Semester	Course	Hours	Credit	Sub. Code	Marks
III	CC9	6	5	18KP3BO9	25+75=100

PLANT SYSTEMATICS AND ECONOMIC BOTANY

UNIT I: TAXONOMY

Introduction, history of classification, A detailed study of classification – Artificial system – Carol Linnaeus, natural system – Bentham and Hooker, modern system – Engler and Prantl, Hutchinson and Takhtajan. Bio systematic, Chemotaxonomy and numerical taxonomy, Role of anatomy and embryology in solving taxonomic problems.

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References:

Introduction to Taxonomy of Angiosperms by B.K.Verma , University of Allahabad

Taxonomy of Angiosperms by B.P. Pandey , CCS University , Meerut.

INTRODUCTION

Plant taxonomy is the science that finds, identifies, describes, classifies, and names plants. It is one of the main branches of taxonomy (the science that finds, describes, classifies, and names living things). Plant taxonomy is closely allied to plant systematics, and there is no sharp boundary between the two. The binomial classification system is hierarchical i. The levels of organization are kingdom, phylum, class, order, family, genus, and species. Each of these levels is called a taxon (plural, taxa). Important of taxonomy it helps us categorize organisms so we can more easily communicate biological information. Taxonomy uses hierarchical classification as a way to help scientists understand and organize the diversity of life on our planet.

Scope of Taxonomy:

The scope of taxonomy and that of systematic in particular are:

1. It works out a vivid picture of the existing organic diversity of our earth and is the only science that does so.

2. It provides much of the information, making it possible for the reconstruction of the phylogeny of life.

3. It reveals various interesting evolutionary phenomena, making them available for casual study by other branches of biology.

4. Almost entirely, it supplies information needed by the various branches of biology.

5. It provides names for each kind of organism, so that all concerned can know what they are talking about and such information can be recorded, stored and retrieved when needed.

6. It differentiates the various kinds of organisms and points out their characteristics through descriptions, keys, illustrations etc.

7. It provides classification, which are of great heuristic and explanatory values in most branches of biology like evolutionary biochemistry, immunology, ecology, genetics, ethology, historical geology etc.

8. It is important in the study of economically or medically important organisms.

9. It makes important conceptual contributions in population thinking, thereby making it accessible to experimental biologists. It thus contributes significantly to the broadening of biology and to a better balance within biological science as a whole.

History of classification

The Swedish botanist Carl Linnaeus is regarded as the founder of the current system of taxonomy, as he developed a system known as Linnaean taxonomy for categorizing organisms and binomial nomenclature for naming organisms.
The basis for the biological classification scheme is similarity of morphology (shape) and phylogeny (evolutionary history). In addition, the processes that led to these similarities are also used in biological classification.
The term taxonomy is derived from two Greek words – taxis meaning arrangement, and nomos meaning law. It was first proposed in 1813 by A.P. de Candolle (a professor of Montpellier University in France) in its French form, for the theory of plant classification. "Taxonomy is the theoretical study of classification, including its bases, principles, procedures and rules". According to Mayr (1982), "Taxonomy is the theory and practice of classifying organisms".
Taxonomy is thus an information system comprising of classification, nomenclature, descriptions and identification. According to Christoffersen (1995), taxonomy has become the most basic activity in biology, dealing exclusively with the discovery, ordering and communication of patterns of biological taxa. It, however, leans heavily on systematics for its concepts.

Development of Plant Taxonomy:
The early history of development of botanical science is nothing but a history of development of plant taxonomy. The herbalists and agriculturists of ancient times gathered some knowledge about plants which was passed on from generation to generation.

Theophrastus (372-287 BC), the Greek philosopher-scientist, placed this knowledge of plants on a scientific footing. In his "Enquiry into Plants" he dealt with the plants at large and attempted to arrange the plants in several groups. He is, therefore, called the "Father of Botany".
Pliny compiled a monumental work entitled "Historia Naturalis" where he incorporated all information about plants gathered up to that time and added much to the same collected by himself from his travels far and wide.
Disocorides was a contemporary of Pliny and like him travelled a lot and gathered information about medicinal plants.

He compiled his famous book "Materia Medica" where he described about six hundred species of plants mentioning their local name and giving their medicinal properties. Along with descriptions he gave sketches

which increased the value of the book very much and gained much popularity among the herbalists and plant-lovers in Europe. For a long period after this there was no contribution in the study of plants worth mentioning till Albert Magnus in the 13th century wrote his "De Vegetabilis" where the difference in the stem structure of Di-cotyledons and Monocotyledons was shown and the two groups were given the terms Tunicate and Corticate.

Printed books on plants were available towards the close of the 15th century and a few German herbalists carried their enquiries about plants still farther making the study of Botany quite popular. Foremost among them was Otto Brunfels who published his book "Herbarium vivae Eiconis" in three volumes (1530-1536) which was profusely illustrated with good figures. Jerome Bock (1498-1554), another German herbalist, published his "Nue Kreuterbuch" which contained accurate descriptions of about 600 species of flowering plants.

In this book the author tried to trace the natural relationship of plants while classifying them into 3 major groups, viz., herbs, shrubs, and trees and also noted the original distribution of each species. Andrea Caesalpino (1519-1603) also classified the plants on the character of their habit, viz., trees, shrubs, and herbs but also took into account the characters of ovary, fruit, and seed. He became famous for his book "De plants" in 16 volumes, the first of which contained his principles of classification.

Leonard Fuchs (1501-1566), Valerius Cordus (1515-1544), Mattias de L'Obel (1538-1616), John Gerard (1545-1612), and Charles L'Ecluse (1526-1909) were others who also advanced the cause of botanical science by their observations and contributions. Then the Bauhin brothers came to the field.

The elder brother Jean (Johna) Bauhin (1541-1631) wrote a book entitled "Historia plantarum universalis" which was published after his death. Gaspard (Casper) Bauhin, the younger brother (1560-1624), published 3 botanical treatises the third one of which, viz., "Pinax theatri Botanic" became very popular. Both the Bauhins made use of the habit-character of plants in classifying them.

Gaspard Bauhin had formulated the idea of a genus and in many cases gave binary nomenclature to his plants. He also collected all names of plants published in different botanical works till his time and referred them as synonyms along with names he used as correct ones.

John Ray, an English naturalist (1628-1705), set himself seriously to the study of plants and gave much thought in proposing a system of classification of plants. He was the first to recognise 2 major taxa of flowering plants, viz., Dicotyledons and Monocotyledons. He also tried to group the plants into several families which he called "classes".

He divided the plant kingdom first into 2 groups, viz., Herbae and Arbores. The Herbae were then divided into Imperfectae and Perfectae, the first of which included the Cryptogams and the second group, i.e., the Arbores included most of the flowering plants.

The Perfectae were subdivided into Dicotyledonae and Monocotyledonae and under Dicotyledonae he placed 25 of his classes and 4 under Monocotyledonae. His system of classification came out in his "Historia plantarum" of which several editions were published and he revised and improved his system in the later editions.

Joseph Pitton de Tournefort was a contemporary of John Ray and tried to work out a system of classification of flowering plants. He too divided the plant kingdom first into 2 groups as trees and herbs and used the character of inflorescence and flower for subdividing the latter group.

He was the first to give a clear concept of a genus although Gaspard Bauhin mentioned it in his works. Tournefort's work proved very helpful in identifying the plants up to the species.

Then came Carolus Linnaeus (1707-1778), a Swedish naturalist (also called Carl von Linne), who gave a new impetus to the study of plants. He was professor of medicine and botany in the Upsala University.

He himself was an arduous collector of plants and made arrangement of collecting plant-specimens from different parts of the world by sending his students to countries far away and through missionary- men and administrators

The discovery of numerous plants from all over the world led him to think about bringing an order into the existing chaos and set himself in grouping and classifying all the plants known till his time. He proposed a system of classification which was published in his "Systema Naturae" (1735).

In this system he used the character of stamens, i.e., the number and nature of stamens, to distinguish the 20 classes in which he divided the plant kingdom. He also used the number and nature of carpels to distinguish the orders, i.e., subdivisions of his classes.

In addition to presenting an excellent system of classification of plants Linnaeus published many botanical works of monographic and floristic nature and also books embodying his ideas of nomenclature of plants.

The "Species plantarum" the first edition of which came out in 1753 contained an enumeration of all plants known to him till that date, accompanied by brief description of each species with distribution and previous reference. In this work he consistently used binary nomenclature for every species with a generic name followed by a specific epithet.:

The modern taxonomists have agreed to consider the year 1753 as the starting point of nomenclature of Phanerogams, Pteridophyta, and Sphagnum. In his "Philosophia Botanica" he laid down some principles which later formed the basis of the International Code of Botanical Nomenclature.

Owing to the efforts of Linnaeus the study of Botanical science entered the modern age and Linnaeus is rightly called the "Father of Modern Botany".
As in Europe, the study of plants was started by the herbalists in other countries boasting of an ancient civilisation. In India the medical men described many plants of medicinal value and classified them in various ways. Atharva Veda and Susruta Samhita were written before the Christian era.

In his treatise on agriculture Parasara in 6th century classified the plants into many "ganas" or families giving clear picture of the morphology of flowers and fruits. Some of his "ganas" correspond to some families of

modern taxonomists. Sarangadhara in 12th century in his "Upaban Vinoda", a book devoted to agriculture and horticulture, dealt with different aspects of plant life and classification of plants.

Artificial system

Carolus Linnaeus (1707-1778):

He was a Swedish naturalist. For his outstanding contribution he is called the "Father of Modern Botany".
He published his work in different times since 1730 to final form in 1753.
The publications are:

1. 1730 — Hortus Uplandicus (contains the plants of Uppsala Botanic Garden at that time).

2. 1735 — Systema Naturae.

3. 1737 — Hortus Cliffortianus (contains the plants in the Garden of George Clifford at Hartecamp).

4. 1737 — Genera Plantarum.

5. 1738 — Classes Plantarum.

6. 1751 — philosophia Botanica (contains the revised revision of his earlier publications Systema Naturae and Classes Plantarum.

7. 1753 — Species Plantarum (contains some 7,300 species described and arranged according to his system of classification). In this book, he constantly used the binomial system in plant names. The Binomial system consists of two names of a specimen, where the first one is the generic epithet and the second is the specific epithet. This binomial system was used subsequently, even by the modern botanists till date.
The classification of Linnaeus is an artificial one. The significance of flower and fruit structures was first recognised by him. He emphasised the basic numerical characteristics of sexual parts i.e., stamens and carpels. Thus the Linnaeus system is also known as sexual system.

Based on the number, size, length and union of stamens, he classified the plant kingdom into 24 classes, such as Monandria (flower with one stamen), Diandria (flower with two stamens), etc. The classes were further divided into orders, based on the number of styles in each flower such as Monogynia (flower with one style), Digynia (flower with two styles) etc.

