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INSTRUCTIONAL MANUAL
ON
INSECT CLASSIFICATION AND SYSTEMATICS
ENT 504

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FOREWORD

Urbanization and industrialization pose a great threat to the soil, water and air specially in metropolitan cities of the country. The monitoring of such pollution is very necessary to reduce its adverse effect to some extent. The manual entitled "A LABORATORY MANUAL ON SOIL, WATER AND AIR POLLUTION" compiled by Dr. K.S. Bangar, Dr. U.R. Khandkar, Dr. V.K. Khaddar and Prof. B.B. Parmar, Department of Soil Science and Agricultural Chemistry, RVSKVV, College of Agriculture, Indore is a foot step to cover all the problems related to soil, water and air pollution. This manual includes recent methods used in the laboratory to judge the degree of pollution. The authors have incorporated various terminology used in the field of pollution in a systematic manner. In my opinion this manual gives in depth knowledge of pollution and its management in a very easy and helpful way to PG students of various departments of agricultural universities.

I congratulate the authors of this manual for their devotion in the field of soil, water and air pollution.

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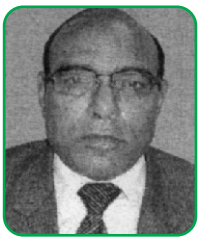

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FOREWORD

Physiology concerns with the functioning of living matter and living process at cell or tissue or organism as a whole. It is a science of life and takes into consideration the mechanisms to sustain life of an organism. A mass of matter in living state comprises of several chemical phenomenons and is regulated by physical laws and thus physiology is linked with biochemistry and biophysics. With the growth of physiology and its ever broadening scope of specialization, several branches exists like cellular physiology, general physiology, stress physiology, comparative physiology, environmental physiology, etc.

The manual contains very basic and practically useful information on processes such as solutions, mineral nutrition photosynthesis, respiration, transpiration, evapo-transpiration, growth and development responsible for crop production with the techniques to quantify and optimization of these processes for final economic yield production.

The pictures illustration the processes and techniques are very educative. I hope the Practical manual entitled "Experiments in Plant Physiology" will be very much useful for the students and the teachers. It seems to be of immense help to the under-graduate students of agriculture in understanding the basics of crop physiology and post-gradute students in carrying out their research studies.

I appreciate the efforts made by authors for publishing experiments in Plant Physiology manual.

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FOREWORD

The secrets underlying the vital processes of plants have attracted the scientists, the world over for centuries. The scientific basis of various metabolic processes have been periodically brought to light by untiring efforts of the plant Physiologists.

Crop Physiology is one of the most important subject to understand the biological processes and functions. Through the science of crop physiology it is possible to understand crop growth and development components of plant yield and their interactions. **The present attempt made by the authors to compile the practical aspects of crop physiological processes that impact production potentials of the crop plants is highly commendable.**

I am confident the present publication including practical aspects of the plant physiological processes would definitely enrich the students and earn laurels for its authors. I would strongly recommend it to the students and teachers of plant physiology.

Dr A.M. Rajput

INSECT CLASSIFICATION

Systematics: -

Systematics simply as the science of classification, making it synonymous with another widely used term taxonomy.

The major tasks of Systematics are:

(1) Identification.

(2) Description.

(3) Concern with the proper application of the rules of nomenclature.

(4) Study of speciation.

These tasks are typically carried out in sequential order for a given group of organisms. Systematics defined as the scientific study of kinds, diversity of organisms & of any or all relationships among them (Simpson, 1961). More simply Systematics is the science of diversity of organisms. It is Latin Greek word "system as applied to the systems of classifications.

Classification: -

The many hundred thousands of species descriptions would be practically impossible to deal with if they were not organized in some fashion. Such organization is necessary because of the differences between organisms and, at the same time, made possible by the similarities among them. By grouping organisms based on degrees of similarity, one can arrive at a system of classification.

Classification serves several purposes (Warburton, 1967): -

(1) Classification provides intellectual satisfaction for the taxonomists who make them.

(2) Make possible the identification of species and higher groupings.

(3) Provide a convenient practical means by which zoologists may know what they are talking about and others may find out.

(4) Provide a system of information retrieved.

(5) May reflect phylogenic relationships.

(6) May serve as summarizing and predicting devices.

The classification is the ordering of organisms into groups or sets on the basis of their relationships (Sneath & Sokal, 1973).

History: -

History of classification can be divided into six following periods.

First period: The study of local fauna.

Aristotle (384-322 Biological Classification) was the first man of biological classification. He was the first man to refer major groups including insects and distinguishing them as mandibulate and haustellate types and winged and wingless. Certain terms like Coleoptera and Diptera used by him persist today. The advances made by him dominated animal classification for next 2000 years. Aristotle, however did not supply, fully consistent classification of animals.

Second period: -

The great Swedish naturalist Linnaeus (1707-1778) exerted such an important influence on the entire subsequent development hence he was called the father of taxonomy. The binomial method of nomenclature was for the first time consistently applied by him to animals in the 10th edition of his systema naturae (1758).

Third period: - The Empirical Approach:

The hundred years between the 10th edition of "systema naturae" and the publication of Darwin's "origin of species" was a period of subtle but steady transition. The taxonomists more and more delimited taxa empirically on the basis of totality of characters, not just a few essential ones. Cuvier (1769-1832) was the influential during this time.

Fourth period: - Darwin & phylogeny:

Darwin realized that two processes occur during phylogeny: branching & subsequent divergence. According to him the taxa must be based on branching but that in the ranking of these taxa into various categories, due consideration must be given to different degrees of modification which they have undergone. The other contribution made by the Darwin was that he proposed a number of empirical rules on how to discover taxonomically useful characters.

Fifth period: - Population systematics:

The history of population systematics began in the first half of 19th century and reached its climax in 1930s and 1940s. In this period taxonomists moved from museum to field. They supplemented morphological characters with behavioral taxonomy.

Sixth period: - Current Trend:

The current period is characterized by three developments.

(I) Renewed examination of whole theory of taxonomy.

(II) The use of electronic computer and associated endeavors to revive nominalistic approach of taxonomy.

(III) Introduction of biochemical techniques and a grouping realizing among molecular biologists of the importance of phylogeny of the organisms.

Evolution of insect:-

Carpenter (1953, 1977) recognized four major stages in the evolution of primitive wingless insects.

1. Evolution of wingless insects: The first was the appearance of primitive wingless insects, which probably resembled contemporary bristle-tail and silverfishes (Order: Thysanura). These primitive apterygotes are thought to have arisen during the Devonian period. The Fossil record of apterygotes is poor because of less sclerotized exoskeleton which was not amenable to fossilization processes. In neither group is there evidence of wings or evidence that they are derived from ancestors that had wings. Thus they are grouped in a separate subclassfrom the wingless insects, called Aperygotea (A= without, Pteron= wing; Greek). The winged insects are grouped in subclass Pterygota. Apterygote insects according to some taxonomists also include three more orders: Protura, Diplura and Collembola. But their affinity is more with myriapod lineage rather than insect lineage.

2. Origin of wings: The second major step was the development of wings. After the origin of insects (terrestrial air breathing tracheate arthropod) the second landmark evolution was the origin of wing which has thought to have occurred prior to the Lower Carboniferous period.

The concentration of walking appendages in the midbody region, the thorax, was undoubtedly an important prerequisite for the later development of wings, required the evolution of a box like, well musculated thorax. The insects having wings and those lost their wings secondarily are grouped in the subclass Pterygota.

The origin of wings is a matter of some dispute. Insect wings are not modified appendages but are entirely new structures arising as outgrowths of dorsal parts of the integument of the mesothorax and metathorax. Following theories have been put forth to explain the origin of wings:

(a) Flying-fish theory: Jarmila Kukalova-Peck of Canada has hypothesized that ancestral pterygote insects were aquatic and evolved movable masculated gill plates on most body segments, comparable to those on the abdomen of immature mayflies today. Living on swampy forests, they may have found it advantageous to climb out of the water to feed on vegetation or escape enemies, and the gill plates could have helped to break falls and to glide to other pools with a flapping motion. Those gill plates toward the centre of balance eventually became enlarged to serve as wings. This is sometimes called "flying fish" theory of wing origin.

(b) Flying squirrel theory: Followers of this theory believe that the ancestral pterygote insects were terrestrial and arboreal. They have developed lateral flangers of the thorax, which at first served for glinding from tree or to the ground. Later, they developed the hingers and musculature necessary for true flight. It is noteworthy that some of the machilids are able to jump and have lateral extensions of the sides of the thorax. The cockroaches, which are earlier generalized insects, include many arboreal species having lateral thoracic flangers in the immature stages and on the prothorax as adults.

(c) Solar- collector theory: Mathew M. Douglas has suggested that the lateral lobes that were precursors of wings may have served a role in thermoregulation, i.e., they may have served as plates to absorb heat. Thereafter, this structure is transferred to the leg muscles, enabling the insect to run, to seek food or escape from enemies at lower temperatures than might otherwise be possible.

Of course, these theories are not mutually exclusive. Thoracic lobes serving originally for thermoregulation might also have served in sexual display (as they are beautifully coloured) and for gliding about in vegetation: then at a later stage, they may have developed sufficient size and an adequate hinge mechanism and musculature to permit true flight.

3. Evolution of wing flexing mechanism: The third major evolutionary advance appears to have occurred prior to the Lower Carboniferous period. This was the development of a wing-flexion mechanism, which enable insects to flex the wings posteriorly over the abdomen, the neopterous (“new winged”) condition. This added the advantage of being able to run and hide from predators and to move into niches in appropriate forms with continuouently outstretched wings. The neopterous insects subsequently radiated rapidly and became dominant group of insects, as they are today. They comprise 90% of the contemporaray orders and 97% of the total number of species (Carpenter 1953). Among extant order, only apterygotes and the Odanata and Ephemeroptera are not neopterous. The extinct order Diaphanopterodea, although closely related to the paleopterous Megasecoptera and paleodictyoptera, and was able to fold its wing. Kuklalova-peck (1974) has shown that the detailed mechanisms of wing fluexure were different than, is found in the true neopterous insects. This apparent

convergent evolution of wing folding should reinforce the need for careful evaluation even in the case of very careful evaluation of homology, even in the case of very complex characters.

4. The evolution of pupal stage: The fourth and final step in insect evolution provided insects with further opportunities to exploit their environments. They developed the capacity to retain their wing pads internally, as imaginal discs, hence they are called Endopterygota. Since wing development is suppressed in the immature stage, the wings must be developed rapidly prior to emergence of the adult, winged form. Thus, an additional, sedentary stage, the pupa, is interposed between larva and adult. Endopterygote insects are said to have complete metamorphosis (Holometabolous insects).

Based on Carpenter's four major evolutionary stages in insects: class Insecta may be divided into groups as follows:

Apterygotes---primitively wingless insects

Pterygotes---winged insects

Paleopterous exopterygotes---wing-flexion mechanism lacking; simple metamorphosis.

Neopterous exopeterygotes---wing- flexion mechanism present; simple metamorphosis

Neopterous exopeterygotes---wing- flexion mechanism present; complete metamorphosis

A widely held concept of the phylogenic relationship between these various groups, this caladogram is superimposed on a geological time scale to indicate approximately when each group originated. The grouping of insect as listed above, has served as the basis of organization. Since fossilization occurs only under certain very uncommon circumstances, the fossils consist mainly of wings, but various other body parts are also commonly represented. In addition to representation of most extan orders (Zoraptera, Grylloblattodea, Mallophaga, and Anoplura) in the fossil record, 52 extinct orders of insects have been described by paleoentomologists. Many of these orders are based on very limited data, such as isolated wings or wing fragments. Carpenter (1977) reduced the number of recognized extinct orders significantly by applying the following criteria; "My acceptance of an extinct order requires the knowledge of both fore- and hindwings (in the case of pterygota) and the nature of the head, including mouthparts." On this basis 10 extinct orders can be recognized.

Apterygotes

Order: Monura

Pterygotes

Paleopterous exopterygotes

Order: Palaeodictyopetera

: Megasecoptera

: Diaphanopterodea

: Protodonata

Neopterous exopterygotes

Order: Protorthoptera

: Caloneurodea

: Miomoptera

: Protlytroptera

Neopterous endopterygotes

Order: Glosselytrodea

Kinds of classification: - There are basically three schools of thought regarding classification, phenetics, cladistics and evolutionary systematics (Mayr, 1982).

