PRACTICAL MANUAL

CLASSIFICATION OF INSECTS

3(2+1)

For M.Sc. (Ag.) Entomology

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Syllabus:

Practical

Study of Orders of insects and their identification using taxonomic keys. Keying out families of insects of different major orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and hymenoptera.

Field visit to collect insects of different Orders.

Name of Student .....

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Exercise no. 1.

Objective: To study about characters of Phylum Arthropoda.

Observation:

Arthropods were first studied by **Aristotle**. It is the largest phylum in the animal kingdom. **Von Siebold** coined the term Arthropoda.

It is derived from the Greek word *Arthos* = jointed; *podas* = legs. It constitutes the largest Phylum of animal Kingdom. At least 80 per cent of all known species of animals are arthropods. This phylum comprises invertebrate animals

General characters

1. Cosmopolitan in distribution found in aquatic, terrestrial and aerial forms. Some are ecto-parasitic and vectors of disease.
2. Body have jointed appendages or legs (which are modified to different structures to perform different functions like jaws, gills, walking legs, paddle). There may be 3 pairs, 4 pairs, 5 pairs, many pairs.
3. Body is triploblastic.
4. Bilaterally symmetrical.
5. Organ system level of organization.
6. Body is divisible into head, thorax and abdomen. **NOTE:** In some (crustacean and arachnids) body is divisible into cephalothorax (head and thorax is fused) and abdomen.
7. This is the first group to develop a true head, which contains sense organs and feeding organs specialized for their particular habitats.
8. Body is covered with chitinous exoskeleton.
9. They are haemocoelomate. Coelom i.e. body cavity is filled with blood or fluid.
10. Head bears a pair of compound eyes and antenna.
11. Locomotion takes place by jointed appendages.

12. Digestive system is complete, straight and well developed. The mouth bears mouth parts for ingestion of foods. Mouths are modified for chewing, biting, sponging, piercing, siphoning.
13. Respiration takes place by general body surface or gills (Crustaceans) or trachea (Insecta, Diplopoda and Chilopoda) or booklungs (Arachnida) and book gills.
14. Circulatory system is of open type i.e. do not have blood vessels and enters directly into the body chambers. The blood is colourless.
15. Excretion takes place through Malphigian tubules (in terrestrial form) or green glands or coxal glands (in aquatic forms).
    NOTE: Aquatic forms are ammonotelic, terrestrial forms are uricotelic.
16. Nervous system is of annelidian type, which consists of brain and ventral nerve cord.
17. Unisexual i.e. sexes are separate.
18. Fertilization is internal or external.
19. They are either oviparous or ovoviviparous.
20. Development may be direct or indirect.
21. Sensory organs include antennae, sensory hairs for touch and chemoreceptor, simple and compound eyes, auditory organs (in insects) and statocysts (in crustacean).

Phylum Arthropoda is divided in the following classes.

Class 1- Onychophora –

1. Terrestrial in habit
2. Body not divided into distinct regions.
3. One pair of antennae many pair of unjointed legs.
4. Breathing through trachea.
5. Example- *Peripatus.*

Class 2- Arachnida –

1. Body divided into cephalothoraxes (Persoma) and abdomen (opesthosoma).

2. Prosomatic appendages are one pair of chelicerae,
3. One pair of pedipalpi,
4. Four pairs of walking legs,
5. True jaws are absent,
6. Terrestrial or aquatic in habit
7. Example- Scorpion, spiders, ticks & mites.

Class 3- Crustacea –

1. Aquatic in habit
2. Body divides into cephalothoraxes and abdomen.
3. Two pairs of antennal and five pairs of walking legs.
4. Breathing through gills.
5. Example – Crab, Prawns.

Class 4- Chilopoda –

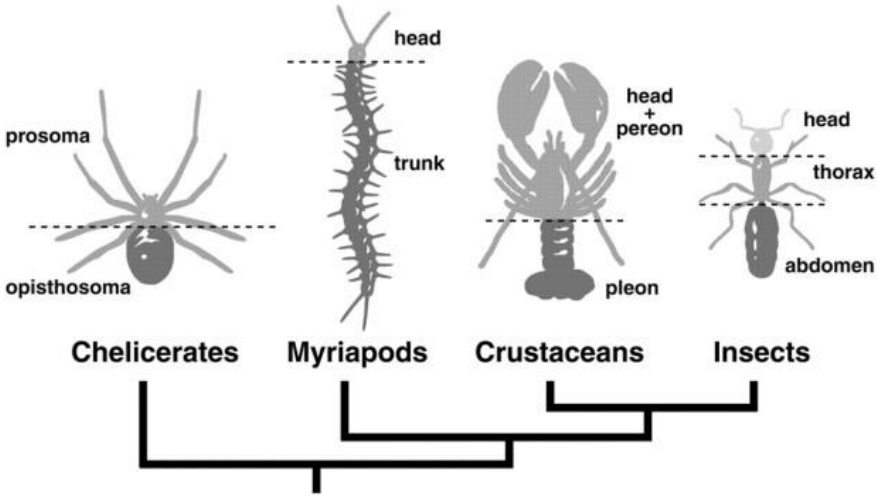
1. Terrestrial in habit
2. Body divided into head and trunk region
3. Head with one pair of antennal, one pair of mandible and two pairs of maxillae.
4. Each trunk segment with one pair of legs.
5. The 1st pair of leg is modified into poison claw.
6. Example- Centipede *(Scolopendra*)

Class 5- Diplopoda –

1. Terrestrial in habit, body divided in to head thorax and abdomen.
2. Body elongated, cylindrical and vermiform.
3. Head five segmented and bears one pairs of antennal, one pair of mandible and a long maxilla.
4. Thorax four segmented and each segment with one pair of walking legs.
5. Each abdominal segment carries two pairs of walking legs.
6. Breathing through trachea.
7. Example – Millipede (*Julus).*

Class 6- Insecta or Hexapoda –

1. Terrestrial or aquatic in habit.
2. Body divided into head thorax and abdomen.
3. Head carries one pair of antennal, one pair of mandible and one pair of maxillae.
4. Thorax three segmented (Pro, meso and metathorax)
5. Each segment carries one pair of legs and meso and meta thorax also carry one or two pairs of wings.
6. Breathing through trachea.
7. Example – Grasshoppers, locusts, crickets, termites, moths, Butterflies, beetles, plants bugs etc.



Different arthropods and their relationship

Exercise no. 2

Objective: To study about Classification of Insects.

Observation:

INSECT CLASSIFICATION

Classification of insects is basically adopted by A.D. Imms (1957), according to him class Insecta or Hexapoda is divided into two sub classes-

Sub Class 1- Apterygota – Apterous insects, the wingless condition presumed to be primitive, metamorphosis slight or absent. Adult with one or more pair of pregenital abdominal appendages. Adult mandible usually articulating with the head capsule at a single point. This sub class is divided into following four orders-

1. Thysaneura " Example Silver fish
2. Diplura " Example Japygids
3. Protura " Example Telson tails or proturans
4. Collembola " Example spring tails

Sub Class – Pterygota – winged or secondarily wingless insects, metamorphosis varied, Adults without pregentital abdominal appendages. Adult mandibles usually articulating with the head capsule at two points. This subclass is divided into following two divisions -

Division I - Exopterygota – Wings develop externally. Metamorphosis simple, pupal stage rarely present. Immature stages are called nymphs which are similar to adults in structure and habit. In this division following orders are present -

5. Ephemeroptera " Eg- Mayflies
6. Odonata " Eg- Dragon flies
7. Plecoptera " Eg- Stone flies
8. Grylloblatoidea " Eg- Gryloblatta
9. Orthoptera " Eg- Grasshoppers & crickets

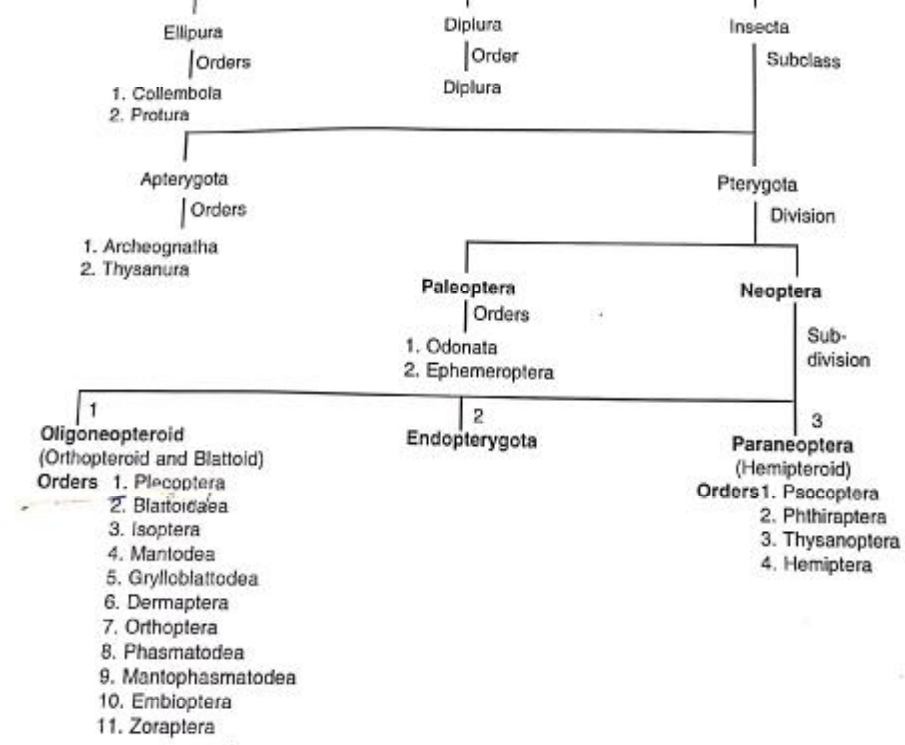
10. Phasmida " Eg- Phasmids
11. Dermaptera " Eg- Earwings
12. Embioptera " Eg- Embiids
13. Dictyoptera " Eg- Cockroaches & Mantids
14. Isoptera " Eg- Termites
15. Zoraptera " Eg- Zorapterans
16. Procoptera " Eg- Booklice
17. Mallophaga " Eg- Birdlice
18. Siphunculata " Eg- Sucking lice
19. Hemiptera " Eg- Plantbugs, Aphids, Whiteflies, mealy bugs etc.
20. Thysanoptera " Eg- Thrips
21. Mantophasmatodea –Eg- Mantophasmatids (New order discovered in 2002)

