animals in which cells combine to form tissues, organs and organ systems. They have muscles, excretory, reproductive and digestive systems. But respiratory and circulatory systems are absent in the animals belonging to Phylum Platyhelminthes.

5. Germ Layers:

Flatworms are Triploblastic Animals having three Germ Layers (Ectoderm, Mesoderm & Endoderm).

6. Transport or Circulatory System:

As respiratory and circulatory systems are absent in these animals so Diffusion is used to pass oxygen and other substances cell to cell.

7. Sensory or Nervous System:

Their sensory system is formed by a nerve net. They have eyespots that are light-sensitive at the foremost end.

8. Mode of Nutrition or Digestive System:

A few flatworms are parasites. Others exist as free-living scroungers or carnivores. Most flatworms (e.g., *Planaria*) have a gastrovascular cavity rather than a complete digestive system. In such animals, the “mouth” is also used to expel waste materials from the digestive system. Some species also have an anal opening. The gut may be a simple sac or highly branched.

9. Excretion or Excretory System:

Excretory system consisting network of interconnecting canals. They also have particular flame cells (have flame like appearance due to presence of cilia) to dispose of the waste.

10. Reproduction:

Most flatworm species are monoecious/bisexuals/hermaphrodite (having both the male and female reproductive organs (Gonads) in the same individual). Fertilization is typically internal. Asexual reproduction is common in some groups.

11. Habit and Habitat:

The most members of Phylum Platyhelminthes are freshwater species found in lakes, ponds, streams, and springs. This Phylum contains free-living and parasitic species.

12. Classification and Examples:

They are classified into three classes;

- a. Class Cestoda (e.g., Tapeworm)

- b. Class Trematoda (e.g., Fluke)
- c. Class Turbellaria (e.g., Free living *Planaria*)

Taenia saginata

CLASSIFICATION

Phylum: Platyhelminthes

Class: Cestoda

Order: Cyclophyllidea

Family: Taeniidae

GENERAL CHARACTERISTICS

1. *Taenia saginata* is commonly known as 'Beef Tapeworm'. It is a parasitic tapeworm is associated with cattle.
2. The body is ribbon-shaped and composed of segments called proglottids.
3. The head is present at the anterior side contains 'hooks' for the attachment to the host body.
4. The segments contain reproductive structures, allowing for the production of thousands of eggs.
5. The tapeworm absorbs nutrients directly through its body wall.
6. As it is parasite in nature therefore it does not contain digestive system.

HABIT AND HABITAT

Taenia saginata is commonly found in the small intestines of humans. It completes its lifecycle by involving cattle as intermediate hosts. The tapeworm's eggs are ingested by cattle, leading to larval development in their muscles.

It cause a disease 'taeniasis' in human and therefore it has a significant medical and veterinary importance.

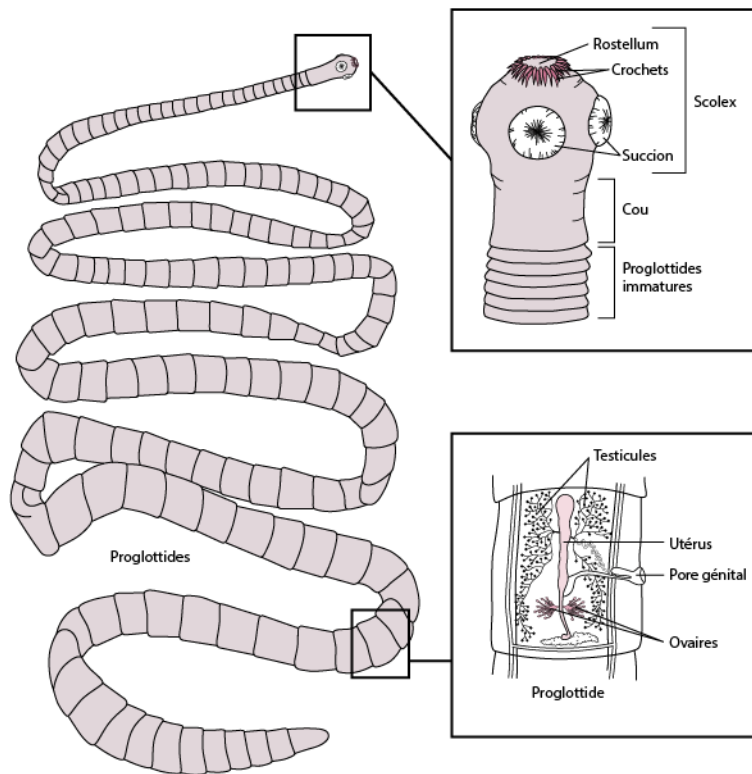


Figure shows the specimen of *Taenia saginata*

Practical # 4

Phylum Rotifera

INTRODUCTION

Phylum Rotifera comprises a diverse group of tiny aquatic animals known as rotifers (Roti means 'wheel' and fera means 'bearer'). They are microscopic, multicellular, and aquatic organisms.