The outline of Linnaeus System of classification with twenty four (24) classes is given:
Classes:

1. Monandria (flowers with 1 stamen).

2. Diandria (flowers with 2 stamens).

3. Triandria (flowers with 3 stamens).

4. Tetrandria (flowers with 4 stamens).

5. Pentrandria (flowers with 5 stamens).

6. Hexandria (flowers with 6 stamens).

7. Heptandria (flowers with 7 stamens).

8. Octandria (flowers with 8 stamens).

9. Enneandria (flowers with 9 stamens).

10. Decandria (flowers with 10 stamens).

11. Dodecandria (flowers with 12 stamens).

12. Icosandria (flowers with more than 20 stamens are attached to the calyx).

13. Polyandria (flowers with more than 20 stamens are attached to the receptacle).

14. Didynamia (stamens didynamous).

15. Tetradynamia (stamens tetradynamous).

16. Monadelphia (stamens monadelphous).

17. Diadelphia (stamens diadelphous).

18. Polyadelphia (stamens polyadelphous).

19. Syngenesia (stamens syngenesious).

20. Gynandria (stamens adnate to the pistil).

21. Monoecia (plants monoecious).

22. Dioecia (plants dioecious).

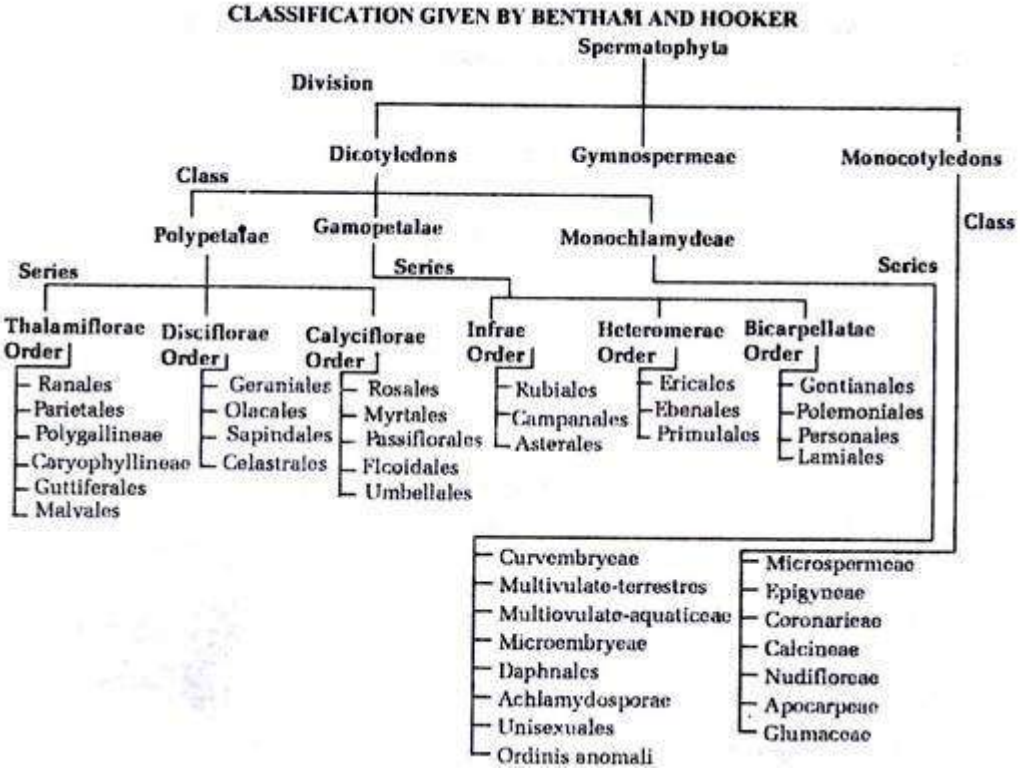
23. Polygamia (plants polygamous).

24. Cryptogamia (non-flowering plants i.e., cryptogams which include algae, fungi, mosses and ferns.

NATURAL SYSTEMS

BENTHAM AND HOOKER SYSTEM OF CLASSIFICATION

Bentham and Hooker classified the plants based on natural characters. He classified the plants in the book called Genera Plantarum (1862-1883). It is a classification of only seed plants.



Merits: 1) It is simple and easy to use for practical purpose.

2) Every genus and species were studied from the actual specimens 3) Ranales is placed first in the dicot which is very reasonable.

4) Monocots followed dicots

5) Gymnosperms were treated by Bentham and Hooker as a third taxon and placed between Dicots and Monocots

Demerits: 1) Placing of Gymnosperms between dicot and monocot is not accepted.

2) Artificial characters are considered here and there.

3) Monochylamydeae is considered to be the most highly evolved among polypetalae is the most primitive groups among dicots

4) Some of the related orders are widely separated from each other.

5) There is no uniformity in the arrangement of groups. 6) In the classification of monocotyledon, importance is not given to all natural characters.

Modern Systems.

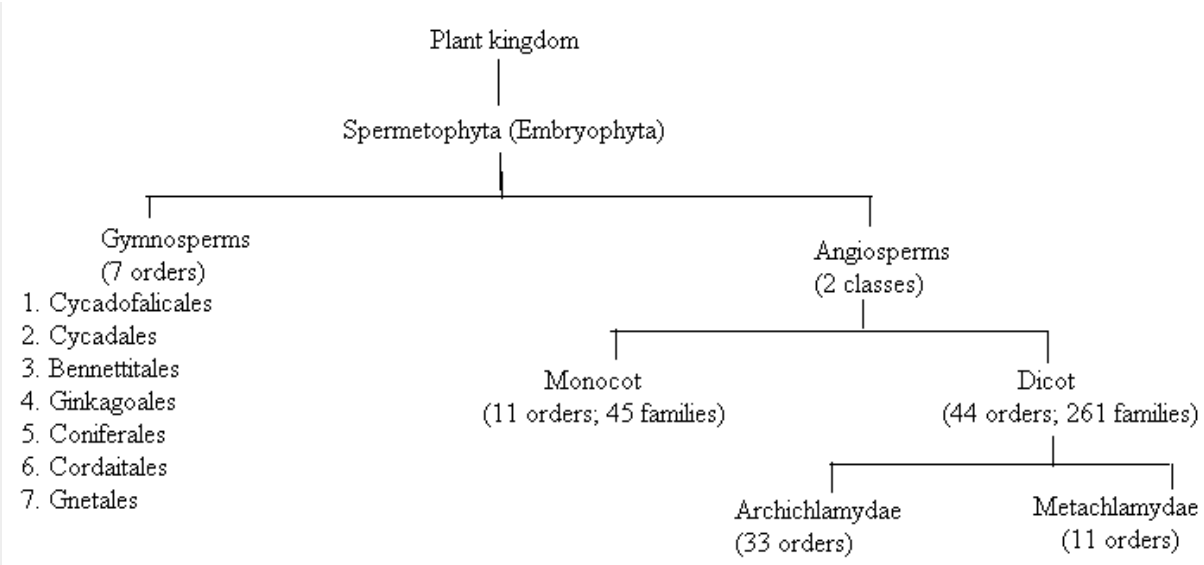
ENGLER & PRANTL'S SYSTEM OF CLASSIFICATION

Introduction • Adolf Engler (1843-1930) • Karl Prantl (1849-1893) • German Botanists • 23 volume monumental work 'De Naturalischen Pflanzefamilien' (The Natural Plant Families). • Classified Algae to Angiosperms • Phylogenetic system based on evolutionary trends. • 303 families of Flowering Plants
Outline and basis of classification • Plant Kingdom has been divided into 13 Divisions • Divisions I to 12 dealing with Bacteria, different types of Algae, Fungi, Bryophytes, and Pteridophytes. • The 13th Division is named as Embryophyta Siphonogamia which includes all seed producing plants. • It is divided into 2 sub-divisions i) Gymnospermae (naked ovules/seeds) ii) Angiospermae (enclosed ovules/seeds) • Gymnospermae has been divided into 7 orders, from Cycadofilicales to Gnetales. • The sub-division Angiospermae divided into two Classes i) Monocotyledonae ii) Dicotyledonae

Outline and basis of classification • Monocots divided into 11 Orders and 45 Families, First order is Pandanales which possesses naked, unisexual flowers with Typhaceae as the Starting family. • The last order is Microspermae with orchidaceae as the last family. • Dicots are divided into 2 subclass namely: i) Archichlamydeae, and ii) Sympetalae or Metachlamydeae • In Archichlamydeae, the flowers are achlamydous or mono/dichlamydous, but petals are mostly free (polypetalous condition).

Outline and basis of classification • In sympetalae, the petals are fused (gamopetalous). • Archichlamydeae has 33 Orders and 206 Families. The first order being Verticillatae and Casuarinaceae as the starting family. The last order being Umbelliflorae with Cornaceae as the last family. • Sympetalae has 11 Orders with 52 Families. The first Order being Ericales with Clethraceae as the starting family. • The last order is Campanulales with Asteraceae as the last family.

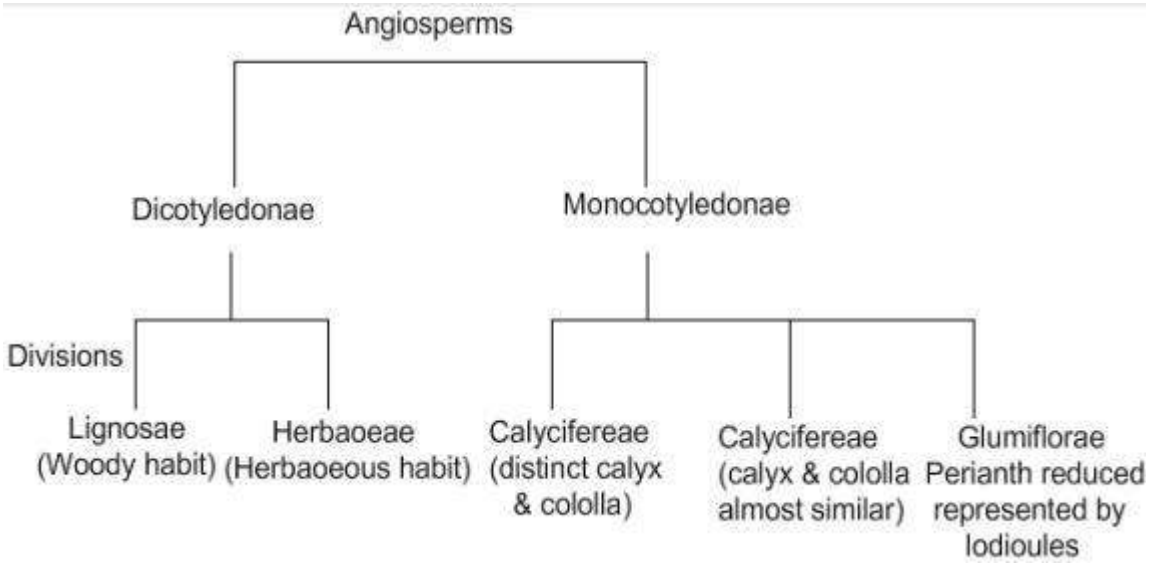
Outline of Engler & Prantl Classification Plants 13. Embryophyta Siphanogamia 1-12. Bacteria - Pteridophytes Divisions Sub Divisions Gymnospermae Angiospermae Monocotyledonae 11 orders, 45 Families Dicotyledonae Sub Class Class Archichlamydeae 33 orders, 206 families Metachlamydeae 11 orders, 52 families



Merits • Its a Phylogenetic system. Plant groups are arranged mostly according to evolutionary affinities (Primitive groups followed by advanced). The system deals with all groups of Plant-Kingdom - Bacteria, Algae, Fungi, Bryophyta, Pteridophyta, Gymnosperms and Angiosperms. The system provides modern taxonomic keys for the identification of each group of plants. Gymnosperms treated as a separate group. Its position before Angiosperms is very accurate and is in perfect accordance to the modern concept of evolution. The position of Asteraceae (Compositae) as the last family of Dicot is very logical and acurate because it is the highest evolved family of Dicots. The position of Orchidaceae at the end of Monocots is also very accurate as its the most evolved family of monocots. Anatomical data were taken into consideration in this system of classification for the first time.

Demerits • Monocots considered primitive to Dicots which is not correct according to modern evolutionary evidences. The concept of primitive flower (unisexual, achlamydous) is against the modern concept of evolution. Combining Apetalous families with Polypetalous families to form Archichlamydeae is not desirable as it has resulted in the formation of a very large group 33 Orders and 206 families. The system is not of much practical utility.

Hutchinson: He proposed the most widely used classification which is also known as the 'Hutchinson's classification'.



The Hutchinson's classification broadly divided angiosperms into:

- Dicotyledons
- Monocotyledons

Dicotyledons/ Dicotyledonous plants

These are flowering plants which have two cotyledons in their seeds. Endosperm may or may not be present in the seed.

The following are the features of dicots:

Roots: They have a tap root system with smaller secondary roots originating from it. Due to its tap root system, they can penetrate deeper into the soil to find water and minerals required for its growth.

Leaves: They have reticulate venation also called net venation on their leaves. They have a stalk that attaches the leaves to the stem.

Vascular system: Cambium is present which helps in secondary growth of the stem.

Stems: The stems are hollow and the plants are generally herbaceous or woody.

Flowers: The parts of the flowers usually exist in numbers of fours or fives.

Dicotyledons are further divided into- Lignosae and Herbaca.