Devision II –**Endopterygota –** Wings develop internally, metamorphosis complex, pupal instar present immature stages are called larvae which differ from adults in structure and habits. It is divided into following order –

Order –22. Neuroptera – Eg - Lace wings, Alderflies, snake flies etc.
23. Mecoptera – Eg – Scorpion flies
24. Lapidoptera – Eg – Butterflies and moths
25. Trichoptera – Eg – Caddish flies
26. Diptera- Eg – Two winged flies or true flies
27. Siphonoptera- Eg- Fleas
28. Hymenoptera –Eg- Ant, Bees, Wasp etc.
29. Coleoptera – Eg- Beetles and weevils
30. Strepsiptera – Eg – Stylops

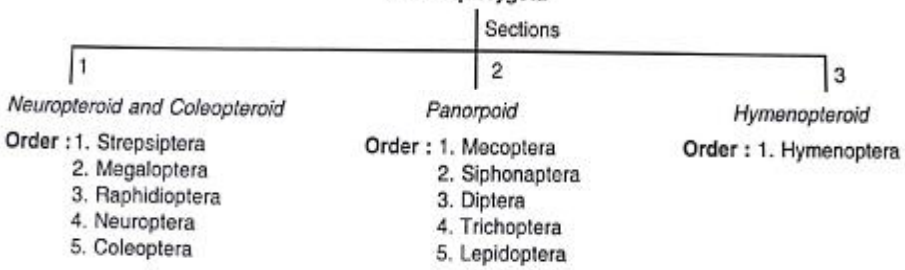
MODERN CLASSIFICATION

Super Class — Hexapoda Class



SUB-DIVISION

2. Endopterygota



Exercise no. 3

Objective: To study about characters and classification of Order Orthoptera and Isoptera.

Observation:

Order – Orthoptera (orthos = straight, pteron = wing)

Grasshoppers, crickets and locusts

Characters -

1. Winged or brachypterous or apterous.
2. Month parts biting and chewing type (Mandibulate type)
3. Hind leg usually enlarged and modified for grouping.
4. Two pairs of wings, sometimes absent or vestigial, following straight, thickened Tegmina, hind pair of wing membranous.
5. Gradual metamorphosis, the nymphs resemble the adults in all essential features and habits.
6. A pair of unsegmented short cerci is present.

This order is divided into two sub orders.

Suborder- 1 – Ensifera:

1. Antennal are longer than their body length and many segmented.
2. Tympanal organs (auditory organs) are located on the tibia of the leg.

Example – Long horned gross hoppers and crickets.

Suborder- 2 – Caelifera:

1. Antennae are shorter than their body length with less than thirty segments.
2. The Tympanal organs are located at the sides of 1^{st} abdominal segment.

Example- Short horned gross hoppers and locusts.

Family – Acrididae

1. These are moderately long insects with prominent head begs.
2. Diurnal in habit.
3. The antennae are always much shorter than the body length.
4. The auditory organs are located on the sides of the Ist abdominal segment.
5. There are usually one generation in a year.

Example- Kharif grass hopper, *Hieroglyphus banian, H. Nigroreplatus,* Desert locust, *Schistocerca gregarea* Migratory locust, *Locusta migratoria*

Order – Isoptera (Iso = equal, ptera = wing)

Termites or white ants

Characters-

1. Moderate sized, thin skinned, social insects, consisting of several castes such as winged king and queen, wingless king and queen, workless and soldiers.
2. Metamorphosis simple.
3. Mouth parts of the typical biting and chewing type.
4. The wings are equal in size, long, narrow, membranous, somewhat opaque.
5. Workers and soldiers of both the sexes are wing less and sterile forms.

Family 1. Mastotermitidae eg.- *Mastotermes* spp.
Family 2. Kalotermitidae eg.- *Kalotermes* spp.
Family 3. Rhinotermitidae eg.- *Rhinotermes* spp.
Family 4. Hodotermitidae eg.- *Hodotermes* spp.

Family - Termitidae:

Characters:

1. Members are mostly subterranean and form a termitarium.
2. Wings only slightly reticulate, wing membrane and margin more or less hairy.
3. Pronotum of workers and soldiers narrow.
4. The queen attains enormous proportions, the increase effecting only in the abdomen and not the head and thorax. This obesity is known as Physagastory.

Example- Termite- *Odontotermes obesus, microtermes obesi.*

Exercise no. 4

Objective: To study about characters and classification of Order Hemiptera.

Observation:

Order – Hemiptera (Hemi = half, pteron = wing)

Characters –

1. Two pair of wing usually present. The anterior pair most often of harder consistently than the posterior pair, either uniformly (Homoptera) or with the apical portion membranous than the remainder (Heteroptera).
2. Mouth parts piercing and sucking type.
3. Metamorphosis usually gradual.
4. The abdomen has no cerci.

Example – Plant bugs, leaf hoppers, coccids, white flies etc.

This order is divided into two suborders.

Suborder 1. Heteroptera (Heter = Different, pteron = wing)

Characters –

1. The fore wing thickened and lengthy basally and membranous apically known as hemelytra.
2. Metamorphosis is complete.
3. Body usually broad and flattened dorsoventrally.
4. A plate usually triangular in outline called scutellum, located between the bases of the wings.

Following are the imporntant families:

Family 1. Pyrrhocoridae Example- red Cotton bug, *Dysdercus cingulatus.*

Family 2. Coreidae Example- Rice gundhi bug, *Leptocorisa varicornis*

Family 3. Pentatomidae Example- 1- Stink bug, *Aspongopus janus*

2- Green bug, *Nezara virudula*

3- Painted bug of mustard, *Bagrada cruciferarum*

Suborder 2. Homoptera (Homo = similar, pteron = wing)

Characters –

1. Two pairs of wings are usually similar in texture and each wing is practically same thickness throughout.
2. Excretion of honey dew is common in many members of this suborder.
3. Metamorphosis usually gradual while in some cases complete metamorphosis is also found.
4. Mouth pests procuring and sucking type.

Following are the important families:

Family 1. Cecadellidae (jassids) leaf hopper or jassids

Example – Paddy leaf hoppers, *Nephotettix apicals.*
Paddy leaf hoppers, *Nephotettix bipunctatus*
Mango leaf hopper, *Idiocerus atkinsoni*
Cotton jassid, *Amrasca beguttula*

Family 2. Lophopidae (Fulgoridae) Pyrilla

Example – Sugarcane Pyrilla, *Pyrilla perpusilla*

Family 3. Aleurodidae – white flies

Example – 1. Sugarcane whitefly, *Aleurolobus barodensis*
2. Cotton white fly, *Bemisia tabaci*
3. Citrus white fly, *Dialeurodes citri*

Family 4. Aphididae – Aphids green flies or plant lice.

Example – 1. Mustard aphid, *Hydophis (Lipaphis) erysimi*
2. Bean aphid, *Aphis craccivora*
3. Cotton aphid, *Aphis gossypii*
4. Potato aphid, *Myzus pessiki*

Family 5. Coccidae – Mealy bugs and scale insects.

Example – Mango mealy bug, *Drosicha stebbingi*

Family 6. Lacciferidae – Lac insect

Example – Lac insect, *Laccifer lacca*

Exercise no. 5

Objective: To study about characters and classification of Order Phthiraptera and Neuroptera.

Observation:

Order Phthiraptera (Greek word Phthir = lice, aptera = without wing)

Suborder - Anoplura

Common Name: Parasitic Lice / Biting Lice / Sucking Lice.

Characters-

Small, wingless insects that are parasitic on birds and mammals.

1. They are usually less than 10 millimetres in length.
2. Lice are short lived and usually host specific. They are-
3. Small, flattened body
4. Wingless and colourless
5. Short, stubby antennae
6. Legs with hooked tarsi adapted to gripping their hosts
7. Chewing or biting mouthparts (biting lice) or piercing and sucking mouthparts (sucking lice)
8. The nymphs resemble adults and have 3 instars before they reach sexual maturity.

Family- 1. Himatopinidae Example - ***Himatopinus asini,***
Family -2. Pediculidae Example - ***Pediculus humanus***

Characters:

- A few species of lice have adapted to live and feed on humans, such as the head louse *Pediculus capitis*, the eggs of which are commonly called nits and the body louse *Pediculus humanus*.

- Most sucking lice species feed on the blood of the animals they live on while biting lice usually feed on the feathers and skin of their hosts.
- *Haematopinus asini* is a common louse found feeding on horses while *Linognathus* species are common parasites of domestic mammals

. **Order Neuroptera (Greek word "neuron" = sinew and "ptera" = wings)**

Net-winged insects, includes the lacewings, mantidflies, antlions, and snakeflies.

Characters-

1. Head well-developed with ocelli, antennae,
2. Chewing or pinching mouthparts.
3. Three pairs of thoracic legs.
4. tarsi 1-segmented; claws paired.
5. Aquatic forms have thread-like gills on most abdominal segments.
6. Most of the insects are biological control agents of other insects and mites.

Family- Chrysopidae (green lacewings) Example- *Chrysoperla carnea*

- Large family Chrysopidae of the order Neuroptera.
- Green lacewings are delicate insects with a wingspan of 6 to over 65 mm, though the largest forms are tropical.
- Adults have tympanal organs at the forewings' base, enabling them to hear well.
- Adults are crepuscular or nocturnal.

Exercise no.6

Objective: To study about characters and classification of Order Lepidoptera.