Phenetics: The systematists who base their classification entirely on the characters of the organisms without any direct reference to their evolutionary history.Michener (a bee taxonomist) and Sokal (1957) described pioneered phenetic classification.

Cladistics: Those systematists who base the classification entirely on the recency of common ancestry, ignoring similarities and differences between existing organisms.Willi Henning (1965, 1966) initiated the cladistic method of classification.

Evolutionary systematics: The evolutionary systematist recognizes that, when a new species arises, it accumulates many unique features through evolutionary processes and these features help the scientist assign this organism to its proper category.

Component of Biological Classification: -

Four components form the basis for most systems of biological classification.

(1) Hierarchy: - "A systematic framework for zoological classification with a sequence of classes (or sets) at different levels in which each class except the lowest, include one or more subordinate classes".

(2) Taxon: - "a group of real organisms recognized as a formal unit at any level of a hierarchic classification".

(3) Category: - "a class, the members of which are all the taxa, placed at a given level in a hierarchic classification".

(4) Rank: - "a category's absolute position relative to other catagories".

Thus insect (taxon) is a class (catagory) that in a widely accepted biological hierarchy, ranked between super class and subclass .

Hierarchy of generally accepted taxonomic catagories:-

Kingdom → Phylum → Sub phylum → Super class → Class → Sub class

Cohort → Super order → Order → Sub order → Super family (Oidea)

Family (Inae) → Sub → family (-inae) → Tribe (-ini) → Genus → Sub genus

Species → Sub species.

Taxonomy and various schemes of classification of class Insecta:

The insect have invaded almost all habitats. They occur commonly everywhere and differ widely in their form, structure and behavior in relation to the mode of life, they adapted. Till now, about 7, 15,000 species of living insects and 12,000 species of fossil insects have been recorded and yet a large number of species to be discovered in future. Due to these facts the insect taxonomy is a very exhaustive and growing branch of Entomology.

Foundation of taxonomy was first laid down by Linnaeus (1758-68). He classified an entire group of insect into nine orders. With advancement, numbers of orders have been re-organized and added from time to time.

Fabricius (1775), Latreille et al (1831), Brauer (1885), Handlirsch (1908), Boerner (1904), Imms (1925), Tillyard (1926), Brues and Melander (1932), Weber (1933), Wilson and Doner (1937), M artynov (1938), Essig (1942), Jeanal (1949), Melandes and Corpentar (1954), Henning (1953), Bey-Biyenko (1962) and other workers made several modifications and additions in the original system of classification of Linnaeus. Braur (1885) divided the class insecta into tow sub class, Aptenygota and Pterygota consisting 16 orders. With the discovery of fossil insects the classification received new dimensions after Handlirsch (1908). Breues and Melander (1932) recognized 34 orders and Martynov (1934) 40 orders, while Imms (1925-51) designed 23 orders of instinct insects and 11 of extinct ones.

The modern scheme of classification was initially proposed by Imms (1925-51) and later on modified by Richards & Davis (1957) and adopted universally as it is justifying phylogenetic interrelationships among various groups of insects and their evolutionary trends.

Various Classification Schemes of Class Insecta:

No.	Scheme classification	Sub class	Super order	Order
1.	Linnaeus 1758 (9orders) based on Wing structure & Evolution.	-	-	1. Coleoptera. 2. Orthoptera. 3. Hemiptera. 4. Lepidoptera. 5. Nueroptera. 6. Hymenoptera. 7. Diptera. 8. Thysanoptera. 9. Aptera.
2.	Fabricius 1775 (8orders) based on Mouth parts.	-	-	1. Eleutherata (Coleoptera). 2. Vlonata (Orthoptera, Blattidae, Dermoptera). 3. Synislata (Ephemera, Phryganes, Apterygota, Perlides, Neuroptera, Psocoptera, Panorpes, Hymenoptera, Isoptera,

				Crustacea). 4. Agonata (Scorpions and Crustacea). 5. Unogata (Libellula, Myriapoda, Arachnida). 6. Glossata (Lepidoptera). 7. Rhynchota (Hemiptera, Aphaniptera, Thysanoptera). 8. Antiliata (Diptera, Anoplura, Mallophega, Arachnida, Crustacea).
3.	Litreille 1831 (12orders) based on Wings & Mouth parts.	I.Aptera II.Alata	- a.Elythroptera b.Gymnoptera	1. Thysanura (Aptererygota). 2. Parasita (Mallophega). 3. Siphonaptera (Aphaniptera). 4. Orthoptera (+Blattidae). 5. Coleoptera. 6. Dermoptera. 7. Hemiptera. 8. Neuroptera (+ Odonota + Ephemerids + Panorpes + Psocids + Isoptera + Embioptera). 9. Hymenoptera. 10. Lepidoptera. 11. Rhipiptera (Strepsiptera). 12. Diptera.
4.	Braur 1885 (17orders) Based on Metamorphesis, Wing, Mouth parts & Malpighian tubules.	I.Apterygota II.Pterygogenea	- -	1. Synaptera (Collembola + Thysanura). 2. Dermoptera. 3. Ephemerida. 4. Odonata. 5. Placoptera. 6. Orthoptera. 7. Corrodentia. 8. Thysanoptera. 9. Rhynchota. 10. Neuroptera. 11. Panorpatae. 12. Trichoptera. 13. Lepidoptera. 14. Diptera. 15. Siphonaptera. 16. Coleoptera. 17. Hymenoptera.
5.	Sharp 1899 (21orders).	I.Apterygota II.Anapterygota	- -	1. Collembola. 2. Thysanura. 3. Mallophaga. 4. Anoplura (Siphunculata).

		III.Exopterygota IV.Endopterygota	- -	5. Siphonaptera (=Aphaniptera). 6. Orthoptera (+Dermoptera). 7. Perlidae (=Placoptera). 8. Psocidae (Psocoptera). 9. Termitidae (Isoptera). 10. Embiidae (=Embioptera). 11. Ephemeridae (Ephemeroptera). 12. Odonata. 13. Thysanoptera. 14. Hemiptera. 15. Neuropteran (+Mecoptera). 16. Trichoptera. 17. Lepidoptera. 18. Coleopteran. 19. Strepsiptera. 20. Diptera. 21. Hymenoptera.
6.	Shipley 1904 (22orders)	I. Apterygota II. Anapterygota III. Exopterygota IV. Endopterygota	- - - -	1. Aptera (=Thysanura). 2. Apontoptera (Collembola). 3. Lepoptera. 4. Elipoptera (=Siphunculata). 5. Apheniptera. 6. Orthoptera. 7. Placoptera. 8. Psocoptera. 9. Isoptera. 10. Embioptera. 11. Ephemeroptera. 12. Paraneuroptera. 13. Thysanoptera. 14. Hemiptera. 15. Neuropteran. 16. Mecoptera. 17. Trichoptera. 18. Lepidoptera. 19. Coleoptera. 20. Strepsiptera. 21. Dipteral. 22. Hymenoptera.
7.	Boerner 1904 (22orders)	I. Apterygota II. Pterygota	- - A. Hemimetabola	1. Thysanura (Ectognatha). 2. Diptura (Entoganatha). 3. Collembolan. 4. Odonata. 5. Agnatha 6. Dermaptera. 7. Placoptera. 8. Isoptera. 9. Orthoptera. 10. Coorodentia (=Psocoptera +Mallophega).

			B. Holometabola	11. Thysanoptera. 12. Rhynchota. 13. Siphunculata. 14. Macoptera. 15. Diptera. 16. Suctoria. 17. Hymenoptera. 18. Neuroptera. 19. Trichoptera. 20. Lepidoptera. 21. Colcopteran 22. Strepsiptera.
8.	Handlirsch 1908 (34orders)	I.Orthopteroidea	-	1.Orthoptera (=Sattatoria). 2.Phasinoidea (=Phasmidaes). 3.Diploglossata (=Hemimeridae). 4.Dermaptera. 5.Thysanoptera.
		II.Blattaeformia	-	6.Mantoidea (=Matidae). 7.Blattoidea (=Blattidae). 8.Isoptera. 9.Corrodentia (Psocoptera). 10. Mallophaga. 11. Siphunculata. 12. Hymenoptera.
		III.Panorpoidea	Hymenopteroidea Coleopteroidea Embidaria Libelluloidea Ephemeroidea Perloidea Nueropteroidea Hemipteroidea	13. Coleoptera. 14. Strepsiptera. 15. Emboiea (Embioptera). 16. Odonata. 17. Placoptera (=Ephemeroptera). 18. Parlaria (=Placoptera). 19. Megaloptera (=Sialoidea). 20. Raphidioidea. 21. Neuroptera. 22. Panorpatae (=Mecoptera). 23. Phryganoidea (=Trichoptera). 24. Lepidoptera. 25. Diptera. 26. Suctoria (=Aphaniptera). 27. Hemiptera (=Heteroptera). 28. Homoptera. 29. Arthopleona. 30. Symphypleona. 31. Dicellura (Japygidae).
		IV.Collembola V.Campodeoidea I. Thysanura		32. Rhabdura (=Projapygidea +Compodeidae). 33. Machiloidea (=Machilidae). 34. Lepismatoidea (=Lepismatidae).

9.	Bruce & Melander 1932 (34orders)	I. Apterygota	A. Thysanura	1. Thysanura. 2. Aptera.
			B. Collembola	3. Collembola.
			C. Protura	4. Protura.
		II. Pterygota	A. Exopterygota (Heterometabola)	5. Emphemerida. 6. Plecoptera. 7. Odonata. 8. Embioptera. 9. Grylloblattoidea. 10. Orthoptera. 11. Phasmida. 12. Dermaptera. 13. Diploglossata. 14. Blattaria. 15. Mantoidea. 16. Isoptera. 17. Zoraptera. 18. Corrodentia 19. Mallophaga. 20. Anoplura. 21. Thysanoptera 22. Heteroptera. 23. Homoptera.
			B. Endopterygota (Holometabola)	24. Coleopteran. 25. Strepsiptera. 26. Hymenoptera. 27. Megaloptera. 28. Neuroptera. 29. Rephidiodea. 30. Mecoptera. 31. Trichoptera. 32. Lepidoptera. 33. Diptera. 34. Siphonaptera.
10.	Martynov 1938 (40orders)	I. Apterygota	A. Entotrophi	1. Collembola. 2. Protura. 3. Diplura.
			B. Electotrophi	4. Thysanura.
		II. Pterygota	A. Palaeoptera	5. Eupalaeodictyoptera.
			B. Polyneoptera	6. Protohemiptera. 7. Meganisoptera.
			C. Oligonieoptera	8. Protephemeroidea. 9. Palaeoptera (Ephemerida).
			D. Paraneoptera	10. Meganisoptera. 11. Odanata. 12. Dictyoptera. 13. Protoblattoidea.

				14. Isoptera. 15. Zoraptera. 16. Protothoptera. 17. Plecoptera. 18. Notoptera (=Grylloblatoidea). 19. Cheleutoptera (=Phasmida). 20. Orthoptera. 21. Embioptera. 22. Protelytroptera. 23. Dermaptera. 24. Coleoptera. 25. Megaloptera. 26. Raphidioptera. 27. Planipennia. 28. Mecoptera. 29. Trichoptera. 30. Lepidoptera. 31. Diptera. 32. Siphonaptera. 33. Hymenoptera. 34. Strepsiptera. 35. Psocoptera. 36. Mallophaga. 37. Anoplura. 38. Thysanoptera. 39. Homoptera. 40. Heteroptera.
11.	Imms 1951 (23orders)	I. Apterygota II. Pterygota	 A. Exopterygota (Hemimetabola) B. Endopterygota (Holometabola)	1. Thysanura. 2. Protura. 3. Collembola. 4. Ephemeroptera. 5. Odonata. 6. Plecoptera. 7. Orthoptera (+Grylloblatodea, Phasmida, Dictyoptera). 8. Dermaptera. 9. Embioptera. 10. Isoptera. 11. Psocoptera (+Zoraptera). 12. Anoplura. 13. Hemiptera. 14. Thysanoptera. 15. Neuroptera. 16. Mecoptera. 17. Lepidoptera. 18. Trichoptera. 19. Diptera. 20. Aphaniptera (=siphonaptera).