DISTINGUISHING CHARACTERS

- ◆ Pseudo-coelomate metazoans (false body cavity)
- ◆ A ring or **crown of cilia** present around the head
- ◆ Digestive system complete
- ◆ **Dioecious** or sexual dimorphism present
- ◆ Some species reproduce by **parthenogenesis**

GENERAL CHARACTERISTICS

1. Body structure:

They possess a crown of cilia known as the corona, which they use both for locomotion and to generate water currents that bring in food. Their bodies are protected with an external layer of chitin or cuticle. The body is externally but not internally segmented.

2. Body size:

They are multicellular and microscopic. Most species of rotifers are about 200 to 500 micrometers long

3. Coelom or Body cavity:

They are pseudocoelomate animals with body cavities that are partially lined by mesoderm.

4. Nutrition and Digestive system:

They are filter feeders and omnivorous. They have complete digestive tract that includes both a mouth and anus.

5. Reproduction:

They have separate genders and their reproduction is sexual. A few animal categories contain just females which reproduce their daughters from unfertilized eggs by parthenogenesis.

6. Diversity and Distribution:

About 2,200 species of rotifers have been identified worldwide.

7. Habit and Habitat:

Rotifers are aquatic animals and can be found in many freshwater environments and in moist soil or in thin films of water that are formed around soil particles.

They inhabit in still water environments, such as lake bottoms, as well as flowing water environments, such as rivers or streams.

They are also commonly found on mosses and lichens growing on tree trunks and rocks, in rain gutters and puddles, in soil or leaf litter, on mushrooms growing near dead trees or in tanks of sewage treatment plants.

8. Classification:

They are classified into three classes;

- a. Class Monogononta
- b. Class Bdelloidea
- c. Class Seisonidea

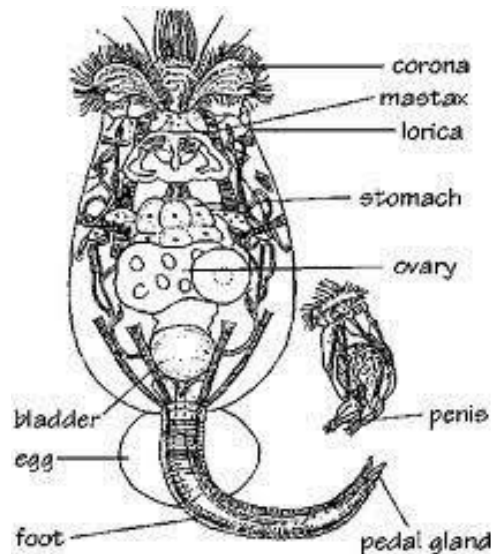


Figure shows the structure of Rotifera specimen

Brachionus plicatilis

CLASSIFICATION

Phylum: Rotifera

Class: Monogononta

Order: Ploima

Family: Brachionidae

GENERAL CHARACTERISTICS

1. The body of is bilaterally symmetrical, with a specialized structure known as the **mastax**. The **mastax** houses a jaw-like structure called the trophi, which is used to **grind food particles**.
2. It is a small zooplankton approximately **0.3 mm** in length.
3. The eyespot is present to detect the light intensity.
4. **It is euryhaline** and can tolerate the extreme salinity range.
5. It reproduces either asexually or sexually, and has one of the highest population growth rate among metazoans.

HABIT AND HABITAT

Brachionus plicatilis is known for its wide distribution, ranging from freshwater ponds and lakes to coastal marine waters. It thrives in environments rich in organic matter, where it feeds on various microorganisms.

ECONOMIC IMPORTANCE

Brachionus plicatilis is possibly the only commercially important rotifer, being raised in the aquaculture industry as food for fish larvae.



Figure shows the specimen of *Brachionus plicatilis*

Practical # 5

Phylum Nematoda

INTRODUCTION

The members of Phylum Nematoda (Greek word nema that means "thread") are commonly known as 'Round worms'. It is a diverse group of organisms found in every environment and habitat.

DISTINGUISHING CHARACTERS

- ◆ Bilateral symmetrical
- ◆ Triploblastic
- ◆ Pseudo-coelomate
- ◆ Thick body covering by cuticle
- ◆ Alimentary canal distinct
- ◆ Dioecious or sexual dimorphism present

GENERAL CHARACTERISTICS

1. Body structure and size:

Nematodes have elongated, cylindrical and unsegmented body with pointed ends. Head is not prominent but mouth is present with 6 lips (two sub-dorsal, two sub-ventral and two lateral lip). One species of parasitic nematode can reach up to 13 meters in length.