Observation:

Order – Lapidoptera (Lapido = Scales, pteron = wing)

Moths, butterflies and skippers

Characters –

1. Insect with two pairs of membranous wings, but not transparent, covered by minute overlapping scales.
2. Mouth parts greatly reduced possessing siphoning type of mouth parts.
3. Metamorphosis complete.
4. Larvae Known as caterpillar or semilooper which possess biting and chewing type of

This order is divided into two suborders-

Suborder 1. Heterocera – Moths

Characters –

1. Mostly nocturnal in habit.
2. Antennae are of varied form, filiform, pectinate bipectinate etc.
3. The wings usually lie horizontally or roof like at the sides of abdomen.
4. Pupae very often protected by cocoon.

Following are the important families.

Family 1. Gelechidae

Example 1. Grain & flour moth, *Sitotroga cerealella*

2. Pupate tuber moth, *Phthoremoea operculella*
3. Pink boll worm, *Pectinophora gossypiella*

Family 2. Pyralidae (Pyraustidae) Pyralid moth

Example 1. Cotton leaf letter, *Sylepta derogata*

2. Jowar stem borer, *chilo partillus*
3. Sugar cane top borer, *Tryporyza novella*
4. Rice stem borer, *Tryporyza incertulus*

5. Rice case worm, *Nymphula depunctalis*
6. Sugar cane root borer, *Emmalocera deprecella*

Family 3. Arctiidae (Hairy caterpillars**)**

Example 1. Bihar hairy caterpillar, *Spilosoma (Diacresia) oblique*
2. Red hairy caterpillar, *Amsacta moorii*
3. Castor hairy caterpillar, *Pericalia riceni*
4. Sun hemp hairy caterpillar, *Utetheisa pulchella*
5. Hairy caterpillar, *Euproctis lunata*

Family 4. Cymbidae (Arctiidae)

Example – spotted bollworm, *Earias vitelli, E. insulana, E. crumataria*

Family 5. Noctuidae (Noctuid moths)

Example – 1. Gram cutworm, *Agrotis ypsilon*
2. Gram cutworm, *A. flamatra*
3. Gram pod borer, *Helicoverpa (Heliothis) armigera*
4. Tobacco caterpillar, *Spodoptera (Prodenia) litura*
5. Cabbage semilooper, *Plusia orichalcea*
6. Army worm, *Mythimna seperata*
7. Fruit sucking moth, *Ophideres (Othris) conjuncta*
8. Fruit sucking moth, *O. fulonica*
9. Fruit sucking moth, *O. materna*
10. Fruit sucking moth, *Calpe emerginata*
11. Fruit sucking moth, *Achoea janata*

Family 6. Bombycidae Silk moth

Example – Mulberry silk worm, *Bombyx mori*

Sub Order 2. Rhopalocera – Butterflies and skippers

Characters 1. Diurnal in habit
2. Antennae club shaped or clavate
3. Wings remain vertical above the body
4. Pupae are necked and they are called chrysalis.

Family – Papilionidae

Example- Lemon butterfly, *Papelio demoleus*

Exercise no. 7

Objective: To study about characters and classification of Order Coleoptera.

Observation:

Order – Coleoptera (Coleos = sheath, Pteron = wing**)**

Beetles and weevils

Characters-

1. Two pairs of wing, fore wing thickened (hard & sclerotized) called elytra, hind wing membranous and protected by fore wing.
2. Both larvae and adult have biting and chewing type of mouth parts.
3. Metamorphosis complete.
4. Larvae of beetles are commonly known as grub. Snout beetle (weevils) grubs are leg less (apodous).

This order is divided into following two suborders

Suborder 1. Adephaga

Characters – 1. Beetles mostly predatory in habit, they feed on other, insects.

2. Antennae generally filiform.
3. Notopleural suture is present.
4. The Ist visible abdominal sternum is divided by the hind coxae and the posterior margin of this sternum does not extend completely across the abdomen.

Followings are the important families –

Family 1. Cicindellidae

Example – Tiger beetle, *Cicindella sexpunctata*

Family 2. Carabidae

Examples- 1. Carabid beetle, *Anthia sexguttata*

2. Carabid beetle, *Chlaenius bioculatus*
3. Carabid beetle, *Calosoma indica*

Suborder 2. Polyphaga

Characters:

1. The Ist visible abdominal sternum is not divided by the hind coxae and the posterior margin of this sternum extends completely across the abdomen.
2. Hind trochanters are small.
3. Notopleural suture is absent.

Followings are the important families –

Family 1. Dermestidae

Example – Khapra beetle, *Trogoderma granarium*

Family 2. Curculionidae (curculioni = weevils or snout beetles)

Examples – 1. Rice weevil, *Sitophilus oryzae*
2. Gujhia weevil, *Tanymecus indicus*
3. Sweet potato weevil, *Cylas formicarius*

Family 3. Bruchidae

Example – Pulse beetle, *Callosobruchus chinensis*

Family 4. Chrysomelidae

Example - 1. Red pumpkin beetle, *Raphidopalpa foveicollis*
2. Rice hispa, *Decladispa armigera*
3. Singhara beetle, *Galerucella bermanica*

Family 5. Tenebrionidae

Example – Rust red flour beetle, *Triboliuam castaneuam*

Family 6. Coccinellidae

Sub family – Coccinellinae lady bird beetles

Example – 1. Lady bird beetle, *Coccinella septempunctata*
2. Lady bird beetle, *Chilomenus sexmaculata*
3. Lady bird beetle, *Rodolia cardinalis*

Family 7. Melolonthidae (Scarabaeidae)

Example **–** White grub, *Holotrichia consanguinea*

Exercise no.8

Objective: To study about characters and identification of insects of Order Hymenoptera.

Observation:

Order – Hymenoptera (Hymen = membranous, pteron = wing)

Bees, wasp, sawflies and parasitic wasp.

Characters-

1. Wings typically four, small and membranous, hind pair of wing smaller, wing venation highly specialized.
1. Mouth parts biting and chewing or chewing and lapping type.
2. Metamorphosis complete.
3. Abdomen of female usually provided with a saw or piercing organ or sting.
4. Larvae either caterpillar like or grub like or leg less.

This order is divided into two suborders –

Suborder 1. Symphyta (Sawflies)

Characters:

1. These insects are characterized by the abdomen being broadly joined to the thorax. with no marked constriction between the Ist and IInd abdominal segments.
2. Ovipositor adopted for sawing or boring but never a sting.
3. larvae (grubs) are caterpillar like which possess well developed thoracic and abdominal legs.
4. Prolegs without crockets.

Family – Tenthredinidae (Saw flies)

Example – 1. Mustard sawfly, *Athalia proxima*

Suborder 2. Apocrita (Bees, Wasp, Parasitic wasp etc.)

Characters:

a. These insects are characterized by a deep constriction between the propodeun (Ist abdominal segment) and the IInd abdominal segment called petiole or waist.

2. The larvae (grubs) are apodous (legless) or grub like with head and mouth parts reduced.
3. They possess a well-developed ovipositor with sting.

Family – Apidae (Bees)

Example – 1. Bush bees, *Apis florae*
2. Rock bees, *Apis dorsata*
3. Indian honey bee, *Apis cerana indica*
4. Italian bee, *Apis mellifera*

Exercise no.9

Objective: To study about characters and classification of Order Diptera.

Observation:

Order – Diptera (Di = two, pteron = wing)

True flies, Houseflies mosquitoes etc.

Characters-

1. Insects with single pair of membranous wings, hind pair of wings modified into halteres.
2. Mouth parts piercing and sucking or sponging type.
3. Prothorax and metathorax small and fused with well-developed mesothorax.
4. Metamorphoses complete.
5. Larvae are apodous (legless) called maggots which have biting and chewing type of mouth parts.

6. Pupa are generally free or enclosed in a puparium.

This order has been divided into three suborders –

Suborder 1. Nematocera (Mosquitoes and Gall midge)

Characters:

1. Antennae of image (adult) usually longer than the head and thorax, many segmented, majority of segments alike, not forming on arista or style.
2. Larvae (maggots) are eucephalous type which have well developed head and horizontally biting mandibles.
3. Discal cell generally absent.
4. Maxillary palpi 4-5 segmented.

Family 1. Culicidae: Mosquitoes

Example- 1. *Anopheles* spp.

2. *Culex fattigaus*

Family 2. Cicidomyiidae: Gall midge

Example- 1. Rice gall midge, *Orseolia oryzae*
2. Mango gall midge, *Dasyneura mangiferae*
3. Linseed gall midge, *Dasyneura lini*

Suborder 2. - Brachycera (Horse flies, Robber flies etc.)

Characters:

1. Antennae of imago are shorter than head and thorax, generally three segmented with the last elongate, arista present terminal.
2. larvae are hemicephalous type which possess an incomplete usually retractile head and ventrally biting mandibles.
3. Discal cell almost always present.
4. Maxillary palpi one or two segmented.
5. Pupa is free.

Family 1. Tabanidae: Horse flies

Example – Horse flies, *Tabanus maculicornis*

Family 2. Asilidae: Robber flies

Example – Robber flies, *Philonicus albiceps*

Family 3. Bombyllidae: Bee flies

Example – Bee flies, *Bombylius major*

Suborder 3. – Cyclorrhapha (Fruit flies, Syrphid flies, Vinager flies)

1. **Characters** – 1. Antennae three segmented with a dorsal bristle like arista.
2. Maxillary palpi one segmented
3. The larvae are acephalous type, in which head is reduced and the mandibles are replaced into mouth hooks which are working in a vertical plane.
4. Pupa are enclosed in a puparium.

Family 1. Tephritidae: (Fruit flies)

Example – Melon fruit flies, *Bactrocera cucurbitae*

Family 2. Syrphidae (Syrphid flies or Hover flies)

Example – Syrphid fly, *Episyrphus balteatus*

Family 3. Agromyzidae:

Example – 1. Pea leaf miner, *Phytomyza atricornis*

2. Arhar pod fly, *Melonaglowyza obtusa*

Exercise no.10

Objective: To study about identification of different Orders using pictorial keys.