Monocots/ Monocotyledonous Plants

These flowering plants have a single cotyledon in their seeds. Endosperm is always present in the seed.

Roots: They have a fibrous root system.

Leaves: Their leaves have parallel venation and the leaves are sessile i.e they do not have a stalk which attaches the leaf to the stem.

Vascular System: Cambium is absent and so there is no secondary growth of the stem.

Flowers: the parts of the flowers exist in numbers of three.

The two divisions of Monocotyledons- Calciflorae, Corolliferae, Glumiflorae.

Armen Takhtajan (1910-2009) was one of the most influential botanists and systematists of 20th century. He worked as a paleobotanist in Komarov Botanical Institue of Leningrad, USSR (present day Russia). While working in the institute, Takhtajan in 1942 developed a classification scheme for flowering plants which emphasized phylogenetic relationships between plants.

This first attempt made the arrangement of classification upto the orders of higher plants, based on the structural types of gynoecium and placentation.

After 12 years i.e. in 1954, the actual system of classification was published in 'The Origin of Angiospermous Plants' in Russian language. It was translated in English in 1958. Later on in 1964, he proposed a new system of classification in Russian language. To trance the evolution of angiosperm, he was particularly inspired by Hallier's attempt to develop a synthetic evolutionary classification of flowering plants based on Darwinian philosophy.

The classification was published in 'Flowering Plants: Origin and Dispersal' (1969) in English. Later on, in 1980, a new revision of his system was published in 'Botanical Review'.

Outline of Classification

Division	Class	Sub-class	Order
Magnoliophyta (Angiosperms)	Magnoliopsida (Dicotyledons)	Magnolidae	7
		Hamamelidae	8
		Ranunculidae	3
		Caryophyllidae	3
		Dillenidae	12
		Rosidae	16
		Asteridae	7
	Liliopsida (Monocotyledons)	Alismatidae	3
		Lilidae	3
		Arecidae	5

		Commelinidae	6

In the class Magnoliopsida,

- Most primitive order: Magnoliales
- Most advanced order: Asterales.

In the class Liliopsida,

- Most primitive order: Alismatales
- Most advanced order: Arales.

Principles of Classification

Character	Primitive	Advanced
Growth habit	Woody habit	Herbaceous habit
	Small woddy angisoperm	Large trees of tropical rain forests
	Sparingly branched trees	Trees with numerous slender branches
	Evergreen plants	Deciduous woody plants
Leaves	Simple leaves	Compound leaves
	Reticulate venation	Parallel venation
	Alternate leaves	Opposite leaves
Stomata	Mesogenous type	Peigenous type
	With subsidiary cells	Lacking subsidiary cells
Nodal structure	Tri to pentalacunar type	Unilacunar type
Inflorescence	Cymose	Racemose
Floral structure	Indefinite and variable number of floral parts arranged spirally on an	Fixed number of floral parts arranged in cyclic

	elongated axis.	pattern on a short axis
Pollen grains	Exine devoid of external sculpturing	Sculpturing is of various types
	Monocolpate (dicots)	Ticolpate (dicots)
Gynoecium	Apocarpous	Syncarpous
Ovules	Anatropous ovule	Other types
	Crassinucellate ovules	Tenuinucellate ovules
Pollination	Entomophily	Anemophily
Gametophyte & fertilization	monosporic Polygonum type	Tetrasporic type
Seeds	Abundant endosperm with a minute and undifferentiated embryo	Endosperm is reduced or wanting and the embryo is large and well differentiated
Fruits	Many seeded follicular fruit develop from multicarpellary apocarpous gynoecia.	Coenocarpous fruits

Merits of Takhtajan's classification

1. The classification of Takhtajan is more phylogenetic than that of earlier systems.
2. This classification is in a general agreement with the major contemporary systems of Cronquist, Dahlgren, Thorne, and others.
3. Nomenclature adopted in this system is in accordance with the ICBN, even at the level of division.
4. The treatment of Magnolidae as a primitive group and the placement of Dicotyledons before Monocotyledons are in agreement with the other contemporary systems.

Demerits

1. In this system, more weightage is given to cladistic information in comparison to phenetic information.
2. This system provides classification only upto the family level, thus it is not suitable for identification and adoption in herbaria.
3. Takhtajan recognised angiosperms as division which actually deserve a class rank like that of the systems of Dahlgren (1983) and Thorne (2003).

4. Numerous monotypic families have been created in 1997 due to the further splitting and increase in number of families to 592 (533 in 1987), resulting into a very narrow circumscription.
5. Takhtajan incorrectly suggested that smaller families are more ‘natural’.
6. Although the families Winteraceae and Cancellaceae showed 99 to 100% relationship by multigene analyses, Takhtajan placed these two families in two separate orders.

BIOSYSTEMATICS

Introduction to Biosystematics

Taxonomy is mostly concerned with the observation of likeness and variations which exist in the morphology of a huge number of plants. Except it has now been accepted that generally, morphological characters alone are not the criterion for distinctive and classifying plants from one other. One has to acquire into consideration, the characteristics and variations from other disciplines of science like physiology, ecology, cytology, genetics, phytogeography, molecular biology, phytochemistry, numerical taxonomy, breeding systems and any other presented sources for classification.

Biosystematics may be described as 'taxonomy of living populations'. In the current day classification of plants, species is taken like a basic unit and it is the local breeding population. Several disciplines of science thus give countless number of data of all the characters of the individual / a species. This assists to clear problems that are regarding those plants that are different in their classification, interrelationship, and evolution. It gives enough genetic variations which warrant separation so like to recognise them as a separate taxon relies on their evolutionary progress.

Differences in a species may be because of various factors like genetic, ecological, physiological, population dynamic study and several other factors. All the proofs provided through the biosystematics are acquired for analysis and considered through the classical taxonomist to reach any controversial problems that may occurs during their phylogenetic classification relies on their evolution of species under study.

Camp and Gily in the year 1943, coined the term 'biosystematics'. The aims of biosystematics are as follows.

To delimit the naturally taking place biotic community of plant species.

To recognise the several groups as separate biosystematic categories like ecotypes, ecospecies, cenospecies and comparium.

Three significant methods are as follows.

i) It includes careful sampling analysis of the taxonomic species under study. The population, geographical range, cultivation, cytology, anatomy, palynology, chromosomal number, phytochemistry, and behaviour of it are eagerly observed and studied for finding any genetic variations that may arise between different populations.

ii) It involves determination of capability of dissimilar populations to interbreed between one another to form a variant species with vigor and fertility of it. This will reveal the existence or absence of breeding barriers among taxa at several levels.

iii) It includes the study of likeness of chromosomes in the hybrids throughout meiosis.

Ecotype is the fundamental unit in biosystematics, adapted to a specific environment but able of generating fertile hybrids with other ecotypes. Ecotype is considered as equal to subspecies of classical taxonomy.

Ecospecies is a group of plants having one or more ecotypes in the cenospecies, whose members are capable to interchange their genes. Ecospecies is considered as equal to species of classical taxonomy.

Cenospecies is a group of plants that presenting one or more ecospecies of general evolutionary origin. It is considered as equal to subgenus of classical taxonomy. Cenospecies of similar comparium is separated through genetic barriers and all hybrids among them are sterile.

Comparium is created of one or more cenospecies which is not capable to intercross. Complete genetic barriers present among dissimilar comparia.

The information acquired from the above described studies was compared with the data acquired by comparative morphology and geographical distributions resulted in the identification and recognition of a total range of species. To finish, biosystematics study in the current and modern taxonomy plays a very important role in separating and solving a number of the problems which may develop in the recognition of plants at the level of species. Biosystematist gives all the essential data in solving the real position of species which was in controversy.

CHEMOTAXONOMY

Introduction

Chemotaxonomy is the method of biological classification based on similarities in the structure of certain compounds among the organisms being classified. As proteins are more closely controlled by genes and less subjected to natural selection than are anatomical features, they are more reliable indicators of genetic relationships. Hence, proteins are more reliable for biological classification. Proteins, amino acids, nucleic acids, peptides etc. are the most studied chemicals in chemotaxonomy. In Chemotaxonomy, chemical features of plants are used in developing classifications or in solving taxonomic problems.

Chemotaxonomy has been used in all the groups of the plant kingdom starting from the simple organisms, such as fungi and bacteria, up to the most highly advanced and specialized groups of angiosperms and at all levels of the hierarchy of classification in plants, starting from the rank of Variety up to the rank of Division.

The use of chemical characters in plant classification has a long history. Since the early 1960s, phytochemical characters started to attract the attention of plant taxonomists. However recently, due to the development of new and powerful analytical techniques and the speed and simplicity of these techniques, it has been possible to screen a large number of individuals in a very limited time and utilize such information in plant taxonomy.

Some of the botanists who have included chemical evidences in plant classification are Nahemia Grew in 1673, William withering in 1785, A P de Condolle in 1804 and so on. But the modern phase of chemotaxonomy began with the publication of the work of Abbott in Botanical Gazzette. Also botanist McNair published a series of papers on the use of chemical evidences in solving taxonomical problems. The main research center of chemotaxonomy is the Institute of Pharmacology at University of Kiel, Germany

Aspects of chemotaxonomy

The chemical characters are considered more important, only when they show a high degree of correlation with other features. Chemotaxonomy should not be considered as more indicative of relationship than other characters such as external morphology, anatomy, cytology, etc. and as a replacement of other taxonomic characters, but at best a major source of new characters and information.

Moreover the evidences from the chemotaxonomic studies are used in plant classification with two main purposes.

To develop taxonomic characters which may improve existing systems of plant classification

To develop present day knowledge of phylogeny or evolutionary relationships of plants.

Significance of chemotaxonomy

Plants store various chemical substances and these substances have significant value in taxonomic studies. Though all the chemicals substances stored in the plants cannot be taxonomically significant and may not give out information valued by taxonomists. The phytochemical constuituents which are important in taxxonomic studies can be grouped into two categories,

- Primary constituents: These include the macromolecular compounds directly taking part in metabolism. These include proteins, nucleic acids, chlorophyll and polysaccharides. All chemical materials synthesized by an organism reflect the information in DNA, RNA and proteins.

- Secondary constituents: They include compounds lacking nitrogen and not involved directly in plant metabolism. For example, simple phenolic compounds like caffeine, benzoic acids, nicotinic acids and polyphenolic compounds like flavonoids, terpenes and coumarines.

Chemical characters and their use in chemotaxonomy

Till date there is no suitable classification of the chemical characters and their use in taxonomy. But according to Naik the chemical characters can be divided into three categories namely,

Directly visible characters (Eg: Starch grains, Silica, Gypsum)

Characters known by chemical tests (Eg: Phenolics, Oils, Fats, waxes)

Proteins

Some other Botanists also use other characters like molecular weight to differentiate chemical compounds. Jones and Luchsinger divided natural plant products useful in taxonomy on the basis of molecular weight.

Low molecular weight compounds (Amino acids, alkaloids, Fatty acids, Terpenoids)

High molecular weight compounds (Proteins, DNA, RNA. Polysaccharides)

Sometimes the term semantides is used for the information carrying protein like DNA and RNA

NUMERICAL TAXONOMY

Introduction

Numerical taxonomy is the method of classifying organisms with the help of numerical methods. This method clarifies and illustrates the degree of relationship among the organisms in an unbiased manner. The organisms are arranged in their respective taxa based on the similarities and differences. Now-a-days numerical taxonomy is a very important in modern systematics.

The main aim of numerical taxonomy is to classify organisms using numeric algorithms. The period from 1957 to 1961 saw the development of first methods and of theory of numerical taxonomy. Plants as we all know are classified based on their characters.

Michel Adanson, a French botanist, planned to assign numerical values to the similarities between organisms and he proposed that equal weightage should be given to all the characters while classifying plants. He used as many characters as possible for the classification, and these classifications came to be known as Adansonian classifications.

Later, Robert R. Sokal & Peter H. A. Sneath in 1963 divided the field into *phenetics* in which classifications are based on the patterns of overall similarities and *cladistics* in which classifications are based on the branching patterns of the estimated evolutionary history of the taxa. Numerical taxonomy was however largely developed and popularized by Sneath and Sokal.