2. Body covering:

The epidermis secretes a thick outer cuticle which is both tough and flexible and protects from harsh environmental conditions.

3. Nervous system:

Nervous system consists of a nerve net. The ventral nerve has a series of nerve centers along its length, and both nerves connect to a nerve ring and additional nerve centers located near the head. The head contains a few tiny sense organs.

4. Digestive system:

Digestive system complete with distinct alimentary canal which starts from mouth and contains pharynx, esophagus and gut.

5. Excretory system:

The excretory system is not well developed in nematodes. An excretory pore is located in mid-ventral line close to the nerve ring.

6. **Reproduction:**

Sexes are separate. Usually male is smaller than the female in size. Sexual reproduction occurs. Fertilization is internal either by cross-fertilization or self-fertilization.

7. **Habit and Habitat:**

They are abundant, aquatic or terrestrial, parasitic or free-living. Free-living nematodes are extremely abundant in soils and sediments, where they feed on bacteria and detritus.

8. **Diversity:**

About 15,000 known species of roundworms have been reported worldwide.

9. **Classification:**

They are classified into three classes;

- a. Class Rhabditea
- b. Class Enoplea
- c. Class Chromadorea

Ascaris lumbricoides

CLASSIFICATION

Phylum: Nematoda

Class: Chromadorea

Order: Ascaridida

Family: Ascarididae

GENERAL CHARACTERISTICS

1. The body of is bilaterally symmetrical, cylindrical and tapered at both ends, resembling a tube.
2. The body wall comprises of three layers namely the outer cuticle, middle epidermis and inner longitudinal muscles.
3. Males are 2–4 mm (0.08–0.2 in) in diameter and 15–31 cm (5.9–12 in) long.
4. The male's posterior end is curved ventrally and has a bluntly pointed tail. Females are 3–6 mm (0.1–0.2 in) wide and 20–49 cm (7.9–19 in) long.
5. It possesses a muscular pharynx used for feeding and a complex reproductive system.

HABIT AND HABITAT

Ascaris lumbricoides primarily inhabits the human small intestine. This parasitic roundworm has a significant impact on human health and is one of the most common human parasites.

LIFE CYCLE AND PATHOGENECITY

The life cycle of *Ascaris lumbricoides* involves both human hosts and soil as intermediate hosts. The eggs are shed in human feces and can persist in the environment, leading to potential transmission.

Infections caused by *Ascaris* can lead to a condition known as ascariasis. Symptoms may include abdominal discomfort and nutrient deficiencies.



Figure shows the specimen of *Ascaris lumbricoides* (Female)



Figure shows the specimen of *Ascaris lumbricoides* (Male)

Practical # 6

Phylum Mollusca

INTRODUCTION

Phylum Mollusca are unsegmented soft bodied organisms, usually covered by a protective shell. It is the second largest phylum after Arthropoda.

DISTINGUISHING CHARACTERS

- ♦ Soft body which has a mantle
- ♦ Presence of radula which is a rasp-like scraping organ used in feeding
- ♦ Specialized foot used in digging, grasping, or creeping
- ♦ Some categories have calcareous shell on their body
- ♦ Body has visceral mass

GENERAL CHARACTERISTICS

1. Body structure:

Body consists of head, foot, mantle and visceral mass.

2. Skeleton:

They consists of outer calcareous shell, secreted by the mantle cavity.

3. Locomotion:

Locomotion occurs by a muscular foot or in some species by tentacles.

4. Circulatory system:

The circulatory system is open type contains hemolymph.

5. Respiration:

Respiration occurs through gills which has osphradium on its base whereas through lungs in terrestrial species.

6. Excretion:

The excretory organ is metanephridia which filters waste from internal body fluid.

7. Reproduction:

Sexes are separate. Some species are bisexual. Fertilization either internal or external. Development is direct or through metamorphosis. Larva is called veliger.

8. Habit and Habitat:

Molluscs are found in nearly all freshwater and marine environments, and some are found also on land.

9. Diversity:

Approximately, 80,000 – 100,000 species have been identified and reported worldwide.

10. Classification:

They are classified into seven classes;

- a. Class Aplacophora
- b. Class Monoplacophora
- c. Class Polyplacophora
- d. Class Bivalvia
- e. Class Gastropoda
- f. Class Cephalopoda
- g. Class Scaphopoda

Octopus vulgaris

CLASSIFICATION

Phylum: Mollusca

Class: Cephalopoda

Order: Octopoda

Family: Octopodidae

GENERAL CHARACTERISTICS

1. The body lacks a protective shell, making it highly flexible and allowing for agile movement.
2. It has an advanced nervous system and intense eyesight contribute to its exceptional ability to interact with its surroundings.
3. It grows up to 1 meter with arms and weigh up to 9 kg.
4. Mating may become cannibalistic.
5. It possesses venom to subdue its prey.
6. They have evolved to have large nervous systems and brains.