				21. Hymenoptera. 22. Coleoptera. 23. Strepsiptera.

MODERN SCHEME OF INSECT CLASSIFICATION

(Richards & Davies (1957)

Sub Class	Division	Orders
I. Apterygota	a.Ectognatha	1. Thysanura.
	b.Entognatha	2. Diplura.
		3. Protura.
		4. Collembola.
II. Pterygota	a.Exopterygota	
	I.Palaeopteron orders	5. Ephemeroptera.
		6. Odonata.
	II.Polyneopteron orders	7. Plecoptera.
	(Orthopteriod gp)	8. Grylloblattoidea.
		9. Orthoptera.
		10. Phasmida.
		11. Dermaptera.
		12. Embioptera.
		13. Dictyoptera.
		14. Isoptera.
		15. Zoraptera.
	III.Paraneopteron orders	16. Psocoptera.
	(Hemipteroid gp)	17. Mallophaga.
		18. Siphunculata.
		19. Hemiptera.
		20. Thysanoptera.
	b.Endopterygota (Holometabola)	21. Neuroptera.
	Oligoneopteron orders	22. Mecoptera.
	(Panorpoid Complex)	23. Lepidoptera.
		24. Trichoptera.
		25. Diptera.
		26. Siphonaptera.
		27. Hymenoptera.
		28. Coleoptera.
		29. Strepsiptera.

Sub Class I: Apterygota

Traditionally the groups included in the term "apterygote hexapods" namely, the Collembola, Protura, Diplura and Thysanura (including Microcoryphia and Zygentoma), were considerd orders of primitively wingless insecs and placed in the sub class apterygota.

Characters:

- Apterous insects.
- Wingless condition presumed to be primitive.
- Metamorphosis slight or absent.
- Adult with one or more pairs of pregenital abdominal appendages.
- Adult mandibles usually articulating with the head capsule at a single point.

Orders: - 1.Collembola 2.Protura 3.Diplura 4. Microcoryphia and 5.Zygentoma (Thysanura).

Sub Class II: Pterygota

Characters:

- Winged or secondarily apterous insects.
- Meta-morphosis varied, rarely slight or wanting.
- Adults without pregenital abdominal appendages.
- Adults mandibles, unless highly modified, articulating with head capsule at two points.

Division-I: Exopterygota (Hemimetabola): Metamorphosis simple, sometimes slight. The pupal instars rarely present. The Wings developed externally. Immature stages generally nymphs which usually resemble adults in structure and habits.

Order 6. Emphemeroptera

Order 7. Odonata

Order 8. Plecoptera

Order 9. Embioptera

Order 10. Dictyoptera

Order 11. Isoptera

Order 12 .Grylloblatoidea

Order 13. Dermaptera

Order 14. Phasmida

Order15. Mantophasmatoidea

Order 16. Orthoptera

Order17. Zoraptera

Order18. Psocoptera

Order19. Phthiraptera

Order120 .Hemiptera

Order21. Thysanoptera

Division-II: Endopterygota (Holometabola). Metamorphosis complex and accompanied by pupal instars. Wings developed internally. Immature stages are larvae which differ from adult in structure and habits.

Order22. Mecoptera

Order23. Diptera

Order24. Siphonaptera

Order25. Trichoptera

Order26. Lepidoptera

Order27. Megaloptera

Order28. Raphidioptera

Order29 .Neuroptera

Order30 .Coleoptera

Order31 . Strepsiptera

Order32 . Hymenoptera

Apterygota Hexapods:

There are five orders of the primitive apterous insects. They are Microcoryphia, Zygentoma, , Diplura, Protura and Collembola. They do not show distinct metamorphosis but undergo moulting several times even after attaining the sexual maturity. Only Lepismatidae of Zygentoma (Thysanura) among apterygota resemble with Pterygota in some respects.

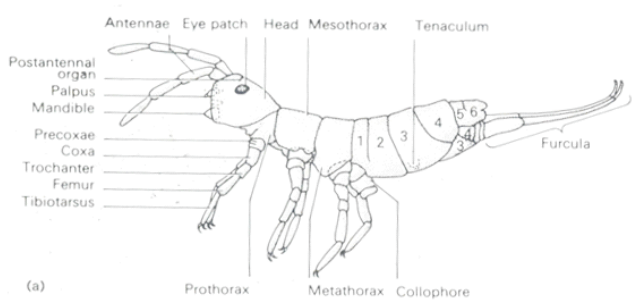
The Apterygota characterized by ectognathous bitting mouth parts,11 segmented abdomens with lateral styliform pregenital segmented appendages, a pair of cerci and a long median caudal filament

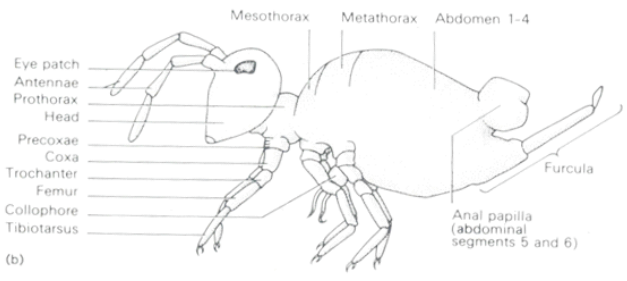
1. Order: Collembola: (Springtails)

Apterygota with entognathous biting mouth parts, 6 segmented abdomens and with a springing apparatus but without compound eyes They occur under stones, soil, decoying vegetables among garbage, bark of trees, on fresh marine water, in termite nests, Cosmopolitan.

Characters:

- Body is covered with hairs & scales, pigmented, white grey, green or black.
- Head is pro or hypognathous.
- Antennae are four segmented, variable in length, bearing receptors on the last two segments, modified as gripping organs in the male Smithuridae.
- Ocelli are variable number but only up to 8 on each side. A pair of ring or rosette like post antennal organs functions as the chemo receptors.
- Mouth parts are elongated & sunk in the head cavity, piercing, sucking or biting-chewing type, mandible mono condylic, slender with toothed extremities and rotary movements, palpi vestigial.
- Super linguae are well developed, lamellate structures above the hypopharynx, labrum well distinct but labium degenerated.
- Thorax is three segmented but prothorax reduced.
- Fore legs are equal in size, without tibio tarsal joint, with a pair of claws or one may be vestigial or absent, Trochanter with a hairy trochanteral organ.





Collembola, Springtails. (a) Arthropleonid. (b) Symphypleonid.

- Abdomen is composed of only six segments.
- Abdominal appendeges - (a). 1st abdominal segment with a ventral tube functioning as a respiratory, Osmoregulatory or adhesive organ.

  (b) 4th abdominal segment bears a jumping organ or furca.

  (c)The 3rd abdominal segment bears a pair of retinaculum or hamula.
- External genetalia absent, cerci absent.
- One or two pairs of salivary gland present. A pair of labial nephridia present.
- Nervous systems with a brain, sub oesophageal & three thoracic ganglia, Corpora allata well developed.
- Heart is a six chambered structure.
- Fat body functions as excretory.
- In Tracheal system tracheae absent in Poduridae, but Sminthuridae with a pair of spiracles in between head end prothorax. Trachea of head thorax and abdomen remain unbranched and separated.
- In Reproductive system testes and ovaries are paired but not sac like structures without ovarioles or testicular follicles. No accessory glands, in male or female gonophores present on 5th abdominal segment.
- Metamorphosis absent and maturity is attained after 4 of 7 moults.

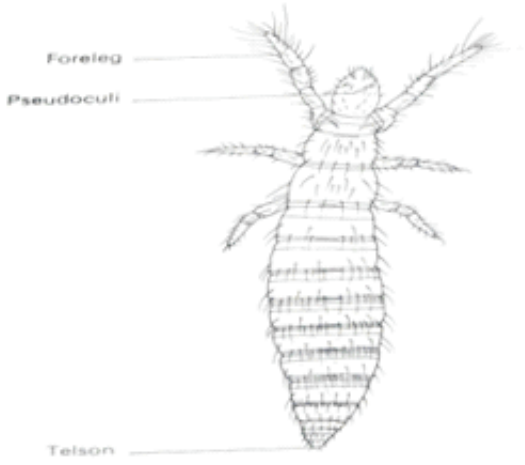
  Ex. Exelsonia & Annurida sp.

2. Order: protura: (Acerentulus barberi barberi Ewing)

Minute soft bodied, unpigmented Apterygota having entognathous piercing mouth parts, compound eyes absent. Occur in moist soil, under stones & beneath bark. Cosmopolitan, 200 species are found.

Characters:

- Minute whitish insects, 0.5-2.5 mm long.
- Head is prognathous, pyriform & narrow anteriorly.
- Mouth parts is piercing sucking type. Labium, mandibles and maxillae are modified into paired stylets. Labrum is pointed or vestigial while hypopharynx present superlinguae absent.
- Antenna absent or reduced into fine tubercles.
- Thorex with reduced Pronotum.
- Legs are long with 1 segmented tarsi and a single claw. The forelegs are long, sensory and function as antennae.
- Abdomen slender & long. Each first three abdominal segments carry a pair of appendages.
- Cerci absent but telson are present.
- External genetalia: Developed behind 11th segment. Male & female consist of a pair of stylests. Male has two gonopores on 11th segment while female bears only a single gonopore



Protura, Acerentulus barberi barberi Ewing

- Malpighian tubules are represented by six minute papillae.
- Cephalic glands are two pairs of maxillary and a pair of labial glands.
- Tracheal systems absent except in Eosentomidae and Sinentomidae provided with only two pairs of spiracles.
- Nervous systems consist of brain, fused sub oesophageal prothoracic ganglion, meso-metathoracic ganglia and six abdominal ganglia.
- Endocrine gland single corpora cardiaca and pair of corpora allata.
- Female reproductive systems consist of a pair of ovaries, oviducts and vagina. Ovary represents a single panoistic ovariole.
- Male reproductive systems consist of a pair of testes, as a pair of elongate sacs united interiorly. Vasa deferentia open independently through a pair of male gonopores.

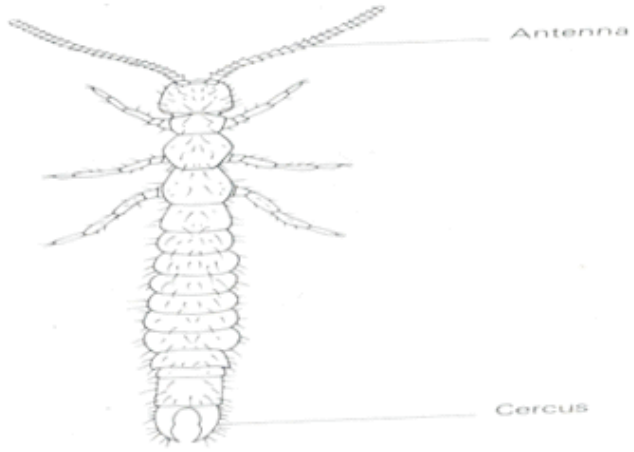
  Ex. Eossentomon.

3. Order: Diplura: (Ex. Projapyx Japyx sp)

The minute flattened apterygota consisting entognathous biting mouth parts, unsegmented tarsi, abdominal segments with paired lateral preginital styliform appendages with a pair of cerci of variable form but without compound eyes, ocelli medium, median terminal filament and Malpighian tubules. Concealed conditions under stones, wood, among fallen leaves or in soil. Cosmopolitan, about 600 species in world and it species in India.

Characters:

- Insects are Soft bodied, unpigmented, wingless, small insect.
- Head is prognathous, oval or quadrangular in shape; clypeus and labrum are well distinct.
- Antennae are long, many segmented, setaceous provided with intrinsic muscles.
- Mouth parts Biting, chewing type but reduced and sunk into head cavity. Mandible elongated, dentate and apically serrated, monocondylic, maxillary and labial palps are reduced into a single segment. Hypo pharynx, superlingue and ad mental plates are distinct.



Diplura, Japyx diversiungus (Mi.)

- Thorax Three segmented, prothorax is smallest one. Thoracic sterna are sub divided by transverse suture. Legs with one segmented tarsi and two pre-tarsal claws.
- Abdomen 11 segmented, Ist or IInd to VIIth abdominal segments with lateral stylliform appendages and some segments with paired eversible vesicles except in projapygidae and the last abdominal segment possesses a pair of cerci, filament elongated in Campodeidae, short, robust in projapygidae and stout hard forceps like organs in japygidae.
- Cephalic glands: Head bears some exocrine, buccal & labial or excretory glands.
- Malpighian tubules: represented by small papillae except Japyx.
- Nervous system: central, stomatogastric and retrocerebral complex are well developed brain, sub esophageal, 3 thoracic & 7-8 abdominal ganglia are present.
- Respiratory system: spiracles are arranged in unusual fashion.
- In campodea two pairs on mesothorax, one on metathorax. Trachea remains unconnected, tracheae without spiral thickening, Abdominal spiracle absent.
- In Heterojapyx and Japyx four thoracic & seven abdominal pairs of spiracles are present & longitudinal trunk unites trachea of either side. There is only a single transverse commissure in between 9th & 10th abdominal segment.Nine pairs of spiracles in Parajapyx and Anajapyx and ten in Projapyx.
- Dorsal Vessel: unique Japyx heart is composed of 10 chambers and in campodea has nine chambers.
- Reproductive system: In female: In Campodea a pair of large polytrophic ovaries but in others panoistic ovaries.
- In Japyx, ovary bears seven metamerically arranged ovarioles on each side, while two pairs in Anajapyx. Accessory glands are wanting.
- In male Campodea and Japyx bear a pair of large testis and Anajapyx bears two testicular metameric lobes.
- Development Direct Campodea survives 2-3 years & moult 20 times in a year.