The application of Adansonian principles and use of modern methods and electronic data processing techniques, have helped in the evolution of several new classifications of plants during the past few decades.

Aspects of Numerical taxonomy

Numerical taxonomy involves the following two aspects,

- **Construction of taxonomic groups:** Individuals are selected and their characters are spotted. Larger the number of characters better is the approach. Then resemblances among the individuals are then established on the basis of character analysis.
- **Discrimination of taxonomic groups:** When the taxonomic groups chosen for the study show overlapping of characters, discrimination should be used to select them.

Principles of Numerical taxonomy

1. The greater the content of information in the taxa, and more the characters taken into consideration, the better a classification system will be.
2. Every character should be given equal weightage in creating new taxa.
3. For comarison purpose, the similarity between any two entities is considered.

4. Correlation of characters differs in the groups of organisms under study. Thus distinct taxa can be recognized.
5. Phylogenetic conclusions can be drawn from the taxonomic structure of a group and from character correlations, assuming some evolutionary mechanisms and pathways.
6. The science of taxonomy is viewed and practiced as an empirical science.
7. Phenetic similarity is the basis of classifications.

Advantages of Numerical taxonomy

- The data of conventional taxonomy is improved by numerical taxonomy as it utilizes better and more number of described characters.
- As numerical methods are more sensitive in delimiting taxa, the data obtained can be efficiently used in the construction of better keys and classification systems.
- Many existing biological concepts have been reinterpreted in the light of numerical taxonomy.
- Numerical taxonomy allows more taxonomic work to be done by less highly skilled workers.

Disadvantages of numerical taxonomy

- The numerical methods are useful in phenetic classifications and not phylogenetic classifications.
- The proponents of "biological" species concept may not accept the specific limits bound by these methods.
- Character selection is the greatest disadvantage in this approach. If characters chosen for comparison are inadequate, the statistical methods may give less satisfactory solution.
- Different taxonometric procedures may yield different results. A major difficulty is to choose an apt procedure for the purpose and the number of characters needed in order to obtain satisfactory results by these mechanical aids.

Applications of Numerical taxonomy

- Can be successfully used in the study of various angiospermic genera like *Apocynum, Chenopodium, Crotalaria, Cucurbita, Oenothera, Salix, Zinnia, wheat cultivars, Maize cultivars*, etc.
- With the help of numerical taxonomy similarities and differences in bacteria, other microorganisms can be studied.
- Phytochemical data from seed protein and mitochondrial DNA RFLP studies has been numerically analyzed to study the interspecific variations.

Role of Anatomy in solving Taxonomic problems:

Anatomical characters of vegetative and floral parts of flowering plants have been successfully employed to solve taxonomic problems and for the elucidation of phylogenetic relationships. It was Bureau, who for the first time used anatomical characters in plant classification for the delimitation of taxa of various levels,

However, anatomical data have been used extensively as a taxonomic tool only after the nineteenth century. Anatomical data has not only been useful at the higher levels but in certain instances, have been successfully employed even at the specific level. Auguste Mathiew is one of the pioneer taxonomists, who used features of wood anatomy in the description of forest plants in Florae forestiere.

Later, another taxonomist Solereder, discussed the systematic value of anatomical structures in dicotyledons in his classic book Systematische Anatomic der Dicotyledonen, the English translation of which was later published in a modified form in the two-volume book Anatomy of the Dicotyledons by Metcalfe and Chalk.

Anatomical evidence can be useful in systematics in several ways:
(i) It can well be exploited taxonomically in the identification of fragmentary material, say a piece of wood.

(ii) When morphological characters prove to be of no help in the preliminary identification of herbarium material, anatomical study may prove helpful.

(iii) Anatomical data has proved to be very useful in discerning evolutionary trends and interrelationships of taxa at and above the species level and at higher taxonomic categories. They are most useful in determining relationship between different genera, families, orders and other taxonomic categories.

While studying anatomical data, it is advised to study the ranges of variability of these characters within the same individual and between different individuals of the same species and not rely on data from a single sample of an organ or tissue, as similarities in structural organization may not necessarily reflect close relationship but may be the result of parallel and convergent evolution.

Types of Anatomy:
1. Vegetative Anatomy:
(a) Leaf Anatomy:
Leaf anatomy provides various characters of taxonomic importance as has been rightly stated by Carlquist, that **"the leaf is perhaps anatomically most varied organ of angiosperms and its anatomical variations often concur closely with generic and specific and occasionally familial lines".**
Leaf anatomy has been used widely in several taxonomically different groups such as Euphorbiaceae, Cyperaceae and Gramineae of Angiosperms and Coniferae of Gymnosperms.

It has been one of the most reliable characters in grass systematics. For example, the leaf anatomy of several species of Cyperaceae, was studied by Koyama and Govindrajalu and they formulated keys to identify various species of Cyperus, Fuirena, etc. Brown surveyed, 72 genera of grasses and on the basis of their tissue arrangement, six main types were recognized.

However, they could not, be segregated into the two traditional subfamilies, Pooideae and Panicoideae. Similarly, Vidakovie have used several characters of leaf anatomy in differentiating species in Pinus. Taxonomic implication of leaf anatomy of several genera of Musaceae, Zingiberaceae, Xanthorrhoeaceae and Ericaceae have also been established by several workers.

Some of the important characters of taxonomic significance in leaf anatomy include the following:
(i) Nature and thickness of epidermis:

The size and shape of epidermal cells is of great value in the taxonomy of several taxa (Fig. 8.2). Cuticular characters of the epidermis and stomata have also proved to be of great value.

For example, Conde studied 5 species of the genus Opuntia with respect to cuticular thickness, epidermal papillosity, stomatal size and frequency, hypodermal thickness, vessel number, etc. and found that each species was distinct in respect of the degree of papillosity of epidermal cells, hypodermal thickness and vessel width.

The information from trichome anatomy has also proved useful in certain taxa, e.g. trichomes have furnished as diagnostic characters in certain species of Veronica.

(ii) Structure and types of mesophyll, storage parenchyma, mid vein structure, bundle sheath, secretory apparatus, etc:

For example, Anderson & Crech suggested precise groupings of Solidago and other species of Asteraceae based on their study of leaf anatomy, including qualitative and quantitative differences in mesophyll, storage parenchyma, secretory apparatus, bundle-sheath extension and midvein structure.

(iii) Pattern of sclerenchyma:

Patterns of the distribution of sclerenchyma in Carex and Festuca have been used in distinguishing species.

(iv) Silica bodies:

Silica bodies in the epidermal cells of members of certain families like Zingiberaceae, Musaceae and Palmae among Monocotyledons and Rosaceae in the Dicotyledons have been used as diagnostic character in systematics at generic as well as specific levels.

(v) Chloroplast structure can also prove to be of taxonomic significance.

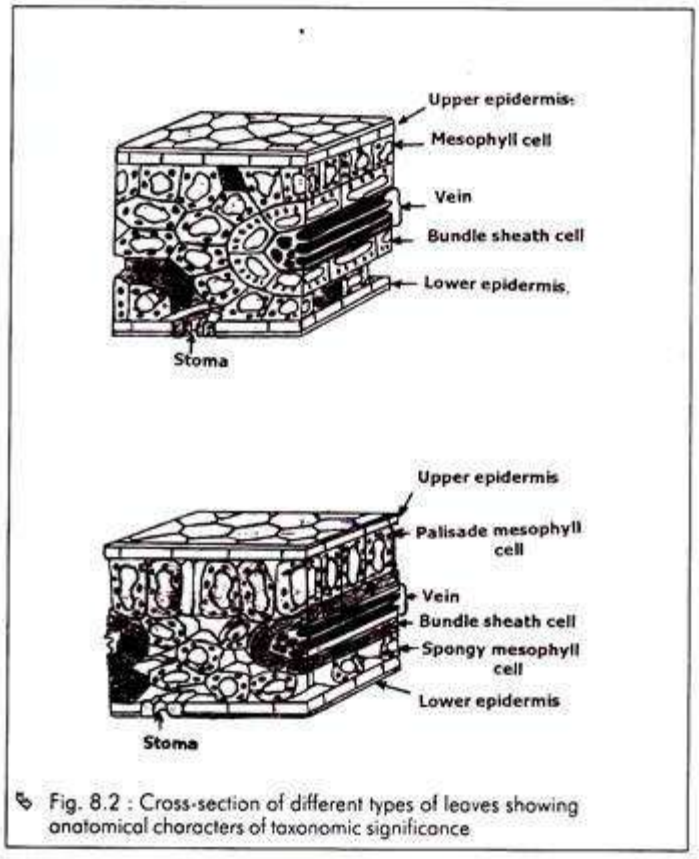


Fig. 8.2 : Cross-section of different types of leaves showing anatomical characters of taxonomic significance

(b) Stem Anatomy:

Stem anatomy has also been long relied on as a taxonomic tool (Fig. 8.3). The two-volume work by Metcalfe & Chalk is an excellent example of an illustrated encyclopaedia of this and of other aspects of plant anatomy, which reveals the taxonomical significance of anatomical characters in plant classification and can be used at various levels from Dicotyledon-

Monocotyledon distinction, to the separation of various species of the same genus. Stem anatomy has particularly proved to be of diagnostic value in the herbaceous members. For example, anatomy of stems has been successfully employed in the delimitation of species of Dioscorea which otherwise are not easily separable on exomorphic grounds.

Carlquist has used anatomical features of the genus Fitchia (Asteraceae) in the classification of various species. Further, it is also possible to identify parents of several hybrids on anatomical grounds.

Role of embryology in solving Taxonomic Problem

The embryological characters in taxonomic studies was indicated much earlier by Hoffmeister and Strasburger . Embryological features obtain special significance in such cases, where exomorphological data exhibit inconclusive correlations or are misleading. Maheswari (1950,64)and Kapil and Bhatnagar (1980) have listed the following characters which can be used in solving many problems concerning systematic.

Anther and Pollen: Number of microsporangia , type of anther wall development –Basic, Dictotyledonous, Monocotyledonous or reduced, nature of tapetum, parietal or sporogenious, glandular or plasmodial, uni,bi, or

multinucleate cells, pollen grains monads, pseudomonads, dyads, tetrads, pollinium, time of divisions of microspore nucleus as related to pollen maturation and exine formation, number of nuclei of pollen at shedding and exomorphic characters of pollen grains size, shape, apertures, exine sculpturing.

Ovule : Placentation, orthotropous, anatropous, hemianatropous, campylotropous, amphitropous, circinotropous or heterotropous, extent of nucellar cells, presence ans absence of nucellar bak. Number and nature of integuments.placental , stylar or funicular, As regards number of integuments is concerned,

Megasporogenesis and Megagametogenesis : Number of archesporium- uni, multicelled, relative frequency of megaspore tetrads-linear, T –shaped, I- shaped,or isobilateral, pattern of megasporogenesis and megagametogenesis Polygonum, Allium, Adoxa type or modified type , shape, size, and organisation of mature embryosac.

Fertilization: Nature of style , solid or open, path of pollen tube porogamous, mesogamous or chalazogamous interval between pollination and fertilization.

Endosperm : Type –Nuclear, cellular or helobial, initial walls and manner of wall formation in nuclear endosperm, presence or absence of haustoria,nature of food reserve, persistence and rumination of endosperm.

Embryo: Type of development ,morphology of mature embryo, number of cotyledon , size, incidence of polyembryony.

Seed: organization of seed coat , number of integument, presence or absence of perisperm and endosperm ,presence or absence of seed appendages.

Fruit: Histogenic differentiation, typology of sclerids and distribution of tannin, crystals,trichomes and stomata.

Certain Abnormalities of the Development : Panthenogenesis, apogamy, adventive embryony , polyembryony.

Semester	Course	Hours	Credit	Sub. Code	Marks		
					Internal	External	Total
III	CC 9	6	5	18KP3B09	25	75	100

PLANT SYSTEMATICS AND ECONOMIC BOTANY

UNIT III

Taxonomical studies of selected families and their economic importance and medicinal uses. **Gamopetalae:** Aizoaceae, Oleaceae, Boraginaceae, Scrophulariaceae, Bignoniaceae, Pedaliaceae, Verbenaceae and Lamiaceae.