HABIT AND HABITAT

Octopus vulgaris inhabits various coastal and deep-sea environments, displaying a range of behaviors that showcase their complex problem-solving skills, camouflage abilities, and hunting strategies.

INTELLIGENCE AND ECOLOGICAL ROLE

Octopus vulgaris is renowned for its intelligence and ability to solve puzzles, manipulate objects, and exhibit complex behaviors.

They play a vital role in marine ecosystems as predators, contributing to the balance of marine food webs.



Figure shows the specimen of *Octopus vulgaris*

Practical # 7

Phylum Annelida

INTRODUCTION

Phylum Annelida (comes from a Latin word annellus, which means a small ring) encompasses a diverse group of segmented worms that inhabit various terrestrial and aquatic environments.

DISTINGUISHING CHARACTERS

- ◆ Metamerically segmented body
- ◆ Bilateral symmetrical
- ◆ Triploblastic
- ◆ Coelomate
- ◆ Organ system grade of body organization
- ◆ Body is covered with a thin cuticle

GENERAL CHARACTERISTICS

1. Body structure and size:

The elongated vermiform body consists of distinct or indistinct head or prostomium and trunk. The microscopically small eyes are scattered over the body. The clitellum, a saddle-shaped thickening of the body wall, is present at sexual maturity. The anus is at the posterior tip. The length of annelids varies from a fraction of an inch to more than six meters (about 20 feet). The width may exceed 2.5 centimeters (about one inch) in the contracted state.

2. Metamerism:

They are metamerically segmented worm-like organisms which means each body segment has complete organ system. The external segments can be seen as a ring-like structure along the body which are divided by an inter-segmental septa.

3. Locomotion:

Each segment contains two or more setae, bristles or parapodia for locomotion. Setae generally arise from the ventral (lower) surface of the body.

4. Circulatory system:

The closed circulatory system is present and some species has hemoglobin in their blood.

5. Respiration:

Respiration occurs through general body surface. Some species has respiratory gills.

6. Nervous system:

Nervous system consists of cerebral ganglia on dorsal side whereas, audible connectives are present at the ventro-median side of the body.

7. Excretion:

Excretion occurs through nephridia.

8. Reproduction:

They are dioecious. Sexual reproduction occurs and fertilization is Segmentation allows regeneration.

9. Habit and Habitat:

Annelids can be found in terrestrial, marine, and freshwater ecosystems.

10. Diversity:

Approximately, 16,500 known species of annelids have been reported worldwide.

11. Classification:

They are classified into three classes;

- a. Class Polychaeta
- b. Class Oligochaeta
- c. Class Hirudinea

Amyntas mekongianus

CLASSIFICATION

Phylum: Annelida

Class: Oligochaeta

Order: Opisthopora

Family: Megascolecidae

GENERAL CHARACTERISTICS

1. The body is segmented into distinct regions.
2. It possesses a specialized muscular structure known as the clitellum, which plays a key role in reproduction.

3. It respire through their moist skin, allowing for gas exchange.
4. It may grow to a length of up to 2.9 m (10 ft). This specimen was recorded one metre long and 8mm (0.3 in) wide.
5. It reproduces through cross-fertilization, involving the exchange of sperm between individuals.

HABIT AND HABITAT

Amyntas mekongianus is commonly found in soil environments, where it contributes to soil aeration and nutrient enrichment through its burrowing activities. They feed on organic matter, processing it through their digestive system. The worms may be collected from the mud, but are more easily collected from underwater at depths around 40 cm.

ECOLOGICAL SIGNIFICANCE

Earthworms enhance soil structure, water infiltration, and nutrient cycling, making them vital contributors to ecosystems.



Figure shows the specimen of *Amyntas mekongianus*

Practical # 8

Phylum Arthropoda

INTRODUCTION

Phylum Arthropoda (Greek word árthron, which means “joint,” and poda means “legs”) which comprises a huge number of species with a tremendous diversity of forms and habits.

DISTINGUISHING CHARACTERS

- ◆ Bilateral symmetrical
- ◆ Body cavity is true coelom called ‘hemocoel’
- ◆ Jointed appendages
- ◆ Highly developed sense organs
- ◆ Exoskeleton made up of chitin
- ◆ Open circulatory system

GENERAL CHARACTERISTICS

1. Body structure:

The body is divided into head, thorax and abdomen and covered by a thick cuticle which is called ‘exoskeleton’. Body segments consist of paired appendages.