  Ex. Projapyx Japyx sp.

4.Order: Microcoryphia :(bristletails.)

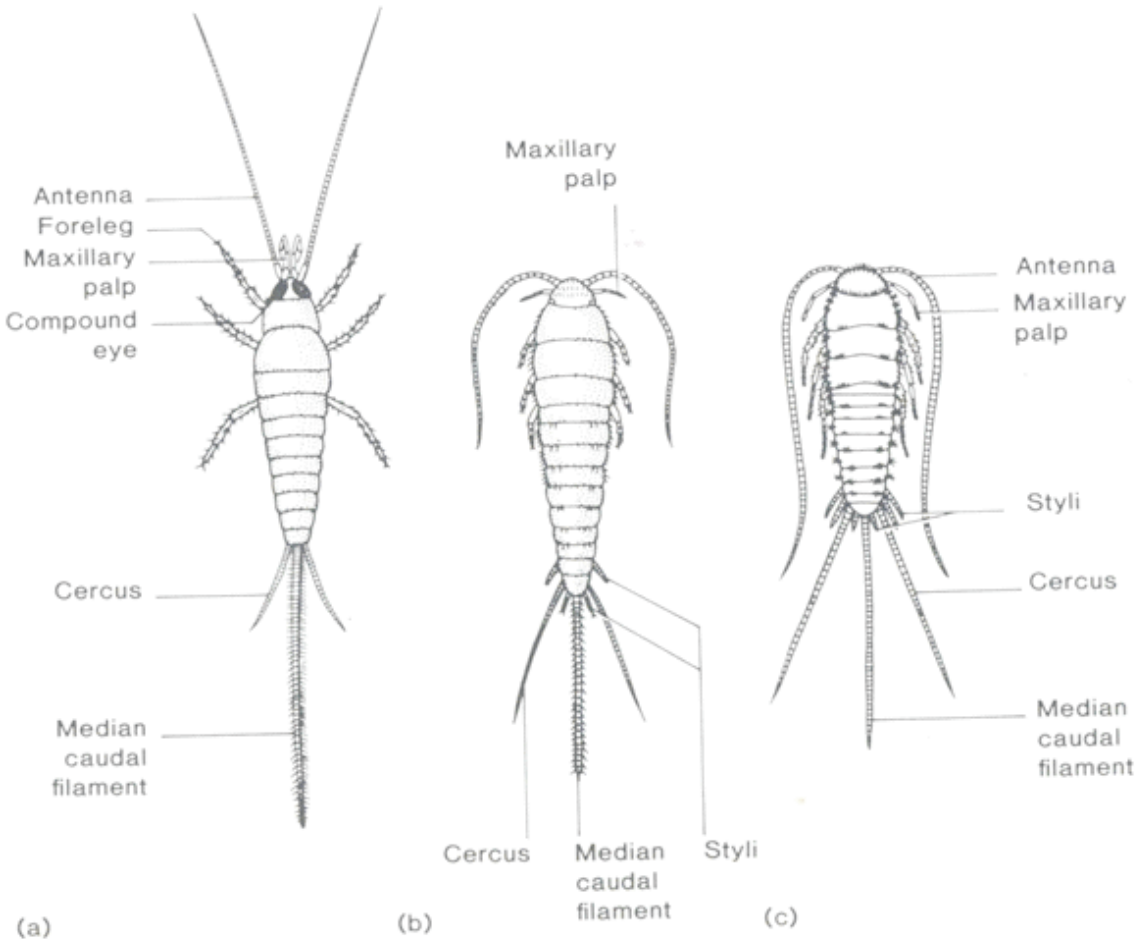
Small or moderately sized apterygote insect, head with long multiannulate antennae, large contiguous compound eye, oeclli, ectgnathous chewing mouthparts, mandibles with single articulation, maxillary palp seven segmented. Thorax strongly arched with terga extending over plura. Legs with three (rarely two) tarsal segments. Abdomen 11 segmented, though 10th segment reduced and tergum of 11th forming median caudal filament, paired styli present on each abdominal segments, long cerci with multiple subdivisions present.

A Machilis sp

5. Order: Zygentoma (Thysanura): (silverfish, firebrats)

They are mostly adapted for a concealed life in the soil, rotting wood, under stones, in the leaf deposits of forest floors, nests of ants and termites, in books, wooden furniture, kitchens etc. Cosmopolitan, about 550 species in the world, while 22 species in India, are recorded. Characters:

- Body is 1- 50 mm long, spindle shaped, dorsoventrally flattened, covered with scales, giving metallic silvery white, grey or brownish colouration.
- Head is prognathous.
- Antennae are filliform and composed of more than 40 segments.
- Compound eyes are large, or reduced or even wanting.
- Mouth parts are ectognathous, biting chewing type.
- Thorax distinct, terga are laterally extended into large paranotal lobes.
- Legs are equal size with a pair of claws.
- Abdomen X 1 segment bears a pair of long cerci and a median long filament.
- Abdominal Appendages each segment bears a pair of styliform appendages and one or two median eversible vesicles.
- External Genetalia 8th & 9th abdominal segments possess an ovipositor in female & male genetalia in male.
- Alimentary canals differentiated into three parts foregut, midgut & hindgut. The foregut bears a gizzard (Lepisma), enteric ceace (Machilis) & salivary glands.
- Malpighian tubules are well developed.
- Nervous systems consist a brain, subsophageal, three thoracic & eight abdominal ganglia.
- Tracheal systems are primitive.
- Dorsal blood vessels differentiated into an anterior short aorta and posterior long heart



consisting 11 pairs of dorsally situated ostia.

.Thysanura. (a) Jumping bristletail, (b) common silverfish, (c) Firebrat

- The ovarioles are panoistic type while testis is composed of a group of multifollicular lobes.
- Ecdysis moult occurs repeatedly even after the sexual maturity is attained (25 to 66 moults in Ctenolepisma and 19 to 58 in Thermobia).

  Ex., Silver fish, Lepisma sp.

PALAEOPTERAN ORDERS

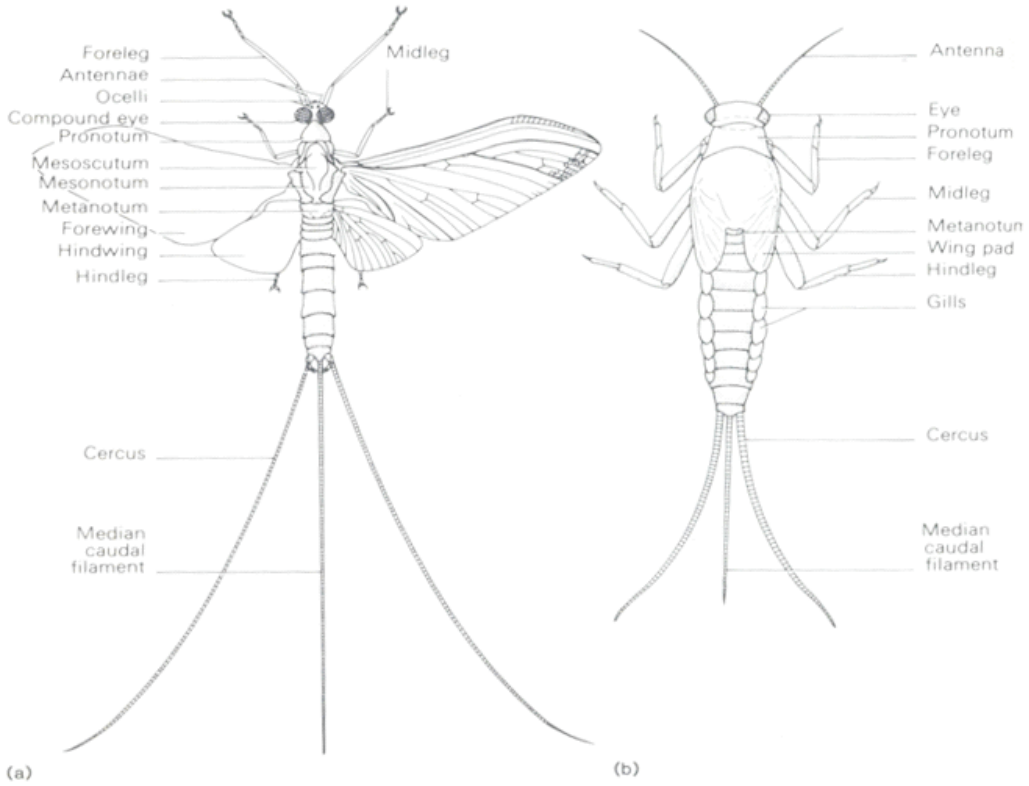
6. Order: Ephemeroptera :(May flies)

The amphibiotic exopterygota with aquatic long lived nymphs and terrestrial very short lived adults.The nymphs bear chewing biting type of mouth parts and metameric seven pairs of abdominal tracheal gills while adults possess vestigial mouth parts, Abdomen with long cerci and frequently a median caudal filament. The wings are held vertically over the thorax at rest. The adults found near ponds, streams, lakes and rivers. They are amphibiotic. The nymphs are aquatic while adults are terrestrial, e.g. Ephemeron, campsurus etc. the adults are 4 mm to 50 mm long.

Characters:

- In nymph rectum is modified into tracheal bronchial basket possessing six longitudinal gills rows. It is chief respiratory and osmoregulatory organ in nymphs while Orthopteran type in adults.
- Heart is tubular with 8 chambers and short aorta.
- In nymph rectum is modified into tracheal bronchial basket possessing six longitudinal gills rows. It is chief respiratory and osmoregulatory organ in nymphs while Orthopteran type in adults.
- Head is Prognathous.
- Antennae are short, setaceous.
- Compound eyes are larger in males than females.
- Ocelli are three, situated between compound eyes.
- Mouth parts are atrophied in adult flies, in nymphs well developed.
- Mesothorax is large, pro & metathoracic segments are comparatively very small.
- Fore wings are larger than hind ones. The hind wings are sometimes greatly reduced or even absent. The wings are triangular, membranous and fragile.
- Unsuitable for walking, weak, legs longer in males than females and are used for grasping the female during copulation.
- Tarsi are five segmented but may reduce to one or two segments. Pretarsus with a pair of claws, one may be degenerated or blunt.
- Abdomen is slender, 10 segmented and 11th segmented is reduced and fused with 10th segment, while its tergite extends a median caudal filament. Female gonopores are paired lying in between the 7th & 8th abdominal sterna.
- External genitalia and appendicular ovipositor is absent except Lepitophle, bittidae. The female genitalia consist of a pair of claspers and a pair of penis, fused basally.
- Tracheal gills Nymphs bear seven pairs of plate like or filamentous abdominal gills on the first seven segments. They are major respirator and chemo regulatory organs.
- Cerci paired, long and multi articulated filaments.
- Digestive system in nymphs is well developed, in adults the alimentary canal is fully filled with air and serves the aerostatic function.
- Male reproductive system is consisting, a pair of ovoid sac-likes testes. Both versa differentia open independently and accessory glands are wanting.

- Female reproductive system is consisting, a pair of ovaries, each composed of a large number of penoistic ovarioles & oviducts of both the ovaries open separately. Accessory glands are lacking.
- Spiracles are two pairs of thoracic & eight pairs of abdominal spiracles and are functional.
- Heart is ten chambered.



Ephemeroptera, mayflies. (a) Adult. (b) Nymph.

- Metamorphosis during post embryonic development diapauses may occur.
- Mating often occurs during swarming.