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AIZOACEAE

Systematic position

- Class :Dicotyledons
- Subclass:Caryophllidae
- Order :Caryophyllales
- Family :Aizoaceae
- Genus :*Trianthema*
- Species:*portulacastrum*

Distribution of Aizoaceae

- A family of 128 genera and c. 1170 species, many of which are cultivated. S. and tropical Africa, S. America, W. Indies, Mediterranean and tropical Asia. Represented here by 8 species.

Characters of Aizoaceae

- Annual or perennial herbs or small shrubs. Leaves fleshy or scale-like, opposite or alternate, exstipulate or with membranous stipules. Flowers usually bisexual, regular. Calyx tubular, 4-8 lobed. Petals more commonly absent or numerous and linear. Stamens 5 too many, the outer ones petaloid staminodes; filaments free or basally connate, anthers bilocular, dehiscing lengthwise. Pistil monocarpellary or 2-5 and syncarpous; ovary inferior or semi-inferior, 1-5 locular or many loculed; placentation axile, parietal or basal, with usually many ovules per locule. Fruit a berry, a loculicidal capsule or of 1-seeded dehiscent or indehiscent parts. Seeds endospermic.
- Aizoaceae are annual or perennial herbs or under-shrubs, usually succulent. Leaves of Aizoaceae are simple, alternate or opposite, stipulate or not. Inflorescence cymose, or flowers solitary. Flowers of Aizoaceae are regular, bisexual, small or often large and showy. Sepals 4—8, more or less united below, imbricate or valvate. Petals numerous or rarely absent.
- Stamens of Aizoaceae many, filaments often connate. Ovary superior or inferior, 1-many chambered; ovules many in each chamber, axile or parietal; stigma 1-many. Fruit capsule, berry or nut. Seeds many; embryo curved, surrounding a mealy endosperm.
- Some plants have succulent roots or caudices. Large watery cells rich in sugar cover the xerophytic plants. Calcium oxalate crystals are often present in epidermal cells. In some

plants, e.g. Lithos species the leaves are somewhat hemispheric in shape and look like pebbles. These grow in rocky areas and resemble small stones scattered on the rocks. In some cases only one pair of leaves appear in a year.

- ✖ The petals are staminodial in origin. The capsule are often hygroscopic the valves opening when wetted.
- ✖ In Mesembryanthemum the ovary behaves peculiarly. The ovules are borne on axile placentas at first but subsequently the placentation becomes parietal.
- ✖ Aizoaceae is a large family containing over 2,000 species, majority of which are found on the sandy tracts of S. Africa and a few in Europe, America, S. E. Asia and the South Seas. Common Indian species are: *Trianthema portulacastrum* Linn., *Mollugo spergula* Linn., *Sesuoium portulacastrum* Linn., etc.
- ✖ The Aizoaceae family is closely related to Phytolaccaceae, Portulacaceae, Chenopodiaceae and Caryophyllacae, and is considered to have .been derived from Phytolaccaceae.
- ✖ Many species of Aizoaceae are cultivated as ornamental plants, otherwise the family is of little economic importance. *Tetragonia expansa* Murr. — the New Zealand spinach is cultivated as potherb. *Trianthema portulacastrum* is also used as a potherb and is said to have medicinal value.

Vegetative character

Habit

- ✖ Wastelands, roadsides, lawns, gardens, cultivated crops, and paddy fields if the water supply is low. Occasionally in perennial crops and pastures, especially in subhumid and semiarid regions.

Root

- ✖ Thin, slender, tapering, and tortuous, with lateral branching fibrous root, 5–15 cm in length; 0.3–2.5 cm in diameter, light yellow externally, creamish white internally, fractures fibrous.

Stem

- ✖ Cylindrical, dichotomously branched, prostrate or trailing, somewhat glabrous, at places reddish tinted, nodes swollen, fresh stem succulent.

Leaves

- ✖ Leaves are simple, entire but of uneven size (a great in front of a small one). Twigs and flowers develop always in the base of the small one. The lamina is ovate and fleshy.

Floral characters

Inflorescence

- ✖ Solitary flowers, sessile, in the armpit of the small leaves and more or less inclusive in the petiolar sheath. Calyx with 5 sepals ovals to lanceolated. Corolla simple, with 5 white petals and pink-purple inside, lengths from 3 to 5mm, presenting a dorsal mucro sub apical. 15 – 20 stamens inserted at the top of the calyx tube.

Flower

- ✖ Small, solitary, sessile, pinkish, nearly concealed by the pouch of the petiole, calyx tube scarious, thin, stamens 10–15, ovary superior, sessile, style single papillose, shorter than the stamens

Calyx

- ✖ Calyx 3-5 mm; calyx lobes purple or white adaxially, lanceolate, 2.5 mm; stamens 5-10.

Fruit

- ✖ Capsule dehiscent, from 4 to 5mm in length, with a single awn at the tip, opening around the middle, containing 2 to 8 seeds.

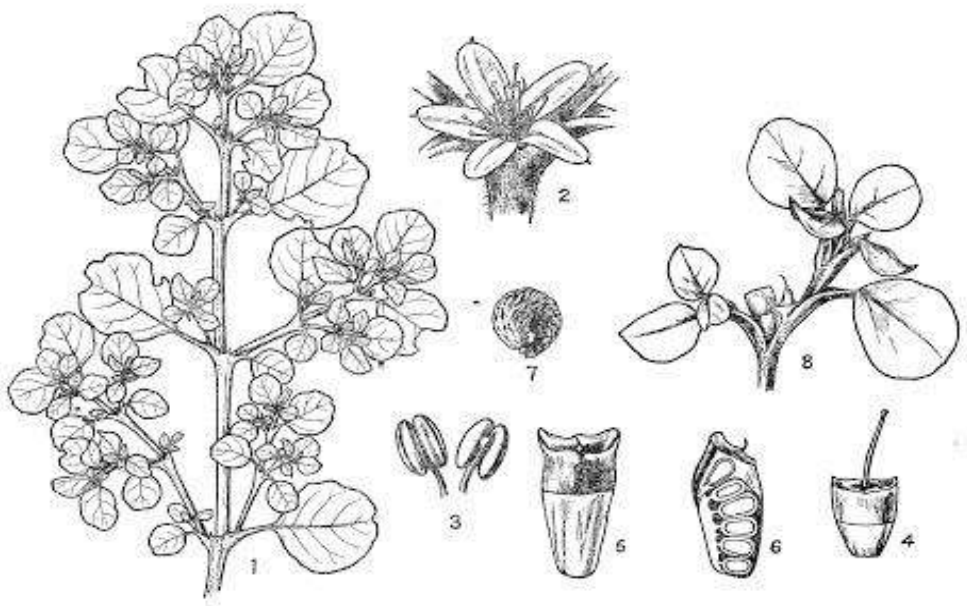
Seed

- ✖ Kidney-shaped, in spiral ended by a beak, 2mm in diameter. The tegument is tuberculate, reddish, brown to black.

Floral formula

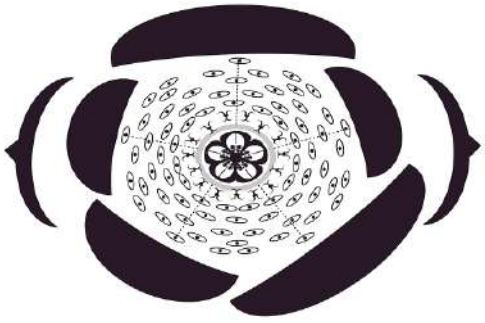
* K (5) ó 5, C muchos, A 5-muchos, G 3-5

Floral diagram



TRIANTHEMA PORTULACASTRUM, *Linn.*

PLATE 60.—Figs. 1. Branch. 2. Flower. 3. Anthers. 4. Pistil. 5. Fruit. 6. Longitudinal section of fruit. 7. Seed. 8. A small branch with stipular sheath open to show position of an immersed fruit.



Economic importance

- ✖ Many species of Aizoaceae are cultivated as ornamental plants, otherwise the family is of little economic importance. *Tetragonia expansa* Murr. — the New Zealand spinach is cultivated as potherb. *Trianthema portulacastrum* is also used as a potherb and is said to have medicinal value.

BIGNONIACEAE

Systematic position

- ✖ Class :Dicotyledons
- ✖ Subclass:Asteridae
- ✖ Order :Lamiales
- ✖ Family :Bignoniaceae
- ✖ Genus :*Tecoma*
- ✖ Species:*stans*

Characters of Bignoniaceae

- Plant predominently lianous, compound leaves, zygomorphic flowers, anthers connivent in pairs; numberous ovule, silique-like woody capsule, large winged seed and non-endospermic.

Distribution of Bignoniaceae

- Bignoniaceae or Bignonia family is primarily tropical or subtropical family comprising 120 genera and 800 species of trees or shrubs, often climbing or twining vines and rarely herbs.

Common plants of the family

- 1. *Crescentia cujete* – Calabash-fruit large, ground-like.
- 2. *Jacaranda acutifolius* – Jack tree a road-side avenue tree with wonderful masses of purplish flowers.
- 3. *Catalpa speciosa* – tree grown for valuable wood.
- 4. *Bignonia vensusta* – Climber, ornamental plant.
- 5. *Millingtonia hortensis* – Indian cork – tree.
- 6. *Tecoma stans* – garden shrub.
- 7. *Tabebuia* – West Indian Box tree.

Vegetative characters

Habit

- Mostly trees or shrubs; often climbing or twining vine, rarely herbs.

Root

- Tap, deep, branched.

Stem

- Hard, woody and branched; weak in climbers and twiners, rootlet or tendril climbers.

Leaf

- Usually pinnately compound, opposite, decussate, rarely simple or alternate, exstipulate, terminal leaflet modified into tendril, adhesive disc or hook.

Floral characters

Inflorescence

- Usually dichasial cyme with bracts and bracteoles.

Flower

- Bracteate, bracteolate, hermaphrodite, hypogynous, zygomophic, complete.

Calyx

- Sepals 5, gamopetalous, lobed or bilabiate, valvate.

Corolla

- Petals 5, obliquely campanulate or infundibuliform, imbricate, gamopetalous, lobes or teeth 5, sometimes bilabiate.

Androecium

- Stamens 4, didynamous, epipetalous, posterior staminode, sometimes 2 (Catalpa); anther two-lobed, lobes divaricate, disc present.

Gynoecium

- Carpels 2, syncarpous; ovary superior, bilocular with axile placentation, each loculus many – ovuled; sometime unilocular (Eccremocarpus) with two bifid parietal placentae; style terminal and single; stigma bifid.

Floral diagram

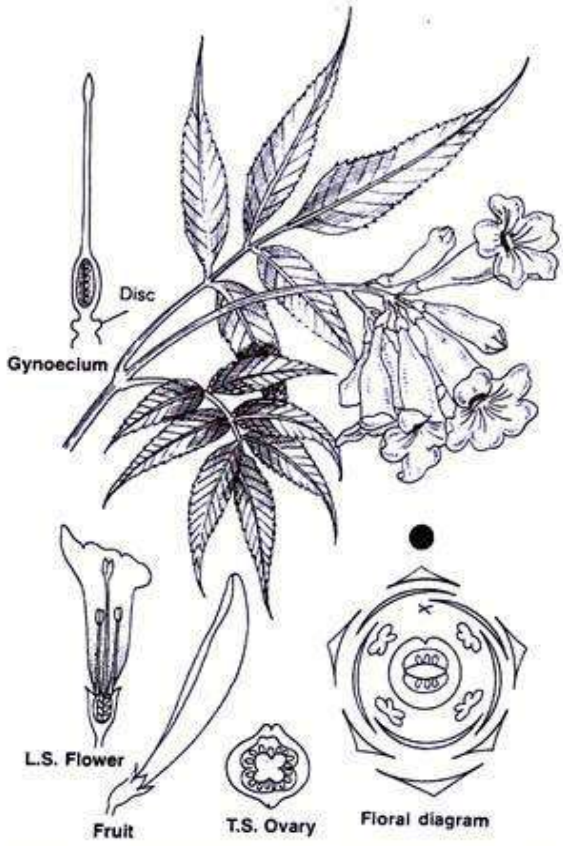


Fig. 82.1. *Tecoma stans* (L). H.B.K., A. Flowering twig with pinnate leaves.