Observation:

PICTORIAL KEY TO THE ORDERS OF INSECTA

Characters of couplet	Draw diagram
1. Winged insects …….. 2 - Wing less or vestigial winged insects……. 23 2. With only one pair of wings…….. 3 - With two pairs of wings…… 5 3. Wings net –veined; haltares absent …….certain mayflies: Ephimeroptera - Wings not net veined; haltares present	

……. 4 4. Wings with highly reduced venation; caudal filaments usually present; delicate insects……..…male mealy bugs and scale insects…….: Homoptera - Wings with longitudinal and a few cross veins; no caudal filaments (Fig. 1) …… flies, mosquitoes, etc….: Diptera 5. Forewings horny, without veins, meeting in a straight line over middle of body and usually concealing membranous hind wings (certain forms have the hindwings vestigial or absent)…… 6 -Forewings not as above ……. 7 6. Abdomen provided with forceps like cerci at posterior end (Fig. 2) ……. Earwigs: Dermaptera - Abdomen without forceps like cerci (Fig. 3) …….. beetles, weevils: Coleoptera 7. Two pairs of wings unlike in structure…… 8 - Two pairs of wings similar in structure ……. 10	

8. Forewings reduced to slender club- shaped appendages; hindwings folded fan like at rest (Fig. 4) ……..…twisted winged insects: Strepsiptera - Forewings not as above ……..… 9 9. Forewings thick and leathery at base and membranous at tip; mouth parts form a sucking beak (Fig.5)…… bugs Hemiptera - Forewings thick and leathery throughout; chewing mouth parts (Fig. 6) ……. grass hoppers, cockroaches, etc.: Orthoptera 10. Wings partially or more often entirely covered by microscopic scales (Fig. 7) ……moths, butterflies: Lepidoptera - Wing transparent or covered with fine hairs …….……11 11. Wings very narrow and fringed with long hairs, small slender – bodied inscts (Fig. 8) …… thrips: Thysanoptera - Wing not as above …….. 12 12. Mouthparts a piercing- sucking beak arising from the rear of the head near the first pair of legs (Fig. 9)	

…..…….. aphids leaf hoppers etc. : Homoptera - Mouthparts not a piercing sucking beak, normally situated at the front of the head …… 13 13. Antennae small and bristle like …… 14 - Antennae conspicuous and of many forms …….. 15 14. Fore and hind wings nearly equal in size; tip of abdomen without terminal filaments (Fig. 10) …… dragonflies, damselflies: Odonata - Forewings much larger than hind wings; tip of abdomen with 2-3 long terminal filaments (Fig. 11)…… Mayflies: Ephemeroptera 15. Wing with many veins and cross veins …… 16 - Wings with few veins and cross veins ……. 20 16. Hind tarsi with fewer than five segments ……	

17 - Hind tarsi with five segments …….. 18 17. Tarsi three segmented; hind wings as large as or larger (wider) than forewings (Fig. 12) ……. stoneflies: Plecoptera - Tarsi four segmented; forewings and hindwings of equal size (Fig. 13) …….termites: Isoptera 18. Head prolonged into a beak (Fig. 14) ……... …….. scorpionflies: Mecoptera - Head not prolonged into a beak ……..19 19. Wings covered with fine hair (Fig. 15) ……. ……. caddisflies: Trichoptera - Wings transparent not covered with hair (Fig. 16) ……... lacewings: Neuroptera 20. Tarsi two or three segmented; wings approximately equal in size ……. 21	

- Tarsi usually five segmented; forewings larger than hindwings (Fig. 17) …….. ants, bees, wasps: Hymenoptera 21. Basal tarsal segment of foreleg greatly enlarged (Fig. 18) ……. web spinner: Embioptera - Basal tarsal segments not enlarged …….. 22 22. Cerci present; body less than 3 mm long (Fig. 19) …… zoraptarans: Zoraptera - Cerci absent; body 3 mm long or longer….bark lice: Psocoptera 23. Abdomen composed of six or fewer segments with ventral spring apparatus (Fig. 20) …….. sprigtails: Collembola - Abdomen with more than six segments and no spring ……24 24. Abdomen segments 1-3 each with a pair of small ventral appendages; antennae, eyes and cerci absent; minute and rare (Fig. 21) …….. telsontail : Protura	

-Abdomen and appendages not as above ……..25 25. Abdomen with 2-3 long terminal appendages or pair of forcep like cerci, segments 2-7 may each have a pair of small ventral leg like appendages …….bristletails: Thysanura - Abdomen without terminal filaments or ventral appendages ……. 26 26. Mouth parts fitted for chewing …….. 27 - Mouth parts fitted for piercing, lapping or sucking, sometime concealed …….. 31 27. Louse like insects ……. 28 - Insect not louse like, various forms…….29 28. Antennae with 5 or less segments (Fig. 23) …lice: Mallophaga - Antennae with more than 5 segments (Fig. 24) ……..booklice: Psocoptera 29. Abdomen constricted at base……ants, wasps: Hymenoptera	

- Abdomen not constricted at base…… 30 30. Body very slender and linear, hind legs modified for jumping, or body oval and flattened…grasshopper, cockroach: Orthoptera - Body or legs not as above, body antlike but abdomen broadly joined to the thorax……termites: Isoptera 31. Tarsi with 5 segments…….32 - Tarsi with fewer than 5 segments ……34 32. Body strongly compressed laterally (Fig. 25)…… ……fleas: Siphonaptera - Body not strongly compressed laterally……33 33. Abdomen not distinctly segmented, covered with hairs…….sheep ked, other flies: Diptera -Abdomen distinctly segmented covered with scales ……..females of bagworms, tussock moth:	

Lepidoptera 34. Last tarsal segment a bladder like organ, without well-developed claws ……....thrips: Thysanoptera - Last tarsal segments with one or two claws ……35 35. Louse like; sucking beak not evident (Fig. 26) ……..... sucking lice: Anoplura - Insect not louse like, sucking beak evident……36 36. Beak arising from front of head …… ……bedbugs, water striders: Hemiptera - Beak arising from rear of head (Fig. 9)……. ……aphids, scale insects etc.: Homoptera	

Figure 1

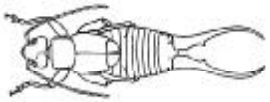


Figure 2

Figure 3

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Figure 13

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Figure 16

Figure 17

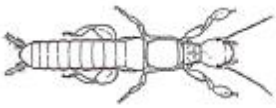


Figure 18

Figure 19

Figure 20

Figure 21

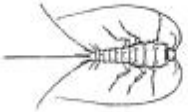


Figure 22

Figure 23

Figure 24

Figure 25

Figure 26

Exercise no.11

Objective: To study key to major families of Order Orthoptera, Hemiptera (Heteroptera and Homoptera) and Coleoptera.

Observation:

KEY TO MAJOR ECONOMIC FAMILIES OF ORTHOPTERA

1. Antennae much longer than pronotum; tympanum in front tibiae …… 2

- Tympanum about as long as pronotum; tympanum present on first abdominal tergum …….. Grasshopper : Acrididae

2. Tarsi four segmented; ovipositor usually sword like or sickle like (long horn grsshoppers) …….…….....katydids and others : Tettigonidae

- Tarsi three segmented; ovipositor spear shaped or awl shaped ..…….. crickets: Gryllidae

KEY TO MAJOR ECONOMIC FAMILIES OF SUB ORDER HETEROPTERA

1. Antennae shorter than head; concealed in grooves beneath the eyes (short horned bugs: most of the bugs) ……

- Antennae longer than head and plainly visible from above (long horned bugs: terrestrial bugs and water striders) …….2

2. Forewings reduced to short pads; body flattened and modified for actoparasitic habit…… bed buds: Cimicidae

- Forewings not reduced to short pads; body not flattened and modified for ectoparasitic habit ……..3

3. Membranous portion of forewing with two closed cells …… …… . plant bugs: Miridae

- Membranous portion of forewing without two closed cells……4

4. Membrane with row of small cells around margin …....damsel bugs: Nabidae

- Membrane without row of small cells around margins……5

5. Membrane with 4-5 open veins ……..chinch bug: Lygaeidae

- Membrane without 4-5 open veins (may be many) ……6

6. Membrane with many branched veins and cells but without numerous longitudinal veins …… …….. Red bugs: Phyrrhocoridae

- Membranes without many branched veins and cells but with numerous longitudinal veins ……..……7

7. Antennae four segmented scutellum usually not large …squash bugs: Coreidae

- Antennae five- segmented; scutellum very large .....stink bug: Pentatomidae

KEY TO MAJOR ECONOIC FAMILIES OF HOMOPTERA

1. Antennae setaceous (bristle like) ……..……2

- Antennae filiform (thread like) or rudimentary ……4

2. Pronotum extending backward over abdomen …..…tree hoppers: Membracidae

- Pronotum not extending backward over abdomen ……3

3. Hind tibiae with one or more rows of spines ……..…leafhopper: Cicadellidae

- Hind tibiae with one or two stout spines and usually a circlet of spines at apex …… ……..…spittle bugs: Cercopidae

4. Tarsi two- segmented and with two claws ….……..5

- Tarsi one segmented and with single claw (Coccoidia) …….8

5. Hind femora large for jumping ; antennae with 5-10 segments (usually 10) segments ….……. Psyllids: Psyllidae

- Hind femora not enlarged for jumping; antennae with 3-7 segments ……6

6. Wings opaque, usually covered with white powdery wax …….
……...white flies: Aleyrodidae

- Wings transparent when present …….7

7. Cornicles (pair of tubules on top of rear of abdomen) usually present and conspicuous; wing venation not highly reduced …..……aphids: Aphididae

- Cornicles not present; wing venation highly reduced ……..……
…….. bark aphids, gall aphid and phylloxerans: Phylloxeridae

8. Body hidden by waxy or scale like covering; sessile during most of life ……..9
– Body covered with powdery wax; mobile throughout life
……...…….. mealy bugs: Pseudococcidae