.Ex. Mayfly, Ephemera sp

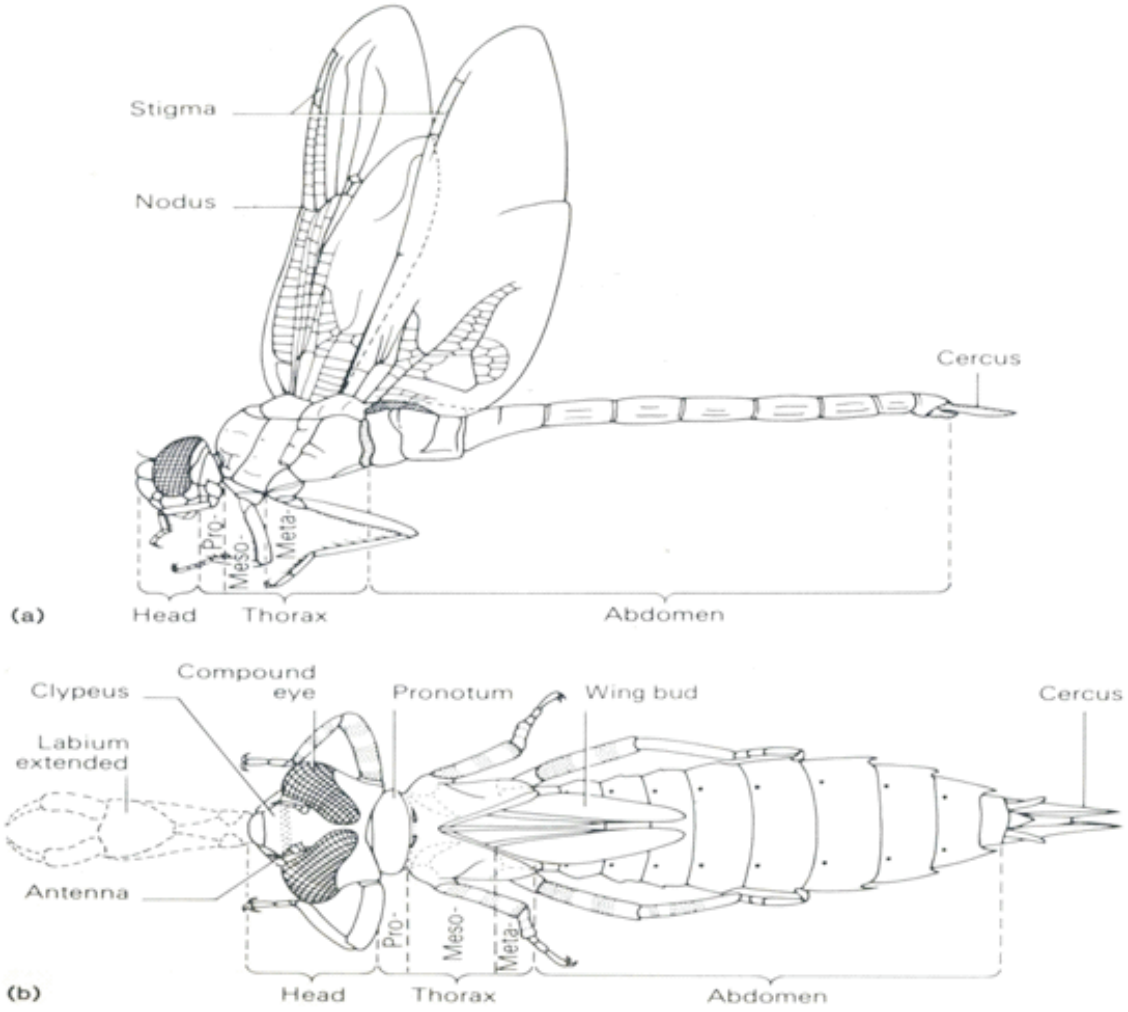
7. Order: Odonata: (Drgonfies)

Exopterygota, adults are terrestrial while nymphs are aquatic. Nymphs & adults are predatory. In male secondary copulatory apparatus are found on 2nd & 3rd sterna of adult.The nymphs are aquatic, freshwater inhabitants while adults are aerial. They are mostly abundant in the oriental Neotropical and Japan of Pala arctic regions (Noctural in habit).

Characters:

- Head large & articulated with a narrow neck. Clypeus is divided into ante clypeus and post clypeus. In dragon flies, most of the dorsum of head is covered by eyes.
- Antennae are very short, inconspicuous three to seven segmented and fill form.
- Compound eyes are greatly developed in Anisoptera and fused mid dorsally occupying most part of the head. Each eye contains about 10,000 (Zygoptera) to 28,000 ommatidia (Anisoptera). 4. Three Occelli
- Mouth parts are biting-chewing type, mandibles with teeth. One segmented maxillary palps and two segmented labial palps. In nymph, labium is modified into prehensile fang mask Nymphs-Carnivorous, adult's predators.
- Prothorax greatly reduced into a neck. The meso & Meta thorax fused & from pterothorax.
- Legs long, thin & unsuitable for walking with large number of spines & bristles.
- Fore & hind wings are membranous, hyaline & pigmented.
- Abdomen long slender. On 10th segment unsegmented cerci is found.
- Proventriculus well developed in nymphs with variable internal teeth while degenerated in adults.
- Rectum in nymph is modified into tracheal bronchial basket possessing six longitudinal gills rows. It is chief respiratory and osmoregulatory organ in nymphs while Orthopteran type in adults.
- Heart tubular with 8 chambers and short aorta.
- Male reproductive system with a pair of tubular testes, Vasa deferentia, very short ejaculatory duct and a median sperm sac. Accessory glands are lacking.
- Female reproductive system With a pair of long tubular, panoistic ovaries, a pair of oviducts, and a medium oviduct, genital chamber, a bursa copulotrix, a single or paired spermatheca. Accessory sex glands are absen
- External male genitalia on 9th sternum, genitalia are rudimentary, without penis.
- On the 2nd & 3rd sterna appears a secondary copulatory apparatus, consisting a look like lamina, a genital sac, a grasping hamules.
- External female genitalia A small orthopteroid ovipositor lies under 9th segment and is composed of three pairs of appendages derived from the 8th and 9th sterna in Zygoptera and Aeshnidae, Petaluridae families of Anisoptera. In other Anisoptera ovipositor is vestigial or absent.
- Terminal processes in Anisoptera nymphs, the abdominal end bears three small processes, a median epiproct (dorsal appendages) & a pair of lateral paraprocts (ventral) concealing the anus.

- In Zygoptera three terminal processes modify into the caudal gills as in these nymphs the rectal tracheal gills are lacking.
- Oviposition endophytic or exophytic or freely into water.
- Nymphal instar varies from 10 to 15, the nymphal period may last a year in Zygoptera & 1.5 years in Anisoptera.



Odonata, Anisoptera, drgonfies. (a) Adult, (b)Nymph

Characters of sub orders:

Zygoptera:

- Wings similar basally stalked fore & hind wings and usually held vertically above the abdomen.
- Compound eyes are widely separated, button like.
- ale with paired superior & inferior and appendages, penis unjointed.
- Female with superior appendages only.
- Ovipositor is well developed.
- Nymphs have three caudal gills as respiratory organs.

Aniso zygoptera:

- Anisopteran like nymphs.
- Adults with anisopteran body but zygopteran wing venation.

Anisoptera:

- Fore & hind wings are dissimilar. Hind wings have large anal lobes.
- Wings are held horizontally at rest.
- Eyes are large and meet each other at mid dorsal line.
- Male with paired superior & single inferior anal appendages, penis jointed.
- Female with superior appendages only.
- Ovipositor ill developed or absent.
- Nymphs with rectal gills as respiratory organs.

The Plecopteroid orders

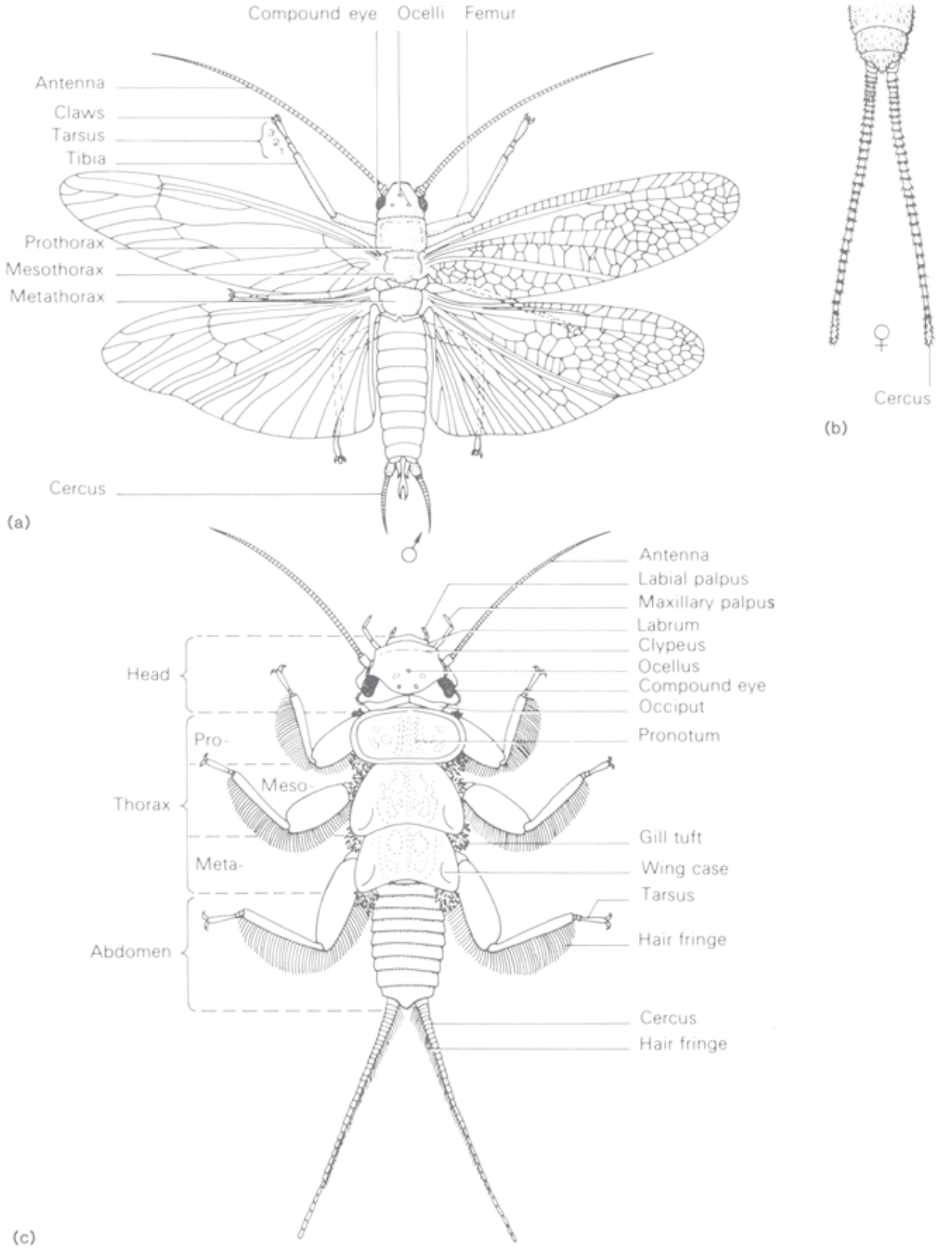
8. Order Plecoptera (Perlaria): (Stoneflies)

Amphibiotic orthopteroid insects with prolonged aquatic nymphs and terrestrial adults. The nymphs have finger like or ribbon like or tubular tracheal gills. The adult female is without ovipositor. Primary male genitalia is lacking while secondary copulatory apparatus develops terminally. They are usually occurring near the cold streams, lakes waterfalls having stony beds or banks. The nymphs live in clear well-oxygenated water beneath the stones while adults on the stones and trunks of the trees. The adults are soft bodied insects and are poor fleirs. They are predaceous.