Economic Importance of Bignoniaceae

1. Timber

- *Catalpa bignonioides, Millingtonia, Spathodea companulata, Tabebuia pentaphylla, Oroxylum* are prized for timber.

2. Dye

- The leaves of *Cybistax antisyphilitica* are used as source of blue dye.

3. Ornamental

- The garden ornamental plants are represented by *Pyrostegia venusa* (Syn. *Bignonia uenusta*), *Spathodea campanulata, Tecoma stans.*

BORAGINACEAE

Systematic position

- Class :Dicotyledons
- Subclass:Asteridae
- Order :Scrophulariales
- Family :Boraginaceae
- Genus :*Heliotropium*
- Species:*indicum*

Characters of Boraginaceae

Plants mostly hispid herbs rarely shrubs or trees; leaves alternate, simple, usually entire; flowers hypogynous, actinomorphic, hermaphrodite; corolla gamopetalous; stamens epipetalous; gynoecium bicarpellary, syncarpous, 2 to 4 loculed due to the formation of a false septum; style gynobasic; seeds non-endospermic.

Distribution of Boraginaceae

Boraginaceae is commonly known as the Forget me-not family. It includes about 100 genera and 2000 species widely distributed throughout temperature, tropical regions and more abundant in Mediterranean region.

Common plants of the family

1. Arnebia hispidissima

A prostrate annual herb flowering from November to April.

2. Borago officinalis

To which the family owes its name.

3. Cordia dichotoma (H. Lasura)

A small tree with mucilaginous fruits.

4. Ehretia acuminate

Tree with numerous white fragrant flowers.

5. Heliotropium indicum (H. Unth chara)

A common weed.

6. Myosotis arvensis (Forget me not)

A herb with bright blue flowers with yellow centre.

7. Nonnea pulla

Much branched hairy herb, common near railway lines and waste places.

8. Trichodesma indicum

Annual herb with pale blue flowers; common throughout India.

Vegetative characters

Habit

Predominantly herbs, mostly annuals (*Heliotropium, Arnebia*), a few shrubs and trees (Cordia); usually covered with dense hair; xerophytic.

Root

A much branched tap root system.

Stem

Erect, aerial, cylindrical, solid, branched, hispid, herbaceous, or woody in arboreal forms.

Leaves

Cauline, ramal, simple, exstipulate, petiolate, alternate rarely opposite, usually converged with hairs.

Floral characters

Inflorescence

Solitary axillary; dichotomous corymb, uniparous scorpioid, with marked dorsiventrality, uncoiling as flowers opens.

Flower

Bracteate or ebracteate, pedicellate or sessile, complete, actinomorphic, rarely zygomorphic, hermaphrodite, hypogynous, pentamerous, polygamous in Cordia.

Calyx

Sepals 5, rarely 4 to 8 lobed (Cordia); gamosepalous or free, imbricate or valvate, usually hairy, campanulate or tubular, persistent, green, inferior.

Corolla

Petals 5, rarely 4 to 8 lobed, gamopetalous, campanulate, tubular or funnel-shaped, imbricate or valvate, inferior.

Corona

Small scale-like or hair-like appendages arise from the throat of corolla tube.

Androecium

Stamens 5, 4 to 8 in Cordia, epipetalous, filaments usually short, anthers dithecous, usually conical or sagittate, introrse.

Gynoecium

Bicarpellary, syncarpous, ovary superior, bilocular, two ovules in each loculus, axile placentation; sometimes ovary becomes tetralocular due to the formation of a false septum so that there is one ovule in each loculus; style simple or 2-4 fid, hairy, terminal or inserted between the lobes (gynobasic); stigma distinct usually capitate, annular or lobed nectar secreting disc below the ovary.

Fruit

A drupe, fruit has 4 nutlets, carcerulus (*Heliotropium*).

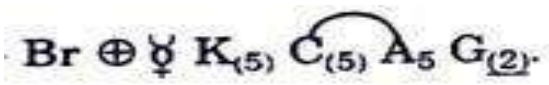
Seed

Non-endospermic or endospermic.

Pollination

Entomophilous.

Floral formula



Floral diagram

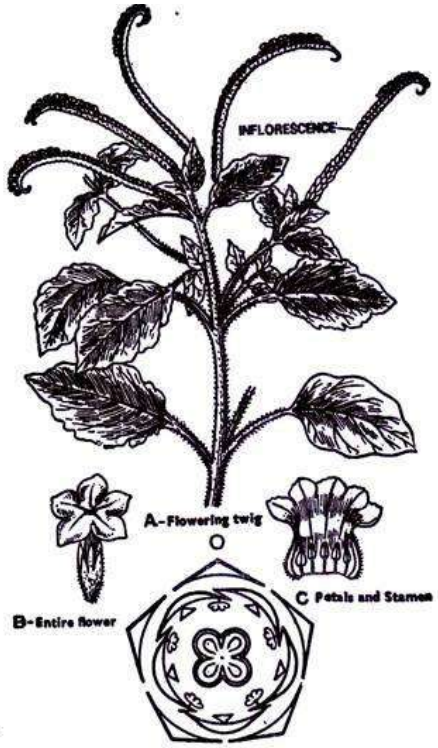


Fig. 76.1. *Heliotropium strigosum.*

Economic Importance of Boraginaceae

The family is of little importance economically.

1. Food

Fruits of *Cordia dichotoma* are used in pickles and jams and those of *Ehretia serrata* are edible.

2. Medicinal

Alkanna tinctoria and *Cordia* are medicinal. *Trichodesma indicum* is diuretic. Symphytum is known to stimulate joining of fractured bones.

3. Ornamental

Mertensia, *Myosotis*, *Cordia*, *Cynoglossum* are cultivated for ornamentals.

OLEACEAE

Systematic position

- ✖ Class :Dicotyledons
- ✖ Subclass:Asteridae
- ✖ Order :Scrophulariales
- ✖ Family :Oleaceae
- ✖ Genus :*Jasminum*
- ✖ Species:*sambac*

Distribution of Oleaceae

Distribution:

    - * **Sub-Class:** Metachlamydeae
    - * **Order:** Oleales
    - * **Genera:** 22
    - * **Spp:** 500
- * Temperate, tropical (warm), subtropical regions

Important Genera + Spp

Olea

- * *Olea cuspidata*
- * *Olea robusta*
- * *Olea wallichiana*
- * *Olea europeana*

Jasminum

- * *Jasminum humile*
- * *Jasminum sambac*

Springa

- * *Springa emodi*

Common plants of the family

* 1. *Jasminum* – name derived from Jasmine, the Persian name signifying fragrant; cultivated in gardens.
* 2. *Nyctanthus* – from Greek nyx, nycols, night and anthos, flower, the flowers open in the evening and fall off the following morning. *Nyctanthus* arbor-tristic – *Harsingar* – ornamental tree.
* 3. *Olea* – Latin name of olive, a tree.
* 4. *Osmanthus* – a shrub or small ever-green tree.
* 5. *Syringa* – a musical pipe, its long, straight branches from which the pith is easily removed to make flute or whistle.

Vegetative Characteristics

Habitat

Medium size, evergreen trees, woody, shrubs, sometimes climber

Root

Taproot system

Stem

Erect, cylindrical, woody, smooth when young

Leaves

Simple, exstipulate, always opposite (except *Jasminum*), alternate, compound sometime stipulate, entire or toothed

Floral Characteristics

* **Inflorescence:** Cymose or compound racemose
* **Flower**: Regular, rarely unisexual tetramerous
* **Calyx**: Sepals are 4-5, small, more or less united persistent, valvate or imbricate
* **Corolla:** 4-5 or more petals, united, valvate, imbricate, rarely free
* **Androecium:** Stamens 2, sometimes 4, anther 2 celled

* **Gynoecium:** Carpels 2, Syncarpous (United), ovary superior, 2 celled, style are short, simple stigma
* **Fruit:** Variable, capsule or drupe
* **Seeds:** Non-endospermic, oily, endospermic
* **Pollination:** Entomophilous

Floral formula

$$\oplus \, ☿ \, ♀ \, K_{(4-10)} \, \overset{\frown}{C_{(4-10)}} \, A_2 \, \underline{G_{(2)}}$$

Floral diagram

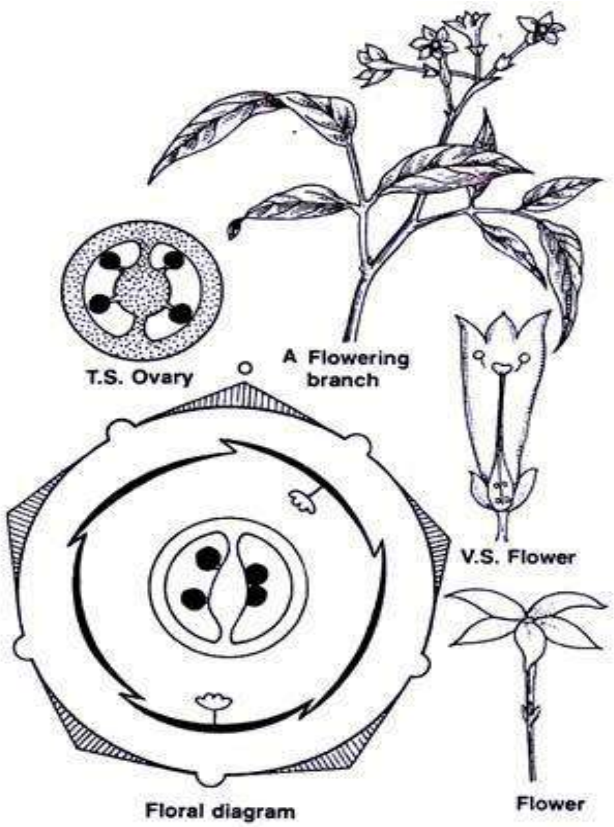


Fig. 72.2. *Jasminum*

Economic Importance of Oleaceae

1. Food

* *Fraxinus ornus* is cultivated in the Mediterranean countries for the sake of saccharine juice which flows out and coagulates into "Manna" a sugary substance.

2. Medicinal

* Leaves of *Jasminum sambac* (Arabian Jasmine) are used in India as lactifuge and are said to be as efficacious as belladona. A decoction of the leaves and roots are used for eye-sore. A decoction of roots of *Jasminum* pubescence has some repute as an antidote for cobra venom while those of *J. humile* and *J. officinale* are said to be useful in curing ringworm.

* The leaves and flowers of *Jasminium grardiflorum* contain a resin, salicylic acid, an alkaloid '*Jasminine'* and an astringent. The whole plant is considered to be anthelmintic, diuretic and emmenagogue.

3. Oil:

* Olive oil is obtained from the fruit-pulp and seeds of *Olea europea*.

4. Perfumes:

* The sweet-scented flowers of *Jasminum grandifiorum* and *J. sambac* contain an essential oil which is used in the preparation of well-known perfume, Jasmine.

5. Timber:

* The wood of *Fraxinus excelsior* (Ash), *Olea dioica* and *Olea robusta*, yield excellent timber which is hard and durable.

6. Dye:

* The corolla of *Nyctanthus* yields an orange dye.

7. Ornamentals:

* Many species of *Jasminum*, e.g., *J. sambac* and *J. grandifiorum* are cultivated as ornamental shrubs on account of their elegant foliage and beautiful sweet-scented flowers. *Nyctanthes-arbortristis* (*Harsinghar*) is very popular for its sweet-scented flowers which open at night. Many species of *Ligustrum*, *Syringa* (Lilac) and *Forsythia* are also beautiful ornamentals.

SCROPHULARIACEAE

Systematic position

- Class :Dicotyledons
- Subclass:Asteridae
- Order :Scrophulariales
- Family :Scorphulariaceae
- Genus :*Lindenbergia*
- Species:*indica*

Distribution of Scrophulariaceae

It is commonly called 'Snapdragon family'. It includes 220 genera and 3000 species which are distributed all over the world but most abundant in temperate regions. In India it is represented by 273 species.

Common plants of the family

1. Antirrhinum majus (Snapdragon or dog flower)

Ornamental herb cultivated in winter.