2. Muscular system:

It consists of striped muscles.

3. Digestive system:

The alimentary canal is complete. The mouth is present at the anterior end whereas anus is present at the posterior end.

4. Respiration:

Respiration occurs through gills in aquatic organisms whereas in terrestrial organisms, it occurs through trachea or book lungs.

5. Vascular system:

The open circulatory system consists of a dorsal heart and blood vessels throughout the body.

6. Excretion:

Excretion occurs through coelomoduct, malpighian tubules, green glands and coxal glands.

7. Reproduction:

Sexes are separate. Sexual dimorphism is present in various forms. Fertilization is internal. Larval development occurs through metamorphosis.

8. Habit and Habitat:

They live in the widest range of habitats and eat the greatest varieties of food. They can be found in terrestrial, aerial, parasitic, marine and freshwater ecosystems.

10. Diversity:

This phylum contains about 85% of all creatures. There are over 30 million species of arthropods identified and described worldwide.

11. Classification:

They are classified into 7 sub-phylums;

- a. Trilobitomorpha
- b. Tardigerada
- c. Pentastomida or Linguatulida
- d. Pycnogonida or Pantopoda
- e. Onychophora
- f. Chelicerata
- g. Mandibulata

Plexippus petersi

CLASSIFICATION

Phylum: Arthropoda

Sub-phylum: Chelicerata

Class: Arachnida

Order: Araneae

Family: Salticidae

GENERAL CHARACTERISTICS

1. They are commonly known as “Jumping Spiders”.
2. The body is compact, with eight legs and a cephalothorax. The body size is about 10mm.
3. The head bears four pairs of eyes, one pair is larger than the others.
4. The cephalothorax is longer than it is wide and is brown with two darker reddish-brown bands on the dorsal surface is segmented into distinct regions.
5. It engage in intricate courtship behaviors, with males often performing elaborate displays to attract females.

HABIT AND HABITAT

Plexippus petersi can be found in various environments, from grasslands to gardens. These agile hunters use their remarkable jumping ability to pounce on prey. They are native to Asia and introduced to Africa and Pacific islands.

ECOLOGICAL SIGNIFICANCE

They play an important role in controlling insect populations and contributing to the food web.



Figure shows the specimen of *Plexippus petersi*

Practical # 9

Phylum Echinodermata

INTRODUCTION

Phylum Echinodermata (Greek word 'Echinos' means "spine" and derma means "skin") are exclusively marine organisms having spiny body surface.

DISTINGUISHING CHARACTERS

- ◆ Radial and penta-radial symmetrical
- ◆ Spiny body surface
- ◆ Water vascular system
- ◆ Calcified endoskeleton
- ◆ Benthic

GENERAL CHARACTERISTICS

1. Body structure:

They are radially symmetrical but bilateral symmetrical in their larval or juvenile stage. They are coelomate and triploblastic animals. The body is divided into oral and aboral surface. Head and body segments are not prominent.

2. Ambulacral system:

Water vascular system or ambulacral system consists of a groove or furrow bordered by large spines extending along the oral surface from which tube feet project through the body wall. This is a hydraulically controlled system consisting of a circumoral ring around the esophagus with connecting radial canals each leading to an ambulacrum.

3. Locomotion:

Tube feet are used for locomotion. Tube feet are small, delicate projections attached along the side of a water-filled tube called a radial canal which extend through the small holes in the skeleton to the outside.

4. Respiration:

Respiration occurs through simple diffusion, using gills or specialized projections, like tube feet or pockets, to circulate water and oxygen through their bodies.

5. Excretion:

They lack specialized excretory organs and so nitrogenous wastes chiefly in the form of ammonia, diffuses out through the respiratory surfaces.

6. **Reproduction:**

Reproduction occurs either asexually or sexually. Asexual reproduction occurs by regeneration. They are usually unisexual. Fertilization is external. Some species are viviparous.

7. **Habit and Habitat:**

They are well known as coastal dwellers, they can be found at depths over three miles deep (5,000 meters).

8. **Diversity:**

Approximately, 7000 species has described in every ocean.

9. **Classification:**

They are classified into five classes;

- a. Class Asteroidea
- b. Class Crinoidea
- c. Class Echinoidea
- d. Class Holothuroidea
- e. Class Ophiuroidea

Astropecten aranciacus

CLASSIFICATION

Phylum: Echinodermata

Class: Asteroidea

Order: Paxillosida

Family: Astropectinidae

GENERAL CHARACTERISTICS

1. It is commonly known as star fish or sea star.
2. The body is characterized by its five arms radiating from a central disc.
3. Its tube feet are equipped with suction cups that aid in movement and prey capture.
4. The mouth is located on its underside.
5. It is usually measured up to 30cm in size.

