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A Review on Plant Taxonomy

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Abstract
The Identification and naming of plants has attracted a lot of attention throughout history. The science that investigates, identifies, describes, naming of the plant and classifies all plants. Plant taxonomy includes the description of the variation of plants, the observation of the characters like morphological, anatomical and phylogenic characters of the plants, variation, comparison and the manipulation of the data obtained from the previous information/ data is useful to arrange plants in a system of classification. The 3 aspects of the taxonomy are Identification, Nomenclature, classification are the main activates of the taxonomy. Taxonomy means law full arrangement of plants and it is a process of grouping the plants and other organisms. In ancient days plants the classification of plants was very easier and the classification of made by taking consideration of one or two morphological characters which is known as artificial classification but in course of time the classification of plants underwent many medications were taken place because of technological development. But end the end of 19th century the system of classification based on external morphological characters especially based on floral characters because floral characters are stable when compare to morphological characters while growth of the plants, this system of classification is classical/ alpha taxonomy. In course of time the classification of organisms/plants taken consideration of the multiple allied disciplines like the evidences from Anatomy, Embryology, Palynology, Cytology and Genetics. This type of classification is used to resolve taxonomic problems in addition to morphology this classification special significance which is called as biosystematics. Of course an insufficient number of experts, and the instability of phenotypes, which are easily affected by environmental factors, made this classification meet difficulties. With the advent evidences of the fields of phylogenetic, cladistics, experimental botanical gardens, field study, herbariums, keys, museums, computers and systematics, the artificial classification have progressed to a system of modern/ Phylogenic system of biological classification based on consideration of the evolutionary relationships between organisms and both biotic and abiotic factors. Here, I discussed the history of Identification, nomenclature classification and its different systems, for the identification of plants, the development of various molecular techniques that generate molecular markers has made it possible to accurately identify plants. Here I referred the reviews which gives information of the modern techniques and traditional methods that can be used for identification plant species through genotypic studies based on DNA barcoding.

Keywords: *Morphological Characters, Identification, Nomenclature, Phenotype, Genotype, DNA barcoding, Plant, Taxonomy, Nomenclature, Anatomy, Embryology, Palynology, Cytology, Genetics.*

1. Introduction to Plant Taxonomy

The word Taxonomy was first used by A.P.de Candolle in the year 1813. It means lawful arrangement of living organisms and is derived for Greek. (Taxis= arrangement; Nomos= law or rule). It is often considered as synonymous with systematic Botany. It mainly deals with identification, nomenclature and classification of Plants. [1-4]

Taxonomy plays an important role in the study of all other branches of Botany. According to Radford (1986), modern taxonomy depends on different branches of Botany like morphology, anatomy, embryology, palynology, cytology, photochemistry genetics, physiology etc., for information and data (Goswami, online reference). There are about

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4,00,000 species of plants on earth, they are mostly useful for us and provide food, timber, oil, fuel, dyes medicines, fiber, spices, rubber and many more economically important products. They exhibit great diversity in their habitat, life span, morphology, mode of nutrition, methods of reproduction etc., Several Scientists use different plants for their experiments. As such taxonomy becomes essential to facilitate better communication and precise identification of a plants (Panawala, 2017). Plant taxonomy is a very old science Stace (1989). The primitive man made a beginning of taxonomy by grouping the plants into useful and poisonous plants. During 1300 B.C. Parasara who is regarded as the Father of Botany in India, gave a detailed account of several medicinal plants in his book Vrikshayurveda. He recognized different types of forests and also classified plants into ganas which corresponded to modern families like Leguminosae, Brassicaceae and Cucurbutaceae. [5-8] Charaka classified plant kingdom into 50 groups on the basis of their medicinal properties and ecological associations. Greek philosophers like Aristotle, Plato, Theophrastus (372-287 BC) and others attempted to group the plants on the basis of their superficial characters into groups like herb, shrubs, trees etc. As time progressed taxonomy also progressed and better and refined systems of classification emerged. Taxonomy purely based on the description of morphological characters is called Alpha Taxonomy. In the recent times, we have crossed the stage of alpha taxonomy and started advancing towards Encyclopediac Omega taxonomy in which information from other branches like embryology, cytology, phytochemistry, palynology etc., is also considered apart from morphological characters and importance is given to phylogeny, Savolainen and Chase (2003) In 2014, Rouhan and Gaudeul defined that taxonomy is branch that `the science which explores, describes, names and classifies all living organisms`. Taxonomy makes communicating biological information much easier because it gives information and facilitates categorizing organisms according to their similar or dissimilar characters (Shipman, 2012). Panawala (2017) defined the main difference between taxonomy and systematics, in his view taxonomy is involved in the classification and naming of organisms whereas systematics is involved in the determination of evolutionary relationships of organisms. But in all circumstances the distinction between the terms systematics and taxonomy is not always sharp. After defining these two concepts and referring to their components, the author summarized the similarities and differences between the taxonomy and systematics. [9-12]