2. Mimulus gracilis (Donkey flower)

An ornamental herb.

3. Digitalis purpurea (Foxglove)

A common ornamental herb with medicinal value.

4. Linaria vulgaris (Toad flax)

A beautiful herb.

5. Veronica

Cultivated herb with 4 sepals, 4 petals and 2 stamens.

6. Bonnaya

An annual glabrous herb of winter.

7. Striga

A root parasite of Pennisetum.

8. Lindenbergia

A common perennial herb on old walls and soil.

Characters of Scrophulariaceae

Plants mostly herbs; leaves alternate or opposite, exstipulate; flowers zygomorphic and hypogynous, hermaphrodite; calyx gamosepalous; corolla gamopetalous; stamens four or two, if four didynamous; epipetalous; gynoecium bicarpellary, syncarpous, bilocular, axile placentation with many ovules; fruit capsule or berry; seeds endospermic.

Vegetative characters

Habit

Mostly herbs (*Antirrhinum*) or shrubs rarely trees (*Paulownia*), climbers (*Maurandia*), root parasites (*Pedicularis*).

Root

Branched tap root system.

Stem

Herbaceous, or woody (*Paulownia*) aerial, erect.

Leaves

Alternate, or opposite, rarely whorled (Veronica), simple; in *Limnophila* leaves are dimorphic, exstipulate, margin entire, unicostate reticulate, in parasitic species leaves are reduced.

B. Floral characters

Inflorescence

Cymose or racemose, it may be spike, rarely solitary axillary (*Scoparia*, *Striga densiflora*).

Flower

Bracteate, pedicellate, or sessile (*Lindenbergia*), hermaphrodite, pentamerous, hypogynous, complete, zygomorphic, rarely actinomorphic, (*Verbascum*, *Veronica*).

Calyx

Sepals 5, rarely 4 (*Veronica*, *Scoparia*), gamosepalous, imbricate or valvate aestivation, persistent; calyx teeth may be 2/5, campanulate or shortly tubular; inferior.

Corolla

Petals 5, gamopetalous, zygomorphic petals, sometimes two petals fused (*Veronica*), campanulate (*Digitalis*), spurred (*Linaria*); saccate (*Antirrhinum*), imbricate aestivation, inferior, variously coloured.

Androecium

Stamens 4 in Digitals, 5 in Verbascum or 2 in Veronica; when didynamous and one staminode present (*Digitalis*); epipetalous, polyandrous; anthers basifixed or dorsifixed, dithecous, filament short, introrse.

Gynoecium

Bicarpellary, syncarpous, superior, bilocular, axile placentation, ovules many in each loculus; style short, simple; stigma bifid; usually nectariferous disc present below the ovary.

Fruit

A capsule or berry.

Seed

Endospermic.

Pollination

Entomophilous rarely self pollination in Veronica.

Floral Formula

$$Br\ \%\ ⚥\ K_{(5)}\ \overparen{C_{(2/3)}\ A_{2+2}}\ G_{(\underline{2})}$$

Floral diagram

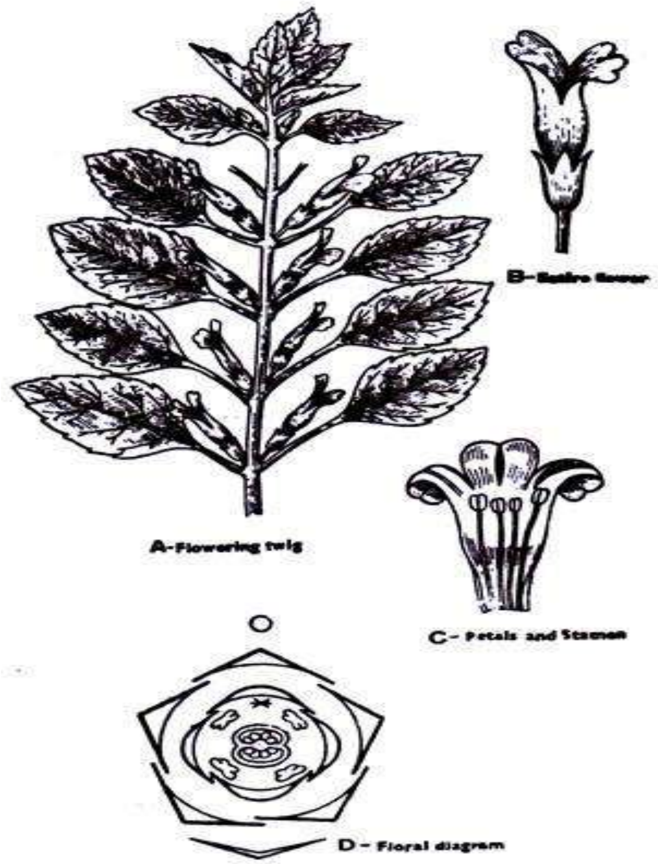


Fig. 79.1. *Lindenbergia indica*.

Economic Importance of Scrophulariaceae

1. Medicinal

Digitalis is used in heart diseases. The leaves of *Verbascum thapsus* are used in asthma and pulmonary complaints. The juice of leaves of *Torenia asiatica* is considered a cure for gonorrhoea. The juice of *Lindenbergia indica* is given in bronchitis. *Anticharis* is used in diabetes.

2. Ornamentals

Antirrhinum, *Veronica*, *Linaria*, *Mimulus*, *Cymbalaria*, *Russelia*, *Torenia* and *Digitalis* are cultivated for ornamental purposes.

VERBENACEAE

Systematic position

- Class :Dicotyledons
- Subclass:Asteridae
- Order :Lamiales
- Family :Verbenaceae
- Genus :*Lantana*
- Species:*camara*

Distribution of Verbenaceae

- The family is commonly called Verbena family. It includes 77 genera and 3,020 species, out of which 21 genera and 125 species occur in India. The members of family are inhabitants of tropical and subtropical regions, they also extend into temperate lands.

Characters of Verbenaceae

- Plants herbs, shrubs or trees, leaves simple, exstipulate, opposite or whorled; inflorescence cymose, racemose or spike, flowers hermaphrodite, zygomorphic, hypogynous, calyx gamosepalous, persistent; corolla 5 lobed, gamopetalous sometimes 2 lipped, stamens four, didynamous, unequally paired, epipetalous; carpels two, syncarpous, superior, axile placentation, fruit drupe.

Common plants of the family

***Avicennia alba* (White mangrove)**

- A tree of Sunderban with long pneumatophore and viviparous seeds.

2. *Callicarpa arborea* (H. Ghiwala)

- A tree with hard, light coloured wood.

3. *Clerodendron (H. Bharangi) (Clerodendrum L.)*

- *Clerodendron* increme – sea shore plant.

4. *Duranta repens*

- An erect shrubby hedge plant.

5. *Lantana indica*

- Lantana indica Weed.

6. *Tectona grandis* (*H. Sagwan*)

- A deciduous tree yields timber teak for furniture.

7. *Verbana officinalis*

- Stem quadrangular, common on waste places.

8. *Vitex negundo*

- *Vitex negundo* (*H. Indrani*).

Vegetative characters

Habit

- Mostly annual or perennial herbs, may be shrubs or trees (*Tectona*) or rarely woody climbers or halophyte (*Avicennia*) in tropical shores.

Root

- Tap, branched, pneumatophore in *Avicennia*.

Stem

- Erect, herbaceous or woody, young branches quadrangular, in some branches spiny.

Leaves

- Simple or palmately or pinnately (*Peronema*) compound, opposite or whorled, exstipulate, entire or divided.

Floral characters

Inflorescence

- Cyme or racemose spikes often with an involucre of coloured bracts; cymose is usually dichasial (*Clerodendron*).

Flower

- Zygomorphic, hermaphrodite, rarely unisexual by abortion (*Aegiphila*), hypogynous, pentamerous or tetramerous (*Physopsis*), rarely actinomorphic (*Physopsis*) complete.

Calyx

- Sepals 5 lobed, gamosepalous, persistent, bell shaped or tubular, rarely 4 to 8 valvate, inferior.

Corolla

- Petals 5 or 4 lobed, gamopetalous petals unequal, tubular or cylindrical, bi-lippod, imbricate, inferior.

Androecium

- Stamens 4, didynamous, fifth stamen may be staminode or absent rarely 5 present (*Tectona*), epipetalous, bithecous, filaments free, dorsifixed, introrse, dehiscence longitudinal.

Gynoecium

- Bicarpellary, syncarpous, rarely carpels 4 (*Duranta*) or 5 (*Geunsia*) superior in early stage bilocular but soon divided into 4 or many loculed by false septa, axile placentation or free central in *Avicennia*; style terminal, stigma entire or bilobed.

Fruit

- Drupe rarely schizocarpic capsule enclosed by persistent calyx.

Seed

- Non-endospermic with a straight embryo.

Pollination

- Entomophilous.

Floral formula

Floral Diagram

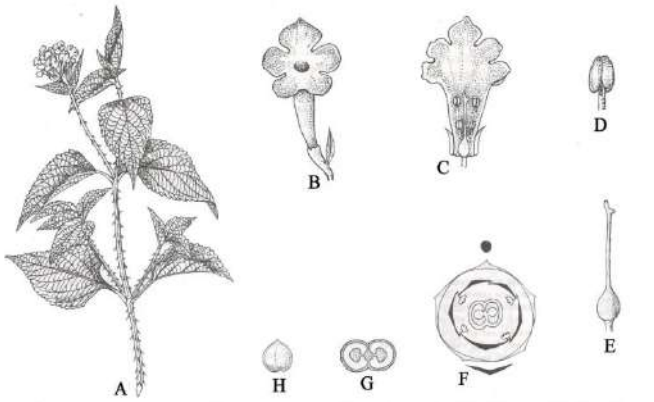


Fig: ***Lantana camara.*** (A) A portion of a flowering twig, (B) Flower (C) Corolla split open showing stamens and gynoecium, (D) Single stamen,(E) Gynoecium, (F) Floral Diagram, (G) TS of ovary, (H) Seed.

Economic Importance of Verbenaceae

1. Timber

- The wood of *Tectona grandis* (Teak, H. Sagwan) is extremely hard and lasting. The wood is largely used in manufacturing of ships and good quality furniture. Teak is grown in forests of Burma, Madhya Pradesh and Assam. The wood of *Gmelina arborea* is used in making drums, sitars and other musical instruments.

2. Medicinal

- The roots of *Clerodendron* are used in asthma and cough. The decoction of leaves of *Lantana camara* is given in tetanus and rheumatism. The leave's juice of *Gmelina arborea* is used in gonorrhoea, cough and ulcers.

3. Oils

- *Lippia alba* produces a valuable oil.

4. Tanning

- The bark of *Avicennia* is used in tanning.

5. Febrifuge

- The leaves of *Vitex negundo* serve as febrifuge. The branches of this plant are kept over stored grains to keep off insects.

6. Ornamental

- *Lantana, Verbena officinalis, Duranta, Congea tomentosa, Callicarpa, Clerodendron, Petrea* are cultivated in gardens.

PEDALIACEAE

Systematic position

- Class :Dicotyledons
- Subclass:Asteridae
- Order : Scrophulariales
- Family : Pedaliaceae
- Genus :*Sesamum*
- Species:*indicum*

Distribution of Pedaliaceae

Sesamum family comprises of 16 genera and 60 species, mostly maritime or desert plants.

Common plant of the family

1. Sesamum, indicum L.

Sesame or Gingelly (H.Til) an oil-seed crop.

Characters of Pedaliaceae

Herbs with opposite leaves, and mucilage containing glandular hairs; flowers zygomorphic, hoypogynous; calyx and corolla 5, fused, corolla bilabiate; stemens 4, epipetalous, sometimes 2; carpels 2, syncarpous, 4-loculed or incompletely 4-loculed, axile placentation; fruit a capsule, beaked or barbed.

Vegetative characters

Habit

Annual or perennial herbs, rarely shrubs.

Root

Tap and branched.

Stem

Erect, herbaceous, branched with mucilage containing glandular hairs.

Leaf

Simple, entire or lobed, opposite or the uppermost sometimes alternate, exstipulate with mucilage glands.