Characters:

- Head is prognathus, orthopteroid type but with extremely reduced epicranial and frontoclypeal.
- Antennae is long, setaceous, multisegmented.
- The Compound eyes and ocelli are well-developed.
- Mouthparts Orthopteroid type but the mandibles are vestigial in Perlidae.
- Thorax Composed of a large movable prothoracic segment in which the pleuron is not differentiated into episternum and epimeron. The meso and metathoracic segments are subequal, typical orthopteroid type.
- Wings are membranous, hind wings are larger than the fore ones and with broad fan-like anal lobe. They are held flat over the abdomen at rest. Brachypterous condition in males showing dimorphism in some species. Venation is archedictyon type due to presence of large number of cross-veins.
- Legs are simple walking type, tarsi are three segmented, with a pair of claws and arolia, and pretarsi are distinct. In nymphs, legs are long and with lateral natatory hair helping in swimming. 8. Ovipositor absent. Male appendicular genitalia and penis are absent, secondary copulatory apparatus develops from the derivatives of the 11th segment.
- Alimentary canal without gizzard, mid gut with gastric caecae. There are one or two pairs of salivary glands; Malpighian tubules vary from 20 to 60.
- Tracheal System Consist of two thoracic and eight abdominal pairs of spiracles. In nymphs, the tracheal system is apneustic; skin as well as secondary tubular tracheal gills on submentum, thoracic pleura, coxae, first 2-3 abdominal segments, at bases of cerci, perform respiration. Rectal blood gills are well developed in Nemura.
- 10Th abdominal segmented and 11th abdominal segment greatly reduced and possess a pair of long slender cerci.
- Abdominal Ganglia Six to eight.
- Testes are fused with each other.
- Ovaries are panoistic type, separated or fused.
- Rudimentary hermaphroditism in Perla marginata is reported.
- A female lays about 6,000 eggs in water; development through 22 instars (Nemura) to 33 instars (Dinocras), 12 instars (Pteronarcys) within 2-4 years. Diapauses in the last instars nymph or in the egg-stage recorded.

  Ex. The stonefly, Perla sp.



Plecoptera, stoneflies. (a) Adult male, (b) Terminalia of adult female (c) Nymph.

9. Order: Embioptera (Ex. Embia sp.)

Slender compodeiform, apterous insects living in silken tunnels and females are always apterous and larviform without undergoing metamorphosis. Metatarsus of foreleg is often flattened. Cerci of male are often asymmetrical; wings are alike with prominent radius and other veins become reduced or vestigial.

The Embioptera are small, fragile, soft bodied, weakly flying somber coloured, brown or yellowish-brown coloured insects. They live under stones or barks and avoid the light but males are generallys attracted by light. They show sexual dimorphism as the males being winged while the females remain apterous. Strikingly they construct silken tunnels for inhabitation and can run forward as well as backward with equal efficiency. They form a colony by living in a series of super imposed tunnels communicating with each other. Males are carnivorous, while females are herbivorous. Females show parental care for their offspring's.

Characters:

- Head is prognathous, freely movable, with ventral gula.
- Compound eyes are elliptical in shape, smaller in female.
- Ocelli are absent.
- Antennae are filliform, short even than head.
- Mouthparts are well developed orthopteroid type. Mandibles are slender in male, broad in female. Maxillary palps are 5- segmented. Labial palps are 3- segmented.
- Prothorax is smaller than meso and metathorax. It is divided into anterior and posterior divisions by a transverse suture in male while in female it is elongate and narrow.
- In males wings are identical, flexible, membranous, covered with hairs; Radial vein is enclosing blood sinus; other veins are reduced, wing membrane is smoky in colour with longitudinal interveinal hyaline areas.
- Legs are mostly equal in length, fore and hind femora are large due to deposition of depressor tibial muscles. Tarsi are 3 segmented. Metatarsus of forelegs is swollen and possesses the spinning gland. They run very fast in both forward and backward directions.
- Abdomen 10 segments well evident, 11th segment is represented by a pair of asymmetrical cerci. Terga of 10th segment are divided into two asymmetrical plates or hemitergites in the males.
- Cerci are two segmented, asymmetrical in males.
- In female genitalia 8th sternum acts as subgenital plates, 9th segment bears female gonopore. Gonopods, Gonopophyses and styli absent.
- In Male genitalia 9th sternum functions as subgenital plate. A single penis is little development or absent. No copulatory organs.
- Alimentary canal is straight tube, proventriculus absent, rectum with 6 rectal pads, Mapighian tubules more than twenty. Pair of salivary glands is present.
- Seven abdominal ganglia present.
- Corpus allatum single bilobed.
- In tracheal system 2 thoracic and 8 abdominal Spiracles are present.
- Female reproductive system with a pair of ovaries, each consisting 5 panoistic ovarioles,

lateral oviducts, a short vagina with a large spermathica.

- Male reproductive system: a pair of testes, each composed of 5 lobules, a pair of vasa differentia posteriorly modified into seminal vesicles, an eiaculatory duct, and two pairs of accessory glands.
- Postembryonic development: only four nymphal instars.

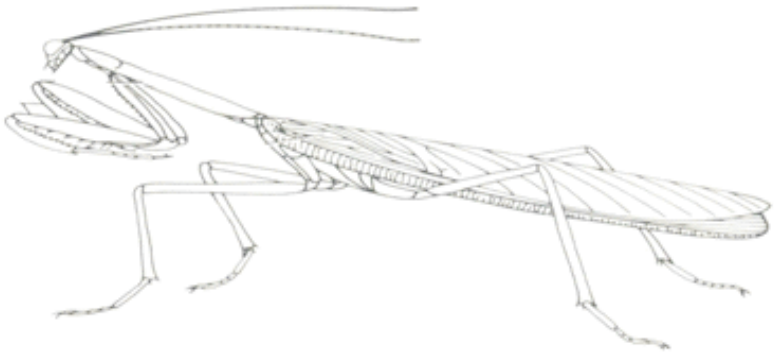
Ex. Embia sp.

10. Order: Dictyoptera:(Cockroaches and mantids)

Terrestrial, orthopteroid insects with long multi-segmented filiform antennae, large pronotum, neck bearing sclerites, greatly-sclerotised tegmina, 5-segmented tarsi, reduced or concealed ovipositor in females; males with caudal styles and without special stridulatory and auditory organs. Eggs are enclosed in ootheca.The order includes medium as well as large sized individuals forming two homologous groups, cockroaches and mantids. They are mostly terrestrial and occur predominantly in typical and subtropical regions. They are very poor fliers. There are several apterous forms. In some species wings are greatly reduced in female or in both sexes. Few are aquatic or semi aquatic, cave-inhabitants (carvenicolous) or myremecophilous cockroaches. They are omnivorous or carnivorous.

Characters

- Head is hypognathous, typical with all sutures. Tentorium bears a central aperture.
- Compound eyes are well developed except cavernicolous or myrmecophilous species.
- Ocelli are 3. In mantids lateral ocelli are represented by fenestrae while median is distinct in cockroach.
- Antennae long, many segmented, filliform.
- Mouthparts are typical chewing-biting type with strong toothed mandibles, maxillary palps-5 segmented, labial palps-3 segmented; glossae and paraglossae well-developed.
- Cervix With well-developed cervical sclerites.
- Prothorax is large and elongate with shield like pronotum in cockroach and narrow but long pronotum in mantids. The meso and metathorax are alike. Pterothoracic sterna are membranous in cockroach. Furcal arms and spina are well-developed.
- Legs in cockroach: legs of all pairs similar with large coxae adapted for running, but in mantids the fore-legs are raptorial type with elongate coxae, spinose and ventrally grooved femora and blade like spinose, tibia bearing terminal hook. Tarsi are five segmented.



Mantid,Tenodera ardifolia

Cockroach, Balattella germanica.

- Fore wings of cockroach are highly sclerotized, hard, leathery, called tegmina and protect hind wings. The hind wings are membranous, with large anal lobe and folded in a fan- like fashion at rest.
- Abdomen is 11 segmented, the last one is greatly reduced and represented by a tergal epiproct, sternal paraprocts and a pair of cerci. 7th and 9th sterna are modified into subgenital plate in the females and males respectively. The 7th, 8th and 9th sterna are membranous in females.
- Ovipositor: 3-pairs of valves are concealed below 7th sternum consisting to dorsal and two ventral phallic lobes.
- Male Genitalia: It is asymmetrical consisting two dorsal and two ventral phallic lobes concealed below the 9th sterna which bears a pair of styles.
- Cerci are short, many-segmented, except Panesthia.
- Alimentary Canal is simple, straight (mantids) or coiled (cockroach) with large crop and gizzard having strong masticating armature (cockroaches) or poorly developed (mantids). Mid gut bears eight tubular caeca. Malpighian tubules are 80 to 100. Hind gut differentiated into colon and rectum, the latter bearing 6 rectal pads. Salivary glands are large with distinct reservoirs.
- Nervous System orthopteroid type, With 4-6 abdominal ganglia.
- Sympathetic System well-developed, consisting a frontal, hypocerebral, and ingluvial ganglia and a single recurrent or oesophageal nerve. Corpora cardiaca and allata are paired.
- Tracheal System: two thoracic and eight abdominal spiracles.
- The Heart long with 3 thoracic and 9 abdominal pairs of incurrent ostia. There are 2 pairs of thoracic and 4 pairs of abdominal segmental vessels in Blattids while only 4 abdominal pains in mantids.
- Male reproductive system: testes are diffused, follicular or enclosed in a common peritoneal sheath, a pair of vasa differentia, a median mushroom gland and a single conglobate gland in cockroaches.
- Female reproductive System: a pair of panoistic ovaries paired lateral oviducts and single median oviduct, a large genital chamber, single or paired spermathecae, a pair of collateral glands.
- Metamorphosis: Cockroach show oviparity (Periplaneta), ovoviviparity (Blattella) and viviparity (Dicloptera). Eggs are enclosed in ootheca consisting 16 (Blatta) or 40 (Blattella) packets, each accommodating a single egg. Pronymphs or 1st instar nymphs emerge out

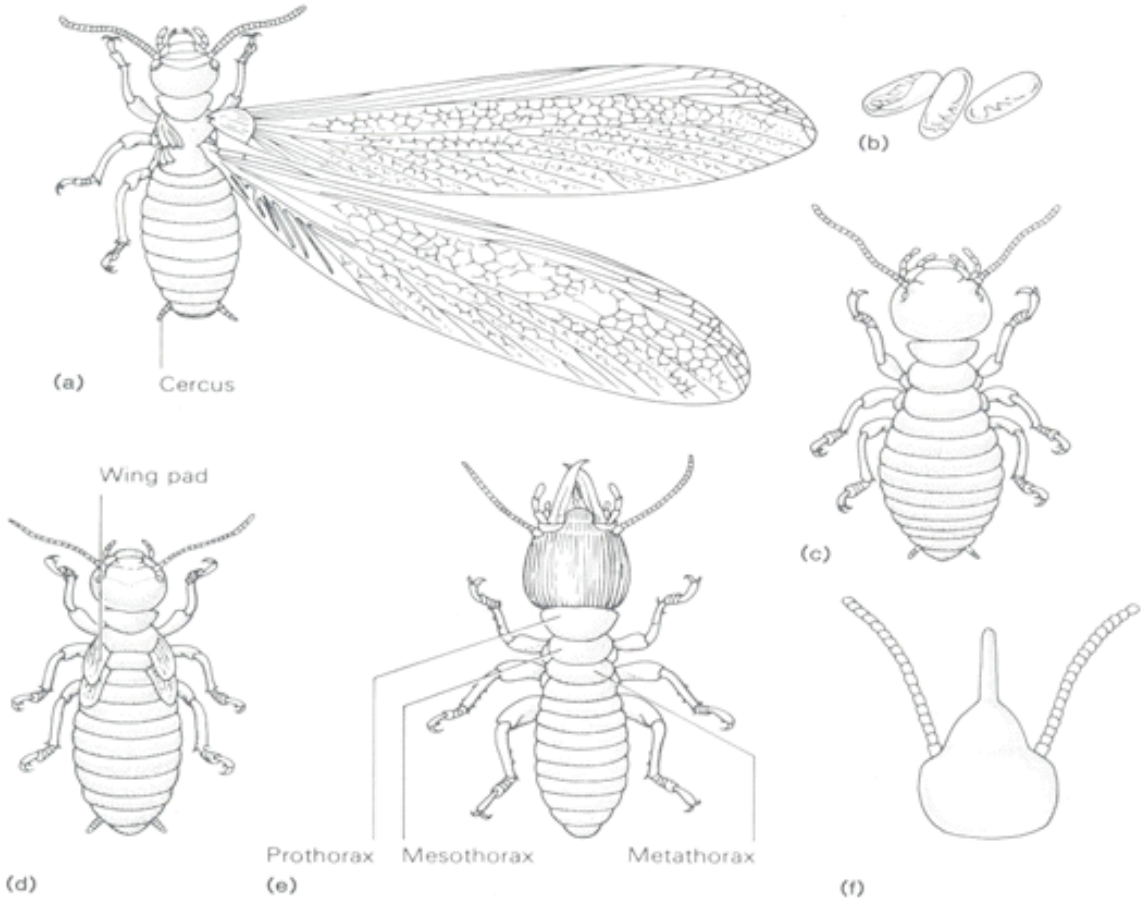
through splitting up of ootheca. Succeeding nymphal instars are 6 in Blatta, 11in female and 12 in male Periplaneta. Blatta completes life cycle within 279 days, Periplneta within 250 to 270 days and Ectobius takes two years with winter obligatory diapause. In mantids during copulation sometimes female eats the body of male. Mantids lay eggs in ootheca having 24 to 40 egg-chambers. Pronymph or first instar nymph is followed by 3 to 12 instars. The life cycle completes by a year.