9. Body covered with hardened shell formed from wax; shed skins and fibrous material easily removable; females without posterior end cleft ……...
……..... Armored scales: Diaspididae

- Body covered with soft wax not easily removable; if not covered with soft wax, then females with hard, smooth, often greatly convex, endoskeleton with posterior end cleft …….. soft scales: Coccidae

KEY TO MAJR ECONOMIC FAMILIES OF COLEOPTERA

1. Head not prolonged into a snout; guar suture (on underside of head) double …2

- Head usually prolonged into a snout; gular sutures fused or lacking ……13

2. First abdominal sternum divided by hind coxae ……...
.....ground water: Carabidae

- First abdominal sternum not divided by hind coxae …….3

3. Click mechanism (prosternal spine fitting into groove in mesosternum) present
……....click beetles, wire worms: Elataridae

- Click mechanism not present ……4

4. First two abdominal sternum fused; body usually metallic ……. ……..……... flat headed wood borers: Buperestidae

- First two abdominal segments not fused; body not usually metallic ……5

5. Hind coxae dilated and grooved not hairy or scaly beetles ……6

- Hind coxae not dilated and grooved; not hairy or scaly beetles ……...7

6. Head concealed from above; front coxal cavities open behind ……..……... ……skin beetles: Dermestidae

- Head not concealed from above; front coxal cavities closed behind …… ……... fruit worm beetles: Byturidae

7. Tarsi usually three segmented (Third segment minute and fused to base of fourth (Fig. 6); body almost hemispherical …….. lady beetle: Coccinellidae

- Tarsi not apparently three segmented; body not almost hemispherical ……8

8. Body highly flattened and narrow (Fig. 7) ……... flat bark beetles: Cucujidae

- Body not highly flattened and narrow …… other coleopterans

Exercise no. 12

Objective: To study about Entomological methods.

Observation:

COLLECTION, MOUNTING AND PRESERVATION TECHNIQUES

Place of Search: -

Insects are present everywhere. In the world where life is possible insect can be found. To begin to study them it is not necessary to go to distant places. You can make a start in your garden, cultivated fields or even in your house. For the collection of insect you want you must have some idea of the following-

1. How they live.
2. What they require at different stages of life.

For example, in complete metamorphosis, there are four stages-

i. Egg stage

ii. Laval stage

iii. Pupal stage

iv. Adult

While in incomplete metamorphosis, there are three stages-

i. Egg

ii. Nymph

iii. Adult

Catching of adult stage is only one part of collection which give very little view of their life cycle. To know an insect, you have to find out the young insects, keep them alive, rear them to maturity. Beside this, things that insect of all stages are concerned with are-

1. Light, 2. Warmth, 3. Food, 4. Moisture and 5. Shelter

Knowing habits of insects makes collection much simpler. Before you start collection, stand and watch the insects for a while. See how pollen loving insects sit on the flower. Some like bees go from flower to flowers without wasting little time. Others like, butterflies, some moths and many flies love the warmth of Sun and spend much of their time just basking, either quite still, or slowly opening and closing the wings. On the other hand, hovers are able to remain poised in the air, apparently motionless but the wings moving at very high rate.

The leaves and stems of the plant shelter many insects. Underneath the leaves clusters of eggs can be seen or hanging pupae as well as many insects. On foliage a number of adult insects may be seen some of which are carnivores and look for a prey.

Insects that fly can be easily caught by the net, but smaller insects that keep still, or hide away are more difficult to collect.

General Collection:

For making general collection one should search the follows places-

1. Scrub land: With low bushes of different species, long and short grasses.

2. Open hill side: At this place the insects are not so crowded together as in scruby land. At hillside most of the collection is done on the tree trunks or on the ground at the foot of the trees. Bigger insects can be stalked and trapped. The new forest is a good locality and tremendous local variation in the number of insects can be seen.

3. Grass Land: It can be looked at following places-

A. Low Land Pasture: It has a much varied insect fauna. The number of individual insects may be mainly butterflies with an occasion bee or beetles. Most of the insects are hidden in the grass or around its root. Sweeping is the best way to the collect them.

B. Open down land: Has a fauna of its own. Flowers are usually plentiful, and there are more insects than on many lush pastures. Butterflies are the common insects at this place.

C. Heath land: Has fewer flowers but more scope for sand living, fossorial insects, especially Hymenoptera and beetles.

D. Limestone fells: They have very poor grass where the species of scale insects can be collected.

All these are more general way of collecting in daylight, but there are other places where you may look for a special and some peculiar fauna. All kind of rubbish and debris have their own insects as rotting and decaying are part of natural cycle. Insects play an important role in this process. These are-

1. Animal dung: Attracts many insects to lay eggs and to use it as food for their larvae.

2. Parasitic insects: Parasitic insects can be caught on the wing by as waiting near a bait animal, such as cow, dog, horse, monkey etc.

Ectoparasite : Are insects that live on the outside of other animals. Fleas and lice are the best known example of this group.

CATCHING AND TRAPING OF INSECTS:

After finding and observing the insects, next step is to obtain some of them for further study either dead or alive. For catching insects some equipments are required such as nets, aspirators and tubes etc. There are various types of nets used for collecting different insects, but the best collection is done by a general purpose net that suits their need.

NETS:

An insect may be captured by net in the following ways-

1. By catching it in flight

2. By stalking the insects until it settles, and them dropping the mouth of the net over it.

3. By sweeping, by swinging the mouth of net through grass or soft hertiae, so that the insects are disturbed are traped in lag of the net.

4. By beating, that is holding the net beneath bushes and beating the foliage with a stick so that insects fall into the net.

5. Insects in the pond and streams can also be captured by net.

General Purpose net:

The general purpose net is either circular or pear shaped. The frame should be 12-18 inches across. The pear shaped frame makes it easier to swing the net close to branches, tree trunk, wall or the ground. This kind of frame is also easier to put one's head into the net to inspect the catch. A frame that can be folded, or taken apart into several pieces, is convenient to carry in the pocket or under the arm when not in use.

A simple frame is made from three or more pieces of cane, joined together either with brass hinges, or with brass tips and sockets pushing into each other. Such a frame is light and strong. Metal frame are made by either a single ring of heavy metal rod or two or more section joined together. The best all-round frame is made from two pieces of steel strip in round or pear-shaped design. When folded it makes a straight object, like a ladies' umbrella.

The bag should be at least twice as long as the diameter of the frame, so that with a twist of the wrist it can be closed over the frame. The material from which the bag is made should be light and soft made of mosquito netting.

For various type of insects' collection, if net is to be used, a general purpose net can be improved upon as follows-

1. For flying insects only: The aperture should be big, the net frame light in weight and bag of open mesh.

2. For stalking individual insects: A smaller frame is most advantageous because the ground is generally uneven, and bigger the frame the more likely it is to leave a crevices and a light flexible frame is easier to press down the ground.

3. Sweeping: The frame should be big for bigger collection and also the collector can put his head and hands inside to inspect the catch. Both the bag and frame should be very strong. Bag should be of denser material. This frame can also be used on the water net with an inter changeable bag.

4. Beating: For this purpose, a simple beating tray can be made from canvas spread over strips of wood bamboo on the same line as making the kite. An old umbrella will also serve the purpose. Beating is intended for catching crawling insects.

5. Water Collection: It is better to carry a separate net for collecting in water. It should be stronger and heavier A square frame is more advantageous.

Handles for Net:

For air collection short handle of about 2 feet is ideal because it is useful in carrying for one place to other. Water nets need a long, strong handle to get enough reach.

TRANSFERRING THE INSECT FROM NET TO CONTAINER:

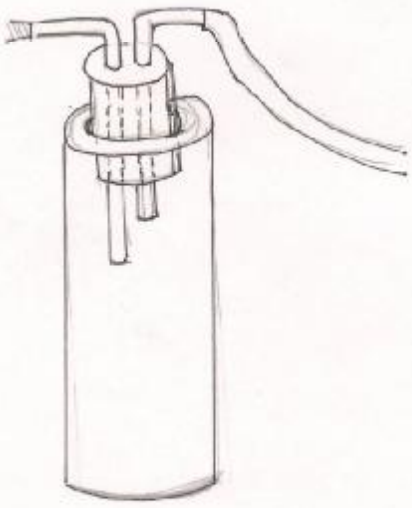
Water insects are helpless when the water is drained away and they can easily be tipped into jar. But other insects are more active and can be transferred in the following ways-

(1) Tubes: Useful size of tubes are10 cm x 2.5 cm or 5 cm x 1.25 cm with cork to fit. Resting insects, plant bugs, mosquitoes can easily be caught by putting a tube directly over them.

(2) Collecting bottles: It is a simplest variation of the tube. In this case both ends of the tube are open which is passed through the cork of an oval bottle which can early be held by hand. The open end of the tube is placed over the specimen and when the insect has walked in the tube the end in corked. This bottle can be converted into a killing bottle also.

(3) Aspirators: After the simple tube and bottles, these as the most useful of collecting equipments. These are used to collect small insects from the net or directly from foliage from walks or even from the ground. A suction bottle is made by taking a small bottle, like collecting bottle, but fitting of the cork with two small tube instead of one. The two tubes are bend at right angle or to any other angle as per convenience of collector. By sucking at the rubber tube, one can draw small insect into the bottle.

COLLECTING BOTTLE



ASPIRATOR

COLLECTING INSECT ON LIGHT TRAP:

Most of nocturnal insects one attracted to light. These may be moths, many kind of midges some beetles and lacewings and stone flies. Collection on light trap is affected by a number of factors and weather conditions i.e. moonlight temperature, humidity, wind velocity etc.

The simplest form of light trap in the box trap which can easily he made. Five of the six faces of the box are solid. The sixth is blocked by two over lapping sheets of glass which slope inwards. Thus an insect seeking the light is guided through the narrow slit between the sheets of glass, but it has a small chance of finding the slit in the opposite direction. An open killing bottle and lamp may be placed inside the box so that the fumes coming from bottle may kill the insect.