HABIT AND HABITAT

Astropecten aranciacus is commonly found in the Mediterranean Sea, where it inhabits sandy or muddy substrates. These sea stars use their tube feet to glide gracefully along the seafloor and capture prey with their unique feeding strategy.

FEEDING AND ECOLOGICAL ROLE

They feed on a diet of small invertebrates and detritus, using its tube feet and unique stomach eversion technique. They play a vital role in marine ecosystems by controlling populations and cycling nutrients.



Figure shows the specimen of *Astropecten aranciacus*

Practical no. 10

Preparation of Keys for the identification of Specimens

What is a Dichotomous Key?

Dichotomous Key is a method used to identify a species by answering a series of questions based on contrasting features (e.g.: physical characteristics) that have two possible outcomes.

“Dichotomous” means divided into two parts, hence the dichotomous keys always present two choices based on the key characteristics of the organism in each step. By correctly selecting the right choice at each stage, the user will be able to identify the name of the organism at the end. The further you divide the key, the more you learn about the specimen you are trying to identify.

When creating a dichotomous key, both qualitative (i.e. physical attributes such as how the organism looks, what color it is, etc.) and quantitative (i.e. the number of legs, weight, height, etc.) factors are considered.

It can be done in both a graphical (as a branching flowchart) or written format (series of paired statements organized sequentially). Most often, they are used to identify plant and animal species, although it can be used to classify any object that can be identified by a set of observable characteristics.

Uses of Dichotomous Key

A dichotomous key is usually used for

- i. **Identifying and categorizing organisms**
- ii. Helping students easily understand harder scientific concepts
- iii. Organizing large amounts of information to make identification of an organism much easier

Steps to Design/Create Dichotomous Key

Below we have listed the steps you need to follow when creating a dichotomous key.

Step 1: List down the characteristics

Pay attention to the specimens you are trying to identify with your dichotomous key. List down the characteristics that you can notice. For example, say you are trying to classify a group of animals. You may notice that some have feathers whereas others have legs, or some have long tails and others don't.

Step 2: Organize the characteristics in order

When creating your dichotomous key, you need to start with the most general characteristics first, before moving to the more specific ones. So it helps to have identified the more obvious and less obvious contrasting characteristics among the specimen before creating your dichotomous key.

Step 3: Divide the specimens

You can use statements (i.e. has feathers and no feathers) or questions (does it have feathers?) to divide your specimens into two groups. The first differentiation should be made on the most general characteristic.

Step 4: Divide the specimen even further

Based on the next contrasting characteristic, divide the specimen further. For example, first, you may have grouped your animals as have feathers and have no feathers, in which case the ones with feathers can be categorized as birds while you can further subdivide the ones that have no feathers as having fur and having no fur. Continue to subdivide your specimen by asking enough questions until you have identified and named all of them.

Step 5: Draw a dichotomous key diagram

You can either create a text-based dichotomous key or a graphical one where you can even use images of the specimen you are trying to identify. Here you can use a tree diagram or a flowchart as in the examples below.

Step 6: Test it out

Once you have completed your dichotomous key, test it out to see if it works. Focus on the specimen you are trying to identify and go through the questions in your dichotomous tree to see if you get it identified at the end. If you think the questions in your dichotomous key needs to be rearranged, make the necessary adjustments.

Best practices to keep in mind

- ❖ Consider only one characteristic at a time
- ❖ Use morphological or observable characteristics as much as you can.
- ❖ Use major characteristics when dividing the organisms in the beginning and use lesser or less obvious characteristics to divide them into smaller groups.
- ❖ When writing contrasting statements, rely on similar word formats (i.e. have feathers and don't have feathers).
- ❖ Be specific in your statements and avoid repeating the same characteristics
- ❖ Use questions that lead to yes or no answers rather than statements

To draw connections between species to better establish evolutionary connections use a Phylogenetic Tree Maker.

Practical no. 11

Methods of statistical analysis of samples from population T-test

T-Test-A type of Parametric Test

A t-test can only be used when comparing the means of two groups (pairwise comparison).

If you want to compare more than two groups, or if you want to do multiple pairwise comparisons, use an ANOVA test or a post-hoc test.

Assumptions of T-Test

The t-test assumes your data:

1. are independent
2. are (approximately) normally distributed.
3. have a similar amount of variance within each group being compared (a.k.a. homogeneity of variance)

If your data do not fit these assumptions, you can try a nonparametric alternative to the t-test, such as the Wilcoxon Signed-Rank test for data with unequal variances.