Floral characters

Inflorescence

Usually solitary in axils or simple axillary dichasial, rarely recemose.

Flower

Zygomorphic, hypogynous, rarely epigynous (Trapelia), hermaphrodite, pedicellate, complete.

Calyx

Sepals 5, rarely 4, gamosepalous, valvate.

Corolla:

Pelals 5 or 4, gamopetaous, tubular, 5-lobed or somewhat bilabiate, (upper 2, lower 3).

Androecium

Stamens 4, epipetalues distinct, didynamous (only 2 fertile stamen in Trapelia), the fifth (posterior) represented by a small staminode, anthers – bithecous, introrse, dehiscing langitudinally.

Gynoecium

Bicarpellary, syncarpous, superior (inferior in *Trapelia*) bi or tetralocular due to false septa, axile placentation, 1 or more ovules in each locule, ovule anatropous; style one and slender; strigma bilobed.

Fruit

Loculicidal capsule or nut, often spiny or with wings, hooks or thorns, beaked or barbed.

Seed

Smooth with a thin fleshy endosperm and a small straight embryo.

Pollination

Entomophilous.

Floral formula

$$\oplus | \circ \, \varnothing \, K_{(5)} \; \overset{\frown}{C_{(5)}} \, A_{2+2} \, , \, \underline{G_{(2)}}.$$

Floral diagram

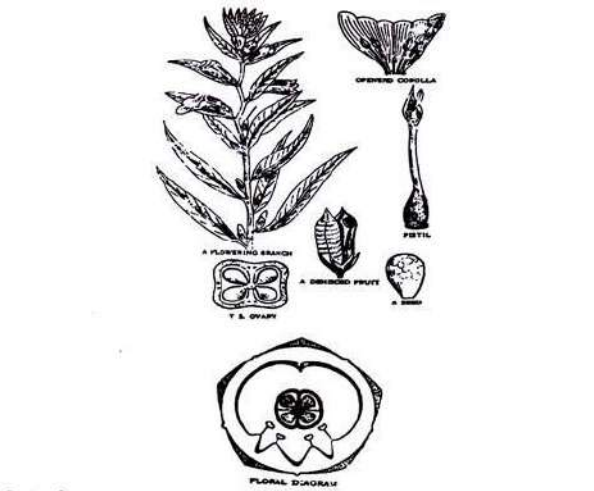


Fig. 84.1. *Sesamum indicum*. A. Portion of plant showing flowers and fruit, slightly reduced. B. Corolla opened from the front. C. Pistil, enlarged. D. Transverse section of ovary, much enlarged. E. Fruit dehiscing, slightly reduced. F. Seed. G. Seed cut lengthwise.

Economic Importance of Pedaliaceae

1. Food

The seeds of *Sesamum indicum* (H. til) yield oil. The seeds of white seeded variety are edible-and largely eaten in the form of sweetmeat. The oil is used for culinary purposes.

The leaves of *Ceratotheca sesamoides* and *Pedailium mures* are used as vegetables.

The oil of black seeded varieties of *Sesamum indicum* is used for burning and anointing the body and manufacture of soaps and perfumes.

2. Medicinal

The seeds of *Sesamum indicum* are used in piles, dysentery and urinary trobules. They are also applied to ulcers in the form of poultice.

The decoction *Pedalium* fruit is used for urinary complaints, spamatorrhoea, and impotency. The infusion of leaves and stem are also useful for veneral diseases such as gonorrhoea, dysuria etc. The roots have antibilous properties.

3. Ornamental

Ceratotheca triloba is cultivated domestically as an ornamental plant to a limited extent.

LAMIACEAE

Systematic position

- Class :Dicotyledons
- Subclass:Asteridae
- Order : Lamiales
- Family : Lamiaceae
- Genus :*Ocimum*
- Species:*santcum*

Distribution of Lamiaceae

It is commonly called Mint family. The family includes 260 genera and 3200 species of world wide distribution. In India it is represented by 400 species.

Common plants of the family

1. *Coleus aromaticus* (H. Ajwain)

An aromatic herb with beautiful variegated leaves.

2. *Leucas lantana*

Herb clothed with white tomentose hairs.

3. *Lavandula vera*

Aromatic smell; flowering shoots yield volatile oil.

4. *Mentha piperata (H. Podina)*

Cultivated, branching herb, perennate by means of suckers.

5. *Roylea*

Woody undershrub with white pinkish flowers.

6. *Ocimum santcum (H. Tulsi)*

Sacred plant for Hindus; also used medicinally.

7. Salvia

Cultivated ornamental herb.

8. *Thymus vulgaris*

Aromatic procumbent shrub; yields oil of much medicinal importance.

Characters of Lamiaceae

Sweet aromatic smell due to essential oils present in sessile glandular hairs; stem rectangular in cross section, leaves opposite decussate rarely alternate, simple, exstipulate with hairs; inflorescence verticillaster; flowers zygomorphic, hermaphrodite, hypogynous, bracteate; calyx gamosepalous, persistent; corolla bilabiate; stamens 4 epipetalous, didynamous; gynoecium 2 four celled by false septum, syncarpous, axile placentation, gynobasic style, seated on lobed disc; fruit schizocarpic carcerulus.

Vegetative characters

Habit

Plants are mostly aromatic herbs or shrubs (*Leonotis*, *Pogostemon*). Tree habit is found in the Brazilian genus Hyptis and climbing habit in American species of *Scutellaria*.

Root

Tap, branched, rarely adventitious (*Mentha*).

Stem

Aerial, herbaceous, rarely woody, erect or prostrate, quadrangular, hairy, branched, solid or hollow, sometimes underground suckers (*Mentha*).

Leaves

Opposite decussate, rarely whorled, simple, petiolate or sessile, exstipulate, hairy with aromatic smell, entire, pinnatifid (*Perovskia*), unicostate reticulate venation.

Floral characters

Inflorescence

Very commonly verticillaster consisting of a pair of condensed dichasial cymes at each node; often the verticillasters are grouped together in a thyrsus form; rarely solitary (*Scutellaria*).

Flower

Pedicellate or sessile, bracteate, complete, zygomorphic rarely actinomorphic (*Mentha*, *Elsholtzia*), hermaphrodite, rarely unisexual (*Nepeta*, *Thymus*), pentamerous hypogynous.

Calyx

Sepals 5, gamosepalous, bilabiate (*Salvia*, *Thymus*) campanulate (*Teucrium*), persistent, valvate or imbricate aestivation. When a bilabiate calyx is present the arrangement of the sepals may be (1/4) as in *Ocimum* or (2/3) as in *Calamintha*.

Corolla

The corolla possesses a tubular base which widens towards the mouth. Petals generally 5, gamopetalous and the five teeth are sub-equal and mostly bilabiate. In *Mentha* a four lobed corolla arises due to the fusion of two upper teeth. When a distinct bilabiate condition is found the arrangement of the petals may be gamopetalous 2/3 i.e. two petals in the posterior upper lip and three in the anterior lower lip (*Salvia, Nepeta*, *Leucas* etc.).

In *Ocimum*, Coleus, *Plectranthus* etc. the petals arrangement is gamopetalous 4/1 i.e. four petals in the posterior upper lip and only one petal in the anterior lower lip. In extreme cases the arrangement may be gamopetalous 0/5 i.e. all the five petals forming the lower lip so that the corolla becomes one lipped. Aestivation in the petals is valvate or imbricate.

Androecium

Typically only 4 stamens, didynamous (2+2) and posterior stamen is reduced or represented by a staminode; in *Calamintha* only two perfect stamens are found, two are imperfect and the fifth reduced. In Salvia only two stamens on the anterior side are found; they are characterised by peculiarly long connectives which help in insect pollination stamens generally introrse and dithecous.

Gynoecium

Bicarpellary, syncarpous, superior, situated on hypogynous honey secreting disc; bilocular becomes tetralocular by the formation of false septum; axile placentation, one ovule in each loculus; style gynobasic (arising from the base of the ovary), stigma bilobed. The gynoecium character is thus uniform without any variation.

Fruit

Usually schizocarpic carcerulus or achenes or nutlets rarely drupaceous.

Seed

Non-endospermic.

Pollination mechanism in the Lamiaceae

According to Delpino there are five important characters of the flower affecting the pollination mechanism viz.

(a) The horizontal position of the axis of the flower;

(b) Division of the corolla into an upper and a lower lip;

(c) Position of stamens and stigma below the upper lip which shelters them;

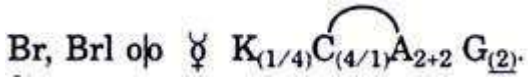
(d) Position of the nectary at the base of the flower below the lower lip whose anterior part forms a platform for insects; and

(e) Well marked dichogamy.

Muller, who is an authority on the pollination mechanism has remarked in this connection that out of the above the first three are generally true but not universal; the fourth is almost universal but dichogamy is not so complete so as to prevent self pollination.

The types of insects visiting these flowers have a remarkable correspondence with the length of the corolla tube. Those with short tubes are pollinated by flies; slightly longer tubed flowers, e.g. *Thymus* or *Origanum* are pollinated by bees; Salvia, *Lamium, Teucrium* with still longer tubes are pollinated by bees as well as other longer tongued insects.

Floral- formula:



Floral diagram

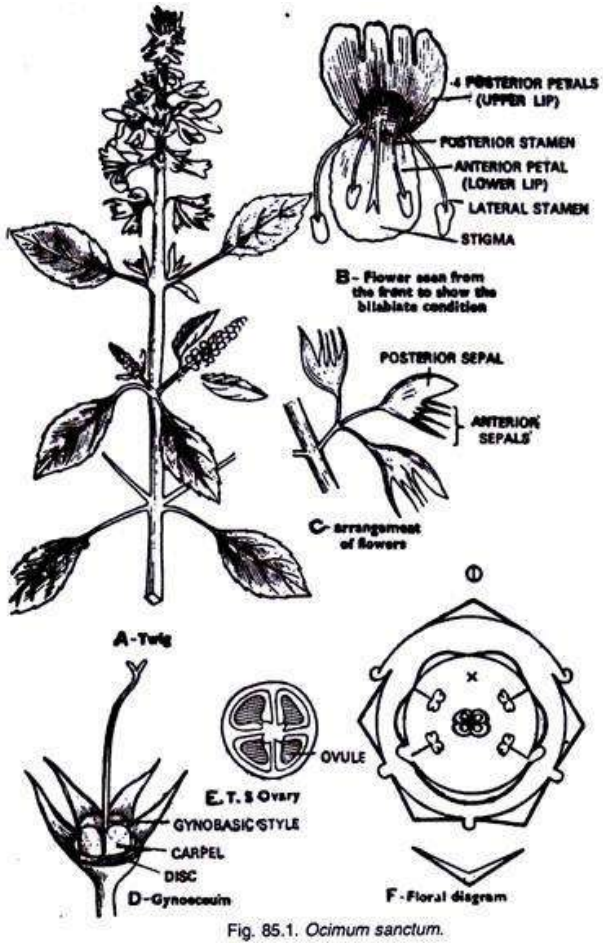


Fig. 85.1. *Ocimum sanctum.*

Economic Importance of Lamiaceae

1. Food

Tubers of Stachys sieboldi are edible. Leaves of *Mentha viridis, Ocimum basilicum, Melissa officinalis* etc. are used as condiments.

2. Medicinal

Many plants of this family are used in medicines. *Ajuga bracteosa, Leucas cephalotes* are used in fever. *Mentha piperata* and *Thymus serphyllum* give *Menthol* and *Thymol* respectively, which are extensively used in medicines. Leaves of *Ocimum kilimandus charicum* give camphor.

Ocimum sanctum and other species of *Ocimum* are used in various ailments.

3. Ornamental

Several species of *Salvia, Coleus, Ajuga, Leonotis, Dracocephalum, Thymus, Laviandula* etc. are cultivated in gardens for ornamental purposes.

4. Perfumes

Aromatic oil is extracted from *Thymus, Lavandula* (Lavender oil), *Rosmarinus* (Rosemary oil), *Calamintha, Pogostemon* etc.

5. Dye

Fruits of *Lycopus europaeus* yield red dye.