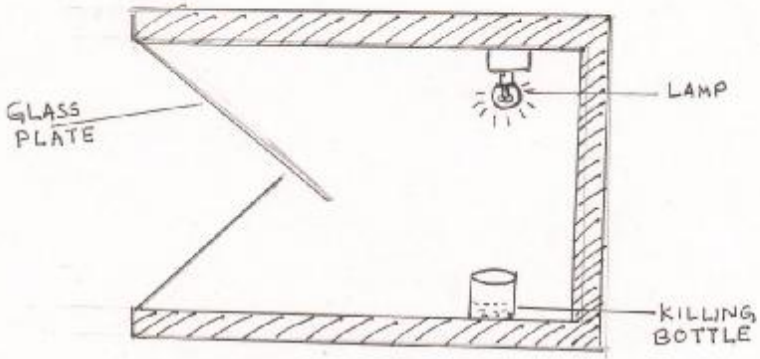
A mercury vapour lamp is more useful because it gives the light with high content of ultra violet.

OTHER TYPES OF TRAP

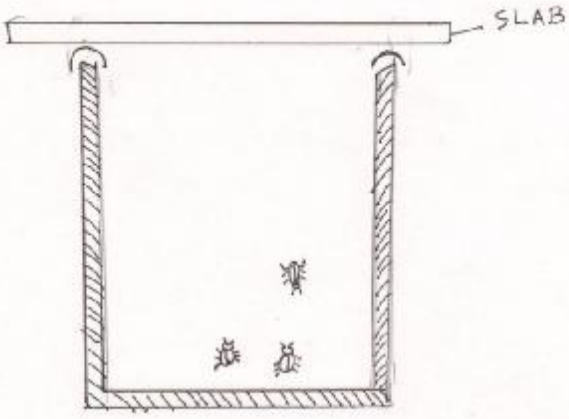
(1) Baits and Bait trap: For this purpose, baits for insects, either a natural substance that is known to attract them or, or a synthetic substance giving off the same odour in ever greater concentration is used. The bait is prepared with a fermenting mixture of sugar, molasses and beer.

(2) Rot-holes in the tree: Different types of insects, their immature stage can be collected from these places.

(3) Pit falls: Crawling and running insects may be caught in baited traps sunk into the ground so as to form pitfalls from where insect cannot climb out again, because the sides are too steep and smooth. Glass jars can be used to make the most convenient containers. A piece of wood is supported over the mouth so that frogs do not get in and eat the insects.



LIGHT TRAP



PIT FALL TRAP

REARING OF INSECTS

For the collection of immature stages, it is necessary that insects should be reared in laboratory. The insect that can be successfully reared continuously in the laboratory are those whose immature stage are all passed in a uniform and stable medium. This include insects living in decaying or fermenting materials (fruit flies), dry stored products (beetles, moths) etc.

The insects can be reared in a glass jar covered with a muslin cloth or netting on desired humidity and temperature. It is better to put some sand or soil at the bottom with one or two twigs of plant so as to provide some natural condition. Moisture can be provided by damping the soil daily. It is better to put a piece of sponge soaked with water or to put a small glass tube filled with water and its mouth plugged with cotton inside the cage.

Larval rearing:

For rearing in laboratory, the immature stages of insects such as nymphs, larvae or pupae are kept alive until they develop into adults. The larval stages can be reared on natural food or an artificial food. West (1951) described in detail a number of artificial foods for rearing larvae of house flies which may be used for other insects too. They are mostly made up from bran, oats or powdered milk which is moistened. Carnivorous larvae can be reared on ground meat provided it does not contain too much fat. Larvae can also be reared on an entirely artificial medium consisting of Agar, baker's yeast and salt.

Pupation:

Suitable site for pupation is very essential for successful rearing. Caterpillar which feed on leaves in the open need support for pupa and some form of shelter also. Fruit flies reared in bottles climb up and pupate on the glass above the culture medium. An artificial site can also be provided by putting a card board inside the bottle.

Many insets pupate in soil. For this purpose, sand may be used in the jar instead of soil. Insects that are usually resistant to drought in the pupal stage (eg. blow flies) will pupate successfully in any crumpled paper and rough cellular material that is used for packing eggs. It will also be useful for lepidopteran larvae

which spin a silken cocoon. Sufficient moisture should also be provided for successful pupation.

REARING OF LEAF MINING INSECTS:

In this case the infested leaves are put directly into an airtight tin or screw topped jar to avoid loss of moisture from the mine. As soon as the insect is seen to have pupated, it is removed from the leaves. The pupae are kept in small labeled tubes initial they emerge when they are killed and mounted with the empty pupal skin on the same mount.

SLEEVING OF LARVAE:

When it is not possible to remove part of the food plant of a larvae and grow this in a small cage, the damaged twigs where larvae are present may be confined by enclosing the twig in a sleeve of fine muslin. Larvae that do not pupate in the soil will make their cocoons inside the sleeve and the twig can be cut off and moved to a separates cage, ready for the emergence of adult insect. For larvae which pupate in soil, when the larvae are fully fed, one end of the sleeve is opened and tilted down in the rim of a pot or jar containing soil. When the larvae move down in the jar, it is transferred to a cage for adult emergence.

KILLING OF INSECTS

Insects caught in various catches may be killed in killing bottle by various methods-

1. Cyanide bottle:

Killing bottles are made in a strong bottle or tube with a specially will filled cork. In the bottom a layer of 5 mm thick broken potassium cyanide is placed. Powdered plaster of Paris is used to fill the space between the lumps of cyanide. Some more plaster of Paris is mixed with enough water to make a slurry and this is poured over the previous mixture. The setting of plaster is an exothermic reaction in which much heat is generated and much water vapour is released. It is necessary, therefore to set the bottle or tube aside, open for a day or so until the plaster is hard and dry. When the drying is finished, the cyanide will be held safely under a hard but porous layer of plaster and the gradual decomposition of

the potassium cyanide will release hydrogen cyanide, which will percolate through the plaster and fill the interior of the bottle. The cyanide bottle is liable to release vapour when in use, therefore, a circular piece of blotting paper may be placed on the top of the plaster which should be renewed when damp. The used blotting paper must be burned.

2. Liquid Killing Agents:

Tubes or bottles are provided with a layer of plain plaster of Paris (without cyanide). This type of bottle is permanent and can be used over and over again with any of the liquid killing agents.

Before going out for collection, a little of the liquid is poured on the plaster, taking care that only limited amount of liquid is poured, that the block can soak up. If it is more, the specimen will get wet and spoiled. The cork is replaced tightly and bottle is ready for use. It is important that excess liquid will harm the person if the bottle is left in sun or kept in warm pocket or held in hand for longer.

Killing agents:

1. Ethyl acetate ($CH_3COOC_2H_5$)
2. Ammonia (NH_4OH)
3. Benzene (C_6H_6)
4. Chloroform ($CHCl_3$)
5. Carbon tetrachloride (CCl_4)
6. Trichloro-ethylene (C_2HCl_3)

Destruction of Killing Bottles:

It is important in case of cyanide bottles, as the other kind of bottles with an absorbent layer for using liquid killing agents may be used over and over again.

The old cyanide bottles should be broken and buried in damp soil, taking care that dog or other animal may not dig it. Never get rid of it by throwing it into a stream.

PRESERVATION OF INSECT

After killing the insects, it is necessary to preserve them permanently for further study or display. Methods of permanent preservation can be categorised into 4 categories.

(1) Preserving the specimen dry (dry preservations)

(2) Keeping it in liquid.

(3) Immersing it in a resinous material.

(4) Mounting on a microscope slide.

DRY PRESERVATION

Insects with their external chitinised skeleton have great advantage over mammals or birds that most of them can be left out to dry naturally without offensive decay. The pinned and dried specimen is the most common and useful for ordinary purpose. Dried insects are extremely brittle and can be broken even with a slight touch, therefore, all manipulation of them should be completed while they are still fresh. That is why pinning as early as possible after collection is advised.

Drying and handing can be postponed by using ethyl acetate as a killing agent and having the specimen in the vapors. Simply keeping the specimens in a tin with moistened blotting paper will delay drying. Any fleshy specimens should be split open and the body contents should be removed, before decay can start and turn the specimen black.

When the person who is collecting is on a long journey and collecting the specimens daily for longer period, it is not possible to pin the specimen daily out of laboratory. After one or two days of collection the specimen will be quite hard and brittle. Such specimen requires relaxing or re-softening of the external skeleton for further studies.

RELAXING:

This can be done simply by keeping the specimen in a humid atmosphere until the integument absorbs enough moisture again to become soft. For this purpose, relaxing tins are prepared which are made of zinc or other rust less metal and these have tightly fitting lids. In the bottom there is fairly thick layer of cork and other synthetic cellular material of an absorbent texture. The absorbent layer is moistened with plain water. An exposure of 12-24 hours will be sufficient to relax most specimens but exceptionally big insects, old ones or greasy ones may take longer. To prevent mould or fungus in the relaxing tin, it is desirable to put in a liquid such as phenol or ethyl acetate.

SETTING:

This is also called stretching or spreading. This is the craft of arranging the soft, relaxed insects with its wings extended horizontally and allowing it to harden in that position.

Setting boards: Can be bought ready-made or easily made. The side boards are covered with cork and a groove in the middle to take the body and legs of the insect. This groove has underneath it a sheet of cork to allow an entomological pin to pass freely through it.

For setting of wings where both wings are membranous, they are set with the hind margins of the fore wing at right angles to the body and overlapping the hind wings, so that the pattern of the fore wing can be seen in its full. Where only hind wings are membranous as in Orthoptera, the fore margins of hind wings are arranged at right angles to the body and the forewings we drawn forwards to get the wings into position. A paper strip is used across the bases and to pin a broader strip across the rest of wing making sure that this is flat and uncreased. Thick pins (No. 2 or No. 3) can be used to flatten the wings.

The antenna may be held under the narrow strips of paper or may be positioned independently and held by pins. Similarly, the legs if they are to be displayed are teased into position with a pin and held there by crossed pins.