Types of T-Tests

When choosing a t-test, you will need to consider two things: whether the groups being compared come from a single population or two different populations, and whether you want to test the difference in a specific direction.

There are three types of T-Tests: -

1. One-Sample T-Test

If there is one group being compared against a standard value (e.g., comparing the acidity of a liquid to a neutral pH of 7), perform a one-sample t-test.

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$

where $\bar{x}$ is the sample mean, μ is the population mean, S is the sample standard deviation, and n is the sample size.

2. Two-Sample T-Test/Independent T-Test

If the groups come from two different populations (e.g., two different species, or people from two separate cities), perform a two-sample t-test (a.k.a. independent t-test).

The t-test equation for equal variances is:

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{s_p \sqrt{1/n_1 + 1/n_2}}$$

where $\bar{x}_1$ is the mean of the first sample, $\bar{x}_2$ is the mean of the second sample, S_p is the pooled standard deviation, n_1 is the sample size of the first sample, and n_2 is the sample size of the second sample.

3. Paired T-Test

If the groups come from a single population (e.g., measuring before and after an experimental treatment), perform a paired t-test. Once all of the values are known, the test statistic formula for paired t-tests can be used to find the t-value:

$$t = \frac{\bar{x}_{diff} - 0}{s_{diff} / \sqrt{n}}$$

Where $\bar{x}_{diff}$ is the sample mean of the differences, S_{diff} is the sample standard deviation of the differences, and n is the sample size.

Example (One-Sample t-Test)

Perform a one-sample t-test for data with a sample mean of 93, population mean of 86, sample standard deviation of 4.2, and sample size of 12. Use a significance level of $\alpha = 0.05$

Substituting these values into the t-score formula produces:

$$t = \frac{\bar{x} - \mu}{s / \sqrt{n}}$$

$$\frac{93-86}{4.2/\sqrt{12}} = 5.77$$

To calculate the critical t-score, recall that the alpha value is 0.05, and the degrees of freedom are equal to $n - 1 = 12 - 1 = 11$

According to the t-table, the critical t-score for a 0.05 significance level and 11 degrees of freedom is 1.796.

Comparing the calculated t-score and the critical t-score, we see that $5.77 > 1.796$, which means that the sample mean is significantly different than the population mean.

Practical no.12

Methods of statistical analysis of samples from Analysis of Variance (ANOVA).

Analysis of variance

Analysis of variance (ANOVA) is a statistical technique that is used to check if the means of two or more groups are significantly different from each other. ANOVA checks the impact of one or more factors by comparing the means of different samples.

- Analysis of variance (ANOVA) is a technique used to compare means of more than two samples.
- This technique can be used only for numerical data as it is a parametric test.”

Assumptions

- Number of samples must be more than two.
- Data should be normally distributed.
- Samples must be independent.
- Homogeneity of variances.

Explanation by Example

Consider a scenario where we have three medical treatments for patients with similar diseases. Once we have the test results, one approach is to assume that the treatment which took the least time to cure the patients is the best among them. What if some of these patients had already been partially cured, or if any other medication was already working on them?

In order to make a confident and reliable decision, we will need evidence to support our approach. This is where the concept of ANOVA comes into play. A common approach to figuring out a reliable treatment method would be to analyze the days the patients took to

be cured. We can use a statistical technique to compare these three treatment samples and depict how different these samples are from one another. Such a technique, which compares the samples based on their means, is called ANOVA.

Another measure to compare the samples is called a t-test. When we have only two samples, t-test, and ANOVA give the same results. However, using a t-test would not be reliable in cases with more than 2 samples. If we conduct multiple t-tests for comparing more than two samples, it will have a compounded effect on the error rate of the result.

Analysis of variance (ANOVA) is a statistical technique used to check if the means of two or more groups are significantly different from each other. ANOVA checks the impact of one or more factors by comparing the means of different samples. We can use ANOVA to prove/disprove whether all the medication treatments were equally effective.

The ANOVA test is the initial step in analyzing factors that affect a given data set. Once the test is finished, an analyst performs additional testing on the methodical factors that measurably contribute to the data set's inconsistency.

F-Statistic (F-test)

The statistic that measures whether the means of different samples are significantly different is called the F-Ratio. The lower the F-Ratio, the more similar will the sample means be. In that case, we cannot reject the null hypothesis.

$F = \text{Between-group variability} / \text{Within-group variability}$

The ANOVA test allows a comparison of more than two groups at the same time to determine whether a relationship exists between them. The result of the ANOVA formula, the F statistic (also called the F-ratio), allows for the analysis of multiple groups of data to determine the variability between samples and within samples. If no real difference exists between the tested groups, which is called the null hypothesis, the result of the ANOVA's F-ratio statistic will be close to 1.