11. Order: Isoptera:(Termites)

Orthopteroid shoft bodied, polymorphic, social, colonial insects with or without wings, with 4-segmnented tarsi but without external genitalia.Order Isoptera bears over 1700 species and 80 genera. They are abundant in tropical and warm temperate regions. They form a colony of 4 categories of individuals: primary reproductives, sterile soldiers and sterile workers. Last two forms are totally apterous. The primary reproductive's found the colony and construct the termitaria or nests of various types for shelter. They are pests of wood, furniture and some agricultural crops also. They are mostly subterranean inhabitants.

Characters:

- Head is prognathous, highly sclerotized, spherical or oval, large and elongate or pyriform in soldiers, dictyopteran type sutures and sclerites. Clypeus is divided into ante clypeus and post clypeus.



Isoptera, termites. (a) Winged form, (b) eggs (c) Third instar nymph. (d) Last instar nymph. (e) Solder. (f) Head of Nasutitermes sp.

- Antennae is short, monilliform consisting of 9-30 segments.
- Compound Eyes are well-developed in reproductive castes, degenerated or absent in sterile forms.
- Ocelli are two in number, median ocellus lacking.
- Mouthparts are mandibulate type, soldiers possess large apically toothed, variably shaped mandibles; nasute soldiers possess vestigial mandibles; 5 segmented maxillary palps, 3 segmented labial palps; salivary glands are large with reservoirs.
- Thorax is narrow but elongate prothorax, short and broad meso and meta thorax. The pronotum is variable, shield, heart or saddle shaped.
- Legs are similar, with large and braod coxae, meron, long and slender tibia armed with or without spines, 4 segmented tarsi. Exception is Mastotermis which bears 5-segmented tarsi. Fore tibia with special acoustics organ.
- Wing are similar in form, size and venation, without cross veins, with basal or numeral suture causing wing shedding during swarming. Wings are mostly membranous with reduced anal lobe. They are present before mating in reproductive caste.
- Abdomen: 11th segment is represented by a pair of paraprocts. 7th sternum in females is modified into sub genital plates.
- Cerci are paired, multi segmented, 1 to 8 segmented as the appendages of 10th segment. 9th sternite bears another pair of small unsegmented styles, in both sexes of soldiers, workers and in males of reproductive caste.
- Ovipositor is absent or reduced, Blattarian type (Mastotermes).
- In male copulatory organs membranous median penis.
- Alimentary Canal is a coiled tube with well developed gizzard, oesophageal valve, tubular coiled mid gut, 2-8 Malpighian tubules, 4-5 enteric caeca, hind gut differentiated into ileum, colon and rectum. Salivary glands are recemose type with salivary reservoirs.
- Heart is 8-10 chambered.
- Nervous System with six abdominal ganglia and dictyopteran type of sympathetic nervous system.
- Epidermal Gland System: a frontal gland (in head) is highly developed in soldiers secreting a defensive (pheromone) substance.
- The Sternal glands on 3rd, 4th and 5th abdominal sterna, secreting required pheromones.
- Two thoracic and eight abdominal pairs of spiracles.
- Male reproductive system developed only in reproductive caste. A pair of testes, simple, consisting 8 to 100 digit follicles, a pair of vasa differentia and an ejaculatory duct receiving a pair of seminal vesicles.
- Female reproductive system: Only in reproductive caste: A pair of panoistic ovaries composed of 30 to 3000 ovarioles as seen in Archotermopsis and Odontotermes , respectively. Sperma theca and colletaral glands are present.
- Metamorphosis: caste differentiation occurs during post embryonic development. Reproductive castes arise from nymphs with wing-pads, soldiers and workers from nymphs

without wing pads. Food quality: hormonal interaction brings out this differentiation. Soldiers are absent only from Anoplotermes and Speculitermes. True workers are absent in Kalotermes.

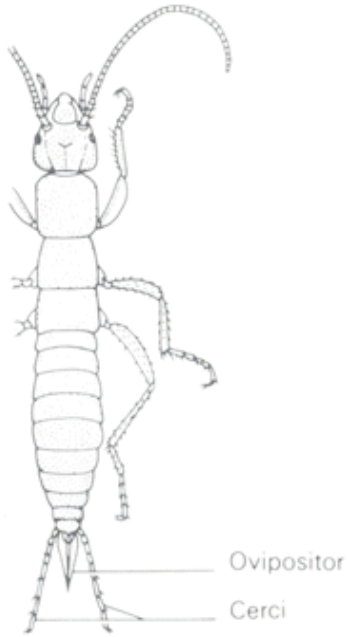
Termitidae: - With reduced wing-venation but with small scales and hairs, ocelli present, narrow pronotum, workers present and are commonly called as the ground dwelling termites, found in tropics. Largest family, soldiers with frontal rostrum on head, they construct very high mounds. E.g. Termes, Odontotermes, Macrotermes, Microtermes.

12. Order :Grylloblattoidea: (rock crawler, ice crawlers):

Apterous, with eyes reduced or absent and no ocelli, Antennae moderately long & filiform, Legs approximately similar to each other tarsi 5 segmented.Female with well developed ovipositor on 8 & 9 segments.Male genitalia asymmetrical, cerci long, 8 segmented. Insects live beneath stones or caves of high mountains and are mostly nocturnal preferring a low temperature at about 100c. This order has 3 genera and 16 species. Mostly lacking in India.

Characters:

- Head is prognathous & flattened; clypeus is divided into ante and post clypeus.
- Eyes absent or greatly reduced.



Grylloblattoidea. A rock crawler, Grylloblatta campodeiformis.

- Ocelli absent.
- Antennae Long, filliform, consisting 20 to 40 segments.
- Mouth parts mandibulate type with well developed mandibles, maxillae with a pair of teath, five segmented palp but with palpifer.
- Thorax Prothorax larger than meso and Meta thorax, with phragmata, Pleura divided into episternum & epimeron.
- Mesothorax & metathorax segments with a pair of large trochantins & broad pre coxal bridges.

- Wings absent.
- Legs Cursorial, mostly equal, with large coxae without mera.
- Tarsi 5 segmented pretarsi with a ventral pad and a pair of terminal claws but without arolium and pulvilli.
- Abdomen 11 segmented. Last segment is represented by the epiproct and paired paraproct. 12. Ovipositor well developed on 8th & 9th segments.
- Male genitalia a symmetrical consisting, a pair unequal coxities with style and penis having a pair of lobes.
- Cerci is Long & 8 segmented.
- Alimentary canal Orthopteroid type, with a pair of gastric caeca. Salivary glands without reservoirs.
- Malpighian tubules are 12 to 24.
- Seven abdominal ganglia first fused with meta thoracic ganglion.
- Two thoracic and 8 abdominal spiracles.
- Development is Hemimetabolous. One year old female lays black coloured eggs singly in the soil. Incubation lasts for a year. Nymphal instars 8 develop within 5 years into the adults.

Classification: It contains only a single family.

Family: Grylloblattidae – It includes 3 genera.Grylloblatta with 9 species inhabiting in mountains and caves of W.N. America.Grylloisiana with 6 species from Japan.Grylloblattina with a species djukonovi in Siberia yet no report from India.

Ex. Grylloblatta sp.

13. Order Dermaptera: (Earwigs)

Cylindrical, orthopteriod insects bearing a pair of short leathery truncated tegmina devoid of veins and semicircular membranous fanwise-folded hind wings with the veins arranged radially or apterous but with strong forceps-like cerci.They are terrestrial but mostly nocturnal insects and are often attracted to light. They cannot fly (exception Labia minor). During day time, they hide away under stones, hollow stems or bark, vegetation or in the cracks of soil. They may live together in colonies (Forficula, Labidura). Female guards her eggs showing unique parental care. Some are parasitic (Hemineus, Arixenia). They are omnivorous.

Characters:

- Head is prognathus; clypeus is differentiated into sclerotized post clypeus and membranous ante clypeus. Epicranium with Y-shaped suture.
- Antennae are setaceous or moniliform with 10-15 segments.
- Compound eyes are well developed.
- Ocelli are often absent or vestigial.
- Mouth parts are biting-chewing type, maxillary palp-5 segmented, ligula and superlinguae bilobed.
- Thorax with large Prothorax, metanotum fused with first abdominal segment. Metasterna with distinct apophysial pits.
- Wings are greatly reduced or absent (e.g. Anisolobis, Hemimerus, and Arixenia etc.). The forewings are modified into truncated, leathery, veinless, very short tegmina about half of the length of an abdomen. The hind wings are membranous, semicircular, mostly formed from greatly extended anal lobe, while preanal part of wings is highly sclerotized, short and with reduced radial and cubital veins. The resting part of wings is provided with radially arranged, secondarily developed veins. They are folded longitudinally in a fan-like fashion along with two transverse folds and at rest, concealed under the tegmina.
- Legs are equal in size, short, with 3-segmented tarsi.
- Abdomen is eleven segmented, last segment modified into and epiproct and a pair of paraprocts. The epiproct modified into the pygidium and metapygidium telson. Frist sternum is wanting, while first tergum is fused with the metathorax. The 8th and 9th segments are reduced or overlapped by the 7th segment, particularly in the females.
- The ovipositor: It is absent or reduced (Forficulina) consisting two pairs of valves.
- The male genitalia: there are two penises in Pygidicranidae, Carcinophoridae and Labiduridae or only one in other families.
- The cerci are modified into unjointed forceps (Forficulina), in female they are short, straight and undented while in male they are long, forked and armed (Forficula). They may be unjointed styliform hairy appendages in Hemimerus cerci serve defensive, prehensile and copulatory functions.
- Alimentary canal is simple orthopteroid but midgut is straight or coiled. No hepatic diverticulae. Hindgut is coiled; rectum with 6 rectal pads; Malpighian tubules 8-20 but grouped in bundles.
- Abdominal ganglia are 6 in number.

- Tracheal system is ideal with 2 pairs of thoracic and 8 pairs of abdominal spiracles.
- In Female reproductive system polytropic ovaries, oviducts either open separately or into vegina.
- In Male reproductive system a paired tubular testes composed of elongated or coiled follicles (Anisolabis) or compact globular, consisting of 16 short follicles-(Arixenia), vasa differentia posteriorly dilated and modified into seminal vesicles opening into single or two ejaculatory vesicle like ducts, depending upon presence of a single or paired penis.
- Viviparity found, in the terminal ovariolar follicles of Hemimerus and Arixenia, placenta is formed by development of amnion and serosa enclosing the embryo. Young nymphs are delivered.
- There are four to five nymphal instars. One generation within a year. Female lays eggs in winter and adults are developed during summer. Care of eggs is taken by mother in Dermaptera.

  Ex. Earwigs Forficulina sp.