Upside down setting:

For bigger insects such as grasshopper which have a large body, upside down setting is recommended. The relaxed insect is pinned upside down on the plain sheet to cork and fixed with paper as before. The legs are stretched out and laid out in the same plane as the wings. When the setting is complete the main pin is removed.

The length of time taken for a specimen to harden depends on the amount of moisture present and on temperature and humidity doing drying. Generally, it takes about a week. After drying remove the pins used for stretching and finally draw the specimen out from setting board on its mounting pin. Put the label on the mounting pin at once and if possible put the specimen into a store box.

BLOWING AND STUFFING

Any insect that has large and soft abdomen will shrink badly on drying as well as discoloured by the decay of the internal tissues before drying is completed. In such case abdomen should be emptied as soon as the insect is dead. To empty in abdomen, the insect is placed on a hard surface and a round pencil is placed across the base of the abdomen. Rolling the pencil gently towards the tip of abdomen with moderate pressure cause the intestine to bulge out of the anus. The rolling is to be continued until all the contents of the abdomen have been pushed out then inflate the abdomen by blowing in its original shape and stuck the cut portion of anus by mending cement.

Insect larvae particularly caterpillars can be preserved dry by the similar process of rolling and flowing but in this case almost whole body is emptied and more care is needed when re-inflating to recover the true shape. It is advisable to keep larvae alive without food for a day or two so that much waste matter from the intestine may be removed. The larva is then killed in an ethyl acetate killing bottle and immediately rolled starting the pencil just behind the head when the skin is empty it is inflated and kept inflated during the period of drying in a warm atmosphere.

Blowing apparatus can be prepared easily. A piece of glass tube is drawn out until it is fine enough to be inserted into the anus of larvae. It is clamped in position by a wire clip made from watch spring. The skin can be inflated by

mouth but since it has to be maintained under pressure while it is drying upto a period of at least one hour, it is better to arrange some form of pressure reservoir. Rubber tubes with double bulb are available at medical stores or an ordinary scent spray bulb can be coupled to a simple reservoir made from toy balloon. In either case, the outer bulb is used to inflate the skin and the reservoir keeps up the pressure until the skin is dry.

Dry Preservation in the solid state:

PRESERVATION OF LARVA

If a soft bodied insect, particularly a larva is to be preserved dry without removing the interior part, it can only be protected against shriveling by removing the moisture either very slowly or very quickly. The very slow method has the advantage that it requires no apparatus but only common reagents. Freshly killed larvae should be used, but the dried larva can be softened again by immersing for one or two days in 2% caustic potash solution when they get their natural shape. They must be partially dehydrated by transferring first to 40%, then 70%, 80% and 95% alcohol. Fresh larvae are put straight into 95% alcohol.

Small larvae are kept in 95% alcohol for one week and bigger one for longer period. Then they are kept is absolute alcohol for 3 days which is changed daily. After this the larvae are treated as follows-

1. Transfer to a mixture of one part of xylol to two parts of absolute alcohol.

2. Then transfer in two parts of xylol to one past of absolute alcohol.

3. Finally transfer in pure xylol.

It would be better if they are kept for one day in each mixture. The finished specimen is bottled dry and may be pinned.

PRESERVATION OF SPECIMENS

1. Keep in 95% alcohol for 7 days
2. In absolute alcohol for 1 day
3. Change absolute alcohol, and keep for 1 day

4. Change absolute alcohol and keep for 1 day

5. One part of xylol + 2 part absolute alcohol for 1 day

6. Two parts of xylol + one part absolute alcohol for 1 day

7. Xylol for 1 day

Total 13 days are required for dehydration of specimen. Then dry and pin the specimen. This method has been described by Van Emden (1942)

METHOD OF PINNING AND VARIOUS NO OF PINS

Insects that can be pinned through the body are those of which the skin is tough enough to grip the sides of the pin, and strong enough to support the weight of the specimen. Very small, fragile or soft bodied insects are damaged or even ruined if they are pinned, so they must be struck on a card or celluloid point. Insect of a number of groups especially the small and soft bodied Apterygota, Thyasnoptera, aphids, lice, fleas and other parasitic group are unsuitable for study if they are preserved dry. They are preserved in liquid and mounted on a microscope slide.

Pinning should be done while the specimen is still fresh. If a hardened specimen is to he pinned, first it should be relaxed. At the time of pinning one should have the idea how the specimen is to be preserved so that a suitable pin is used from the start.

Pin and their Nos:

There are 3 series of Entomological pins, English, Continental and "Points" (or minuten)

1. English pins: offer a range, not only in thickness, but also of length, particularly in the range 18-30 mm.

English pins Nos – 9,10,11,13,16 and 20 are made of stainless steel. They are sold by weight ¼ or ½ and 1 ounce.

2. Continental pins: are used for direct pinning and so they concentrate on length, thinness and sharpness of point. They generally vary in thickness, but available in three lengths-

35 mm (Nos. 000,00,0 and 1-7)

38 mm (Nos. 8-10)

50 mm (Nos. 11-12)

Nos 2 and 3 are useful size for general use. Common nos. are 2,3,5 and 8 made of steel. They are sold in hundreds.

3. True minute: are very fine, black pins used for pinning the smallest and softest insects and are extremely fragile is use. they are used exclusively for staging.

DIRECT PINNING:

Direct pinning is done for bigger insects. A pin passes through the specimen and all the various labels, and still has enough length to insert firmly into the bottom of the box. The pin must be sharp as well as long. The drawbacks of direct pinning are-

(1) If the specimen is small it is difficult to choose a pin that suits the specimen and get stout enough to hold all the tables firmly and stick into the box without bending.

(2) Once the pin has been bent it is nearly impossible to get it truly straight again.

(3) At the time of taking off labels to read them, it may easily break the legs.

These risks are reduced by following 3 methods of double mounting, this is called Indirect pinning.

INDIRECT PINNING:

1. Staging:

Staging is done for those insect which are small to be pinned directly. They are pinned on to the support or stage. For medium sized insects, a stainless steel, headless pin is used because one with a head is liable to twist suddenly in the pinning forceps and damage the specimen.

For smaller insects, these are very fine black steel pins known as “minuten nadeln” or “minuten”.

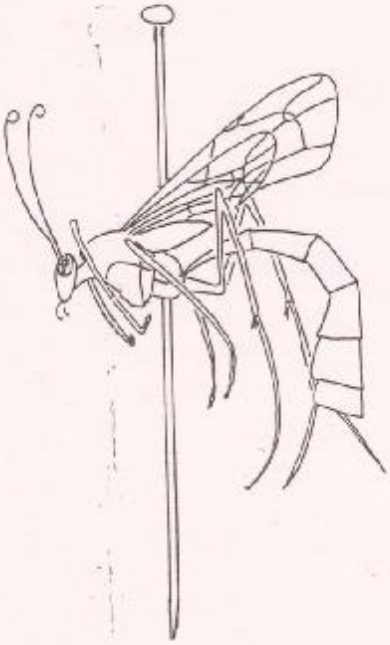
2. Carding:

A rectangle piece of white card may be used as a stage and the specimen is stuck on it instead of being pinned.

3. Pointing:

This is the best way of mounting the smallest dry insects. A small triangle is cut from the white card. Normally the tip of the point should be a little broader than the thorax of the insect to the mounted on it.

Mounting methods



large specimen

small specimen

Hymenopteran
parasite with host remains
on card point.

Mounting of large & small specimen

LABELLING

A specimen requires certain information for which labels are used. Without labels specimens are useless for taxonomic study.

Information on Labels:

(1) The name of the country should come first and should be written in full. The locality is essential.

(2) Detailed locality should be clear, and provide the information of place. Also part of the plant should also be mentioned.

(3) Date of collection

(4) Collector's name

India
Uttar Pradesh
CSAU, Kanpur
On flower
17.01.2021
N. Agrawal

STORAGE OF INSECTS IN BOXES

Permanent collection of pinned insects one kept either in store boxes or in cabinet of drawers.

Stores Boxes:

These may be either of wood or of card a board, but they should be strong. Boxes for permanent storage are invariably rectangular and flat so that they can easily the stacked in a pile or arranged neatly like books on a shelf. Size of box commonly ranges from 10 x 8" to 18 x 12". These boxes may be either single or double sided i.e. they may have specimens in the bottom only or in the lid as well. The pining material is cork, or one of the synthetic material and is covered with white paper. The wood of box should be well seasoned so that it may not turn out of shape. In the front wall of box there should be a small cell for holding

naphthalene or paradichlorobenzene. The depth of the box is generally about 1½" on each side, if double sided, including the soft lining material. Extra deep sized boxes are only needed for bigger insects.

Cabinets:

Cabinets consist of a number of glass topped drawers, each sliding on a pair of runner so that any drawer can be pulled out without disturbing the drawers above and below it. These drawers should be completely interchangeable without sticking or exerting any force.

LABELLING OF BOXES AND DRAWERS:

The labelling of boxes and drawers acts as a guide and an index to the collection. The boxes should be arranged in order, families, genera and species. The outside of box or cabinet drawers should have a general label either stuck on or fitted into a little frame. The label should bear the name of order of insects in capital, the family etc. Inside the drawer rectangular labels should be cut and fixed with short pins.

PROTECTION AGAINST PESTS, MOULD AND GREASE:

Most cabinet drawers and store boxes have a compartment at the front for preservatives. A piece of gauze or mesh in the wall of the box through which the fumes of the preservative can escape into the interior. The most convenient general preservative is flake of naphthalene. If there is no cell in the box flake of naphthalene should be wrapped in muslin cloth which is tied in the corner of box with the help of pins to avoid loose lumps in the box as they may damage the insects by shaking.

Moulds can be removed by cleaning the specimens in a solution of glacial phenol benzene in the ratio of 1:10 or a dilute formaldehyde.

Grease oozing out or the surface of a specimen can be dissolved by putting the specimen in benzene for few hours.