Basic Concepts/Terms Used in Statistics/Statistical Analysis

Population Vs. Sample

A **population** is the entire group that you want to study/draw conclusions about. A **sample** is the specific group that you will collect data from. The size of the sample is always less than the total size of the population.

In research, a population doesn't always refer to people. It can mean a group containing elements of anything you want to study, such as objects, events, organizations, countries, species, organisms, etc.

In statistics, a population is a set of similar items or events which is of interest for some question or experiment. A statistical population can be a group of existing objects or a hypothetical and potentially infinite group of objects. While in statistics and quantitative research methodology, a sample is a set of individuals or objects collected or selected from a statistical population by a defined procedure.

Sample size

The number of individuals you should include in your sample depends on various factors, including the size and variability of the population and your research design. There are different sample size calculators and formulas depending on what you want to achieve with statistical analysis.

Example

If we are conducting a study on patients with cardiovascular diseases, it will be difficult to include the whole population of cardiovascular diseases all over the world. It is difficult to locate the whole population everywhere and to have access to all the population. Therefore, the practical approach in clinical research is to include a part of this population, called **"sample population"**. The whole population is sometimes called **"target population"** while the sample population is called **"study population"**. When doing a research study, we should

consider the sample to be representative to the target population, as much as possible, with the least possible error and without substitution or incompleteness.

Sampling methods

The process of selecting a sample population from the target population is called the “sampling method”.

There are two primary types of sampling methods that you can use in your research:

- **Probability sampling** involves random selection, allowing you to make strong statistical inferences about the whole group.
- **Non-probability sampling** involves non-random selection based on convenience or other criteria, allowing you to easily collect data.

Normal and Skewed data

Sr. #	Normal data	Skewed data
1	In normal data, values of means, median mode are equal.	In Skewed/ asymmetric data, values of means, median mode are Not equal.
2	Normal data follow a bell shape curve.	In skewed distribution one tail is larger than other as in above figure.
3	In normal data, most of the individual values are close to the mean of the data.	In skewed data, there is larger difference between individual values and mean values.
4	Extreme values are almost negligible in normal data.	Extreme values are higher in skewed data.
5	Values of standard deviation are less for normal data compared to skewed data.	Values of standard deviation are more for skewed data as compared to normal data.

6	Measure of central tendency for normal data is its mean value.	Measure of central tendency is its median for skewed data.
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Parametric tests

Parametric tests are used for Normal data. For measuring the degree of association between two quantitative variables, **Pearson's coefficient of correlation** is used in the parametric test.

Names of Different Parametric tests are as follows: -

1. T-test
2. Z-test
3. F-test
4. ANOVA
5. Regression
6. Correlation

Non-Parametric tests

Non-parametric tests for skewed data. For measuring the degree of association between two quantitative variables, **Spearman's rank correlation** is used in the non-parametric test.

Names of Different Non-Parametric tests are as follows: -

1. **Wilcoxon** Signed Rank Test
2. **Mann** Whitney U Test
3. **Kruskal**-Wallis test
4. Principal Component Test
5. Friedman Tests

Mean Vs. Grand Mean

Mean is a simple or arithmetic average of a range of values. There are two kinds of means that we use in ANOVA calculations, which are separate sample means and the grand mean. The grand mean is the mean of sample means or the mean of all observations combined, irrespective of the sample.

Hypothesis

A **hypothesis** is an educated guess about something in the world around us. It should be testable either by experiment or observation.

There are **two** types of hypothesis used in Statistical Tests (e.g., ANOVA)

1. **Null hypothesis**

The Null hypothesis in ANOVA is valid when all the sample means are **equal**, or they don't have any significant difference. Thus, they can be considered as a part of a larger set of the population.

In mathematical form, it can be represented as:

$$H_0: \mu_1 = \mu_2 \dots \dots \dots \mu_L \quad \text{Null hypothesis}$$

2. **Alternate hypothesis**

On the other hand, the alternate hypothesis is valid when at **least one of the sample means is different from the rest of the sample means**. In mathematical form, it can be represented as:

$$H_1: \mu_1 \neq \mu_2 \neq \dots \dots \dots \mu_L \quad \text{Alternative hypothesis}$$

Between-group variability

It refers to variations between the distributions of individual groups (or levels) as the values **within each group differ**. Each sample is examined, and the difference between its mean and grand mean is calculated to calculate the variability. If the distributions overlap or are close, the grand mean will be similar to the individual means, whereas if the distributions are far apart, the difference between means and grand mean would be large.

Within-group variability

The variations within a sample are denoted by Within-group variation. It refers to variations caused by differences within individual groups (or levels), as not all the values within each group are the same. Each sample is looked at on its own, and variability between the individual points in the sample is calculated.