14. Order Phasmida: (Stick and Leaf insects)

Orthopteroid cylindrical or leaf like apterous or winged insects. Mouth parts mandibulate, Prothorax short, meso and Meta thorax usually elongate. Legs similar to each other. Tarsi 5 segmented fore wings usually small & with sub marginal Costa, ovipositor small & concealed by 8th abdominal sternum. Male genitalia variable & asymmetrical, concealed by 9th abdominal segment. Cerci short, unsegmented specialized auditory and stridulatory organs absent. Eggs deposited singly. Metamorphosis slight.Insects live on foliage or twings of vegetation, predominantly in typical climate:

Characters:

- Body is elongate, apterous, cylindrical stick like forms resembling the leaves in general appearance.
- Head is prognathous, without ecdysial and occipital sutures, freely movable.
- Compound eyes well developed.
- Ocelli is absent in apterous while present in some winged forms.
- Antennae is long, filliform or moniliform.
- Mouth parts biting chewing type, 5 segmented maxillary palps, 3 segmented labial palps Prothorax is shorter than meso & Meta thorax. The pleura are greatly reduced & terga and sterna form a long tube in stick insects.
- Forewings are reduced, tegmina and hindwings are differentiated in an anterior thick part like tegmina and posterior thin membranous part representing the anal lobe. Venation of forewings shows arrangement of veins like leaf. Anal lobe of hind wings can be folded in a fan like fashion.
- All legs are alike, coxae are very small in phyllidae, and the femora and tibia have lamellate expansions, tarsi 5 segmented except in Timema.
- Abdomen is 11 segments, last segment represented by epiproct, a pair of paraprocts and cerci.
- Ovipositor is typical orthopteroid, concealed inside the operculum formed of 8th sternum.
- Male genitalia: Aedeagus is asymmetrical & composed of lobes fused together.
- Alimentary canal is straight, without crop, gizzard & gastric caeca, posterior half of mid gut with numerous glandular papillae.
- Abdominal ganglia of first 1-3 are fused with metathoracic ganglia. Oesophageal nerve is single one. Corpora alata are arranged asymmetrically.
- In male reproductive system a pair of tubular or oval testes, vasa differentia, ejaculatory duct & tubular accessory glands are of common occurrence.
- In female reproductive system a pair of panoistic ovaries, lateral oviducts, a common oviduct, a large bursa copulatrix, a pair of spermatheca, & a pair of accessory glands are present.
- A pair of repugnatorial glands in Prothorax, open separately near coxae of forelegs.
- Eggs are laid singly on the ground. Female develop from unfertilized eggs. Female life span is about 3 months, while that of male is less.
- They have great power of regeneration, particularly, in case of leg injury. The adults are well adapted for physiological colour change, polymorphic.

Classification

The Phasmida are thought to be evolved from the Permian Ensiferan-like Orthoptera (sharov, 1968). About 2500 species are distributed mostly in oriental region. The order is classified into only two families:

1. Phyllidae-Includes flattened leaf-like forms, e.g. Phyllium, Colonopsis, Bacillus, Timema.
2. Phasmatidae- includes elongate stick-like forms, e.g. C arausius, Clitumnus etc.

15.Order: Mantophasmatodea: (heelwalkers, gladiators)

Medium sized insects, wingless insects, hypognathous head with mandibulate mouthparts; well developed compound eyes, filiform multisegmented antennae, ocelli absent; prothoracic pleuron large and fully exposed, legs uniform except fore femora thickened and both fore and mid femora with ventral rows of short spines, coxae elongate, tarsi five segmented; female with well developed ovipositor, cerci unsegmented (shorter in male thane in female) and modified for clasping.

This is the most recently established insect order.

Praedatophasma maraisi (Female)

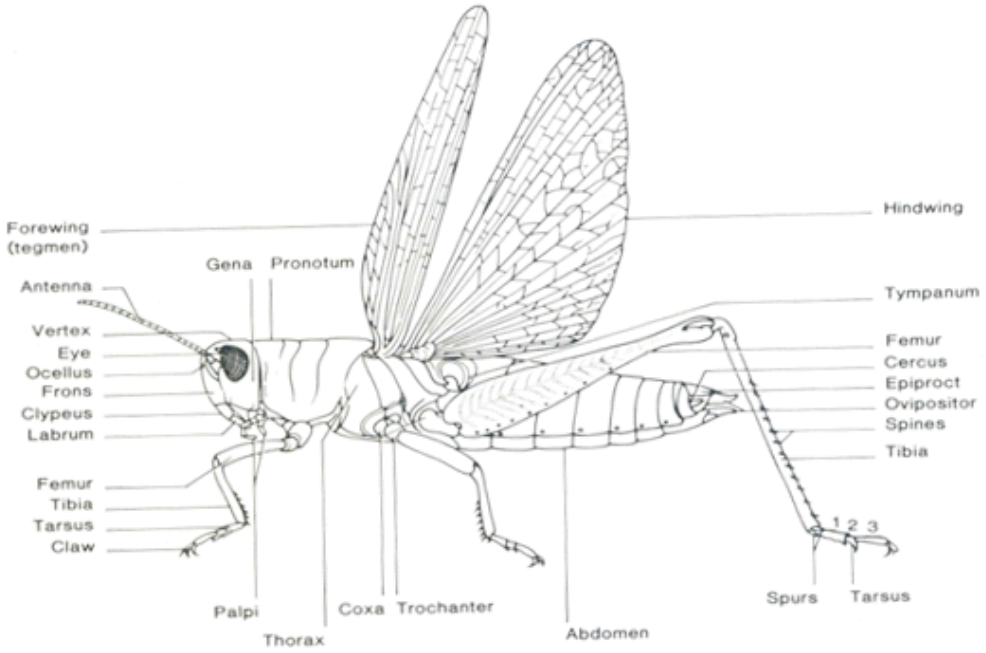
16. Order: Orthoptera: (Grasshoppers, Locusts, Crickets, Mole crickets)

The Saltatorial exopterygotes with mandibulate mouthparts, large prothorax, and hind legs modified for jumping, forewings modified into leathery tegmina, often with auditory and stridulatory organs, a pair of short unsegmented cerci and female with ovipositor.They are medium or large, terrestrial, saltatory jumping insects. Some are strong fliers, few are apterous while some are subterranean or cavedwelling species. They constitute a large order comprising about 17000 species. Several species are of economic importance. They are more abundant in tropic region.

Characters:

- Head is hypognathous, rarely prognatous, frontoclypeal and transclypeal sutures are distinct, X-shaped tentorium without a central aperture. Widely attached to the thorax, Free movement of the head is limited.

- Antennae are filliform, short or long but rarely clavate, serrate or pectinate.
- Ocelli are well developed, 3 but 2 in some tettigonids, absent in apterous forms.



short-horned grasshopper (Acrididae) , showing major external structures.

- Compound eyes are large except in some stenopelmatids and cylindrachetids.
- Mouthparts are mandibulate type. With well developed mandibles, male stenope Imatids with large, tusk-like mandibles, maxillary palps are 5 segmented, labial palps are 3-segmented.
- Prothorax is large pronotum extended backwards and laterally, meso and Meta thorax form a strong pterothorax. Pterothoracic tergites, sternites and pleurites represent all typical features.
- Legs are unequal in length, hind legs with enlarged femora due to deposition of strong tibial levator muscles and are adapted for jumping (accept, Gryllotalpids, Pneumorid, Cylindractetids etc.).
- Forelegs are modified into fossorial type as foretibia become broad and bear teath in Gryllotapidae and Cylindrachetidae. Tettigonidae and Gryllidae posses proximally a pair of tympanal organs on foretibia.
- Fore and hind wings are unequal and dissimilar. Forewings are small, sclerotized, leathery, forming tegmina. In tettigonidae and Gryllidae stridulatory apparatus occurs in cubito-anal area. The hindwings are membranous with large anal lobe folded fanwise.
- Abdomen is long, 11-segmneted. Acridoidea posses a pair of membranous tympanal organs on either the side of the first abdominal segment.
- Cerci are short unsegmented except Grylloidea where they are the elongated structures.
- Female genitalia well developed ovipositor comprising three pairs of long valves, the inner valves are vestigial in Gryllidae; totally lacking in Gryllotalpidae and reduced in Acridoidea.

- ale genitalia well-developed composed of a pair of styles on the 9th sternum. An aedeagus or penis is a complex structure.
- limentary canal is straight or slightly convoluted, with large crop, gizzard bearing variable armature internally, mid gut with anterior long gastric caecae, Malpighian tubules are numerous and form an ampulla basally (tettgonidae) or ureter, opening in the gut (Grylloidea). Hind gut with a rectum containing 6 ractal pads. Salivary glands with reservoir in ensifera, without it in Acridoidea.
- Central nervous system with 4 to 6 abdominal ganglia.
- ympathetic nervous system well-developed, consisting frontal and hypocerebral ganglia, a pair of oesophageal nerves; corpora cardiac, corpora allata and a pair of ingluvial ganglia. Thoracic and abdominal medial and transverse nerves and neurohaemal organs are well-developed.
- racheal System is open type with two pairs of thoracic and 8 pairs of abdominal spiracles. Trachea with segmental air-sacs.
- eart elongates with pairs of abdominal incurrent ostia and 2/3 pairs of thoracic ones. 2 pairs of excurrent thoracic ostia and 5 pairs of abdominal ones.
- ale Reproductive System comprising a pair of multi-follicular testes, fused in Acridoidea. A pair of vasa differentia, anteriorly modified into convoluted epididymis, median ejaculatory duct, a pair of seminal vesicles and a median mushroom gland.
- emale reproductive system consists of a pair of panoistic ovaries, a sperm theca, and a pair of tubular accessory glands. In Acridids, a pair of Comstock-kellog glands and a genital chamber is present.
- ggs are elongate or oviodal and are laid singly or in clusters in or on ground. The first instar nymph is vermiform, called pronymph. Total number of nymphal instars varies from 4 to 15. In apterous forms, metamorphosis is slight.

Classification: The order orthoptera is classified into two suborders, Ensifera consisting 3 superfamilies and 8 families and Caelifera consisting 2 superfamilies and 9 families.

1. **Suborder: Ensifera or Tettigonioidea:**

   (long horned grasshoppers, bush-crickets, crickets and molecrickets).

Characters:

- Antennae very long; longer than the body.
- Tympanal organs on foretibiae.
- Ovipositor-elongate.

Family: Tettigoniidae: - This is a large family that includes the long-horned grasshoppers (or bush crickets) and katydids. These insects, in addition to having long hair like antennae, possess 4-segmented tarsi, a bilaterally flattened bladelike ovipositor, and wings with less than 8 longitudinal veins. Except for a small portion that is held horizontally and dorsally over the body, the wings, at rest, slope vertically. Tettigoniids are usually greenish and cryptically coloured; males of most species are songsters. Although the majority of tettigoniids are phytophagous, a few species are predaceous.

2. Suborder: Caelifera or Acridoidea:

(short horned grasshoppers, locusts, grouse-locusts and pigmy mole crickets.)

Characters:

- Antennae: Shorter than body and consisting less than 30 segments.
- Tympanal organs: Always on 1st abdominal segment.
- Stridulatory organs: Femoro-tegmen type in one or both sexes or absent.
- Ovipositor: Short and robust or absent.

Family: Acrididae: - It includes short horned grosshoppers and locusts. It is the largest family consisting of 9000 species. It is characterized by Stridulatory organs of hind femora –tegmen type , Auditory organs lie on either side of first abdominal segment, Ovipositor is short, curved at tip and performs function of digging a hole for laying the eggs, Nymphal stages are 4 to 8 and one or two generations per year,Phases: Diphasic. Ex. Desert Locust, Schistocerca.

17. Order: Zoraptera (Ex. angel insects.)

A small group of minute, dimorphic, termite-like orthopteroid insects with or without eyes, ocelli and wings.They are minute, less than 3 mm long. They occur under bark, decaying wood, vegetation etc. they also occur near colonies of the termites. They are reported from everywhere except Palaeartic region. Both apterous and alate forms are fertile.

Characters:

- Head is prognathous, with Y-shaped ecdysial suture.
- Antennae are moniliform, 9 segmented, elongate.
- Compound eyes are alate forms bear well developed compound eyes while apterous forms without eyes.
- Ocelli are three, present in alates, absent in apterous forms.
- Mouth parts are generalized orthopteroid type, maxillary palps 5- segmented, labial palps 3-segmented.
- Prothorax is larger and globular.
- Hing legs with expanded femora, 3 segmented tarsi. Pretarsus with 2 claws adapted for walking.
- Wings are shed as in termites; venation is greatly reduced, membranous, folded. Forewings larger than hind wings. The maximum wing expanse is about 7 mm long.
- Abdomen is composed of 11 segments.
- Cerci present as a short, paired, and single-segmented appendages of the 11th segment.
- Ovipositor is absent.
- Male genitalia present but not homologous with that of orthopteroid insects.
- Tracheal system with two pairs of thoracic and three pairs of abdominal spiracles.
- Alimentary canal with large crop, 6 Malpighian tubules and 6 rectal pads.
- Nervous system with only two abdominal ganglia.

- In Male reproductive system a pair of ovoid testes, a pair of vasa differentia, a large seminal vesicle and a long ejaculatory duct and with a pair of accessory glands.
- Female reproductive system consists of a pair of ovaries, each composed of 4-5 panoistic ovarioles, a pair of oviducts, a spermatheca and a genital chamber.
- Nymphs are of two types, developing into alate or apterous adults. Total number of nymphs unknown.

Ex. Zorotypus sp.