LIQUID COLLECTION

Soft bodied larvae and nymphs of most of the soft bodied insects are to be stored permanently in a liquid. The best liquid for general use is 70-80% ethyl

alcohol. Other liquid agents are chloral hydrate and pampel's fluid; Glacial acetic acid in 95% alcohol (industrial methylated spirit) 12 parts, chloroform 2 parts and glacial acetic acid 1 part. Fix for 12 hours then rinse the specimen in 80% alcohol and finally preserve in 80% alcohol, for the early stages of preservation. Formalin is also used for preservation but it should be avoided as it has a strong handing effect and is troublesome to the eyes and nose when the specimen is being examined under the microscope.

For liquid collection normally glass tubes are used and the size of tube depends on the size of specimens. It is very important to restrict the movement of the specimens otherwise they will soon breakup. These tubes are stored in jars which have the straight side walls, a little higher than the length of the tube and with a close fitting lid. The bottom of jar should be covered, either with two layers of blotting papers or shallow layer of cotton wool so that the tubes to do not strike against the glass bottom of jar. The sprit collection should be checked frequently to see that no tube ever dries up.

MAKING SLIDE MOUNTS

For making permanent slide mounts we have to do the following steps.

1. Removed of hardened or chitinised parts of the insect. It will be done by destroying all the soft, internal tissue leaving the rest soft and transparent.

2. These transparent portion are then stained or bleached as may be necessary.

3. Dehydration

4. Clearing in oil and finally immersed in Canada balsam or DPX on a slide to make a permanent mount

(1) Caustic Potash (10% KOH in water) used both to soften the specimen and to destroy the soft internal tissues. The soft to small specimen may be left in cold potash overnight. Bigger and more substantial specimens may be boiled for about 5 minutes and should have a small cut made in skin underneath the base of the abdomen to allow the potash to penetrate quickly.

(2) The next step is to rinse away potash as much as possible with tap water.

(3) Third step is dehydration of specimen. This is done in small dish like solid watch glass. Put glacial acetic acid in one dish and clove oil in other dish. Transfer the specimen with fine forceps in the glacial acetic acid for dehydration, then in clove oil for clearing.

(4) If the specimen is very dark even after washing it may be desirable to bleach it by immersing in a weak solution of bleaching power (NaOCl) or parazone and adding a drop or two of glacial acetic acid.

(5) To stain very transparent specimen such as skin of small larvae, small insects, wings etc., use a solution of Fuchsine in 2% alcohol. Put the specimen in glacial acetic acid and add a few drops of the stain.

(6) After this the specimen is to be put in glacial acetic acid for about 5 minutes to remove all the water from it. Transfer the specimen to clove oil or cedar wood oil for clearing. After clearing, display the specimen on glass slide and little Canada Balsam or DPX mountant is dropped on the specimen and cover it with cover slip. It takes few days to harden the mountant therefore, slide must be kept horizontal. Finally label the slides.

Direct mounting:

Small soft bodied insects may be mounted direct in one of the compound media such as de Faures, Gum Chloral, Polyvinyl lactophenol or Shellac gel. For these media, no treatment in potash nor dehydrating process is required and the specimen may be transferred direct from spirit or put into the medium while they one still alive.

APPENDICES

IMPORTANT DEFINITIONS:

Phylum: A large group of taxa (singular Taxon which include many classes).
Class: A unit of Classification in animal kingdom which is a part of the phylum and includes many orders.
Family: A classification category that includes a number of genera sharing one or a number of characteristics, ending in suffix "idae" (eg. Acrididae).
Genus: A special group or taxa of animals having similar characters which include many species. In the Binomial Nomenclature, the first name is genus which starts with capital letter.
Species: Groups of actually (or potentially) interbreeding natural populations which are reproductively isolated from other such groups.
Types: Whenever a new species or other group is described, a describer is supposed to designate a type, which is used as a reference, if there is ever any question what that species or group includes. The type of a species or subspecies is a specimen, the type of a genus or subgenus is a species and the type of a family or sub family is a genus.
Biotype: A population or group of individuals composed of a single genotype.
Genotype: In nomenclature, the type species of a genus (ef. Type species); in genetics, the class in which an individual falls on the basis of its genetic constitution, without regard to visible characters (ef. Phenotype)
Strain: A biological strain of an organism, morphologically indistinguishable from other members of its species but exhibiting distinctive physiological characteristics; particularly in regard to its ability to successfully utilize pest-resistant host organisms or to act as an effective beneficial species.
Holotype: Species selected by the author of the species from the type species.
Syntype: A series of specimens designated by the author of first species at the time of establishing species.
Lectotype: A specimen selected by reviser from among Syntypes.
Neotype: In case Holo, Syn or Lecto types are lost or destroyed, a new specimen is designated.
Specific name: "The binominal combination of a generic name and a specific trivial name which constitutes the scientific designation of a species" (International Commission 1948); also used by many workers and in the original rules in place of trivial name.
Scientific name: The binomial or trinomial designation of an animal, the formal nomenclatural designation of a taxonomic category.

Senior homonym: The earliest published of two or more identical names for the same or different taxonomic categories.

Senior Synonym: The earliest published of two or more available synonyms for the same taxonomic unit.

Primary homonym: One of two or more identical trivial names which, at the time of original publication were proposed in combination with the same (or an identical) generic name (eg- *X-us albus* Amith 1910 and *X-us albus* Jones 1920); the later of such primary homonyms are to be permanently rejected; also one of two or more identical names for genera or higher categories .

Secondary homonym: One of two or more identical trivial names which , at the time of original publication ,were proposed in combination with different generic names but which through subsequent transference, reclassification or combination of genera have come to bear the same (or an identical combination) trivial name (for nomenclatural status see Bulletin of Zoological nomenclature, 4:97 – 105 (1950).

Phylogeny: The study of the historical development of the line or lines of evolution in a group of organisms; the origin and evolution of higher categories.

Polytopic: Occurring in different places as, for instance, a subspecies composed of widely separated populations.

Polytypic: A category containing two or more immediately subordinate categories, as a genus with several species or a species with several subspecies.

Natural classification: As currently used, classification based on characters or groups of characters which indicate phylogenetic relationship.

Law of Priority: The provision in the international rules of zoological nomenclature that the correct name for a genus or species can be only that name under which it was first designated in conformance with the requirements laid down in these rules.

Hierarchy: In classification, the system of ranks which indicates the taxonomic level of various taxonomic categories (i.e. kingdom of species).

Sibling species: This name is applied to pairs or groups of very similar and closely related species. They occur commonly from protozoa to mammals. Sibling species are not a separate taxonomic category. They do not differ from other species in any respect for the miniatures of their structural differences.

Polytypic species: It was found that some species are wide spread and consist of many local populations. If these local populations are sufficiently distinct from each other they are called subspecies. Species that consists two or more subspecies are called polytypic species.

Monotypic species: Species which have no subspecies or which to be more precise consist of only a single subspecies are called monotypic species.

Super species: Super species is a monophyletic group of very closely related and largely or entirely allopatric species.

Subspecies: Subspecies are geographically defined aggregate of local populations which differ taxonomically from other such subdivisions of a species.

Not more than one subspecies can exist in breed condition in any one area. Adjacent subspecies interbreed or are potentially capable of doing so if separated by extrinsic barriers.

Origin of the Bionomial System:

January 1, 1758 is the starting date of all valid zoological names.

Zoological Nomenclature:

The role of nomenclature is to provide names for taxonomic categories in order to facilitate communication among biologists. They are bound by law of availability.

EXPECTED QUESTIONS FOR VIVA- VOCE:

Q1. In which order of insects do cerci are found?

Ans. Blattodea (Super order- Dictyoptera).

Q2. What is the position of head in Mantoidea?

Ans. Hypognathous.

Q3. To which family does silkworm belong to?

Ans. Bomycidae.

Q4. The hind wings in Dipterans are represented by a pair of?

Ans. Haltere.

Q5. What is the full form of CAB?

Ans. Commonwealth Agricultural Bureau.

Q6. What is the book written by Linnaeus on Taxonomy and in which year it was published ?

Ans. *Systema naturae*, 1735.

Q7. In which order fore wings are modified into leathery elytra?

Ans. Coleoptera.

Q8. What is the lowest category in classification?

Ans. Species.

Q9. Who introduced the term binomial nomenclature?

Ans. Linnaeus.

Q10. Who studied evolution of animals?

Ans. Darwin.

Q11.Who wrote the book “Principles of systematic zoology”?

Ans. E. Mayr.

Q12. Which order do dragonflies belong to?

Ans. Odonata.

Q13. To which family do *Holotricha consanguinea* belong to?

Ans. Scarabaeidae.

Q14.To which order and family Robber fly belongs to?

Ans. Diptera , Asilidae.

Q15. Which super family does mulberry silk moth belong to?

Ans. Bombicoidea.

Q16. Which order do bristle tails belong to?

Ans. Thysanura

Q17. Which order do chalcid parasite belong to?

Ans. Hymenoptera.

Q18. Which is the lowest category in classification?

Ans. Species.

Q19. Which is the smallest insect order and has been reported in 2002?

Ans. Mantophasmatodea.

Q20. How many suborders do order Lepidoptera divided into? Name them.

Ans. (i) Monotrysia (ii) Ditrysia.

Q.21. Name the Hemipteran insect and family which secrete sweet substance?

Ans. Aphid, Aphididae.

Q22. Give name of insect orders represented by the following taxa?

a) Cecidomyidae b) Noctuidae

Ans. (a) Diptera (b) Lepidoptera.

Q23. To which order do bristle tails belong to?

Ans. Thysanura.

Q24.To which family do ants belong to?

Ans. Formicidae.

Q25. What is the lowest category in classification?

Ans. Species.

Q26. Chalcid parasite belongs to which order and family?

Ans. Hymenoptera, Chalcididae

Q27. To which order does sliver fish belong to?

Ans. Thysanura.

Q28. In which order all the thoracic and abdominal ganglia have coalesced to form a single mass?

Ans. Hemiptera.

Q29. Which class do millipedes belong to?

Ans. Diplopoda.

Q30. Insects belong to which subphylum?

Ans. Uniramia.