2. Objectives of Taxonomy

The main objectives of taxonomy as follows:

- Providing an inventory of world's flora through identification and description.
- Providing convenient method for identification and communication of plants.
- Collection and preservation of plant taxa in herbaria for future use.
- Providing classification which is phylogenetic and universal as far as possible.
- Providing an insight into the diversity and evolutionary progress among different taxa.

According to Goswami (online reference), the term taxonomy was first introduced to the plant science in 1813 by A. P. de Candolle, which meant the theory of plant classification. However, with the huge diversity of plants, it has been extremely essential to define a particular plant of our interest by noting the similarities or differences with other plants. Thus, it became highly substantial that the plant is first identified, given a proper scientific name for communication about it, and also know the group to which the plant belongs (Goswami, online reference). This made plant taxonomy term become more inclusive to have at present the three activities of identification of plants, their nomenclature and classification as its main functions. Shodhganga (online reference) presented an annotation to taxonomy of plants. Goswami (online reference) discussed the need and importance of taxonomy, and its different aspects and phases. Pyšek et al. (2013) reviewed the literature on the current situation in taxonomy. Recently, Pullaiah (2015) referred to the phases of development in plant taxonomy. [13-15]

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3. Aspects of Taxonomy

There are three basic aspects of taxonomy, there are

1. Identification
2. Nomenclature
3. Classification

3.1. Identification

Identification was defined by Dallwitz (1992) as 'the process of assigning a specimen to a (pre-existing) taxon'. In 1999, Winston defined identification as 'refereeing a species to a previously classified and named group'. The introduction of printing into Europe allowed the production of the 'herbals' that were concerned with the classification of plants that are valuable to mankind either as food or medicines. Ancient Greeks were the first people to provide a written record of plant classifications in the form of herbals, such as the Codex of Dioscorides introduced in the middle ages. Many other early herbals were discovered and improved by taxonomists of Europe during that period (Porter, 1967). Determining whether a collected plant is entirely new or already known is called identification. Correct identification is an important prerequisite in taxonomy. It can be done by directly comparing the characters of the plant with an authentic herbarium specimen or indirectly with the help of keys in Florasd (Sivarajan and Robson, 1991). The modern method is the use of computer punch card keys royal botanical gardens at Kew in England has a largest herbarium and is an international center for plant identification. It regularly publishes 'Index kewensis' for reference. Botanical survey of India helps in the identification of plants in our country. [16-18]

3.2. Nomenclature

Providing a correct scientific name to an identified plant is called Nomenclature it is necessary for proper communication and identification of a taxa. A plant may be known with different common names in different parts of the world in different languages. Sometimes different plants may have same common name. In some cases, there may be more than one common name for the same plant in the same language in different regions. For example Hibiscus rosasinensis has two common names in Telugu – Mandara and Dasani. Such situations lead to a lot of confusion. To avoid such confusions, a universal acceptable name becomes necessaryg (Bhan, online reference). The scientific name of a plant is always Latinized. Binomial nomenclature: the earliest scientific names of plants were polynomials in which several Latin words were used giving the description of the plant. Subsequently Gaspard Bauhin (1613) used only two words for the first time and introduced the binomial system of classification. However the credit using binomial system consistently for the first time in his species plantarum goes to carolus von Linnaeus 1753. In binominal system every plant name will have two names and invariably they should be in latin. The first word will be the name of the genus and the second will be the name of the species. The generic name will be in the noun form and always begins with capital letter. The specific name will be in the adjective form and starts with small letter. For example Solanum tuberosum is the name of potato plant in which Solanum is the genus and tuberosum is the species. The third element is the name of the person who formally gave the name (e.g. Solanum tuberosum L.). The scientific name of a species can also be Trinomial (e.g. Orysa sativa subsp. Japonica), or Quadrinomial (e.g. Bupleurum falcatum ssp. Eufalcatum var. doffmeisteri) (Gatan, 2015). International code of botanical nomenclature (ICBN) Naming all the plants should be done in accordance with the principles laid down by ICBN. These rules are formed at the periodical meetings of International Botanical Congress held once in five or ten years. The first meeting was held at Paris in 1867 which resulted in Paris code. According to ICBN the following rules must be followed while naming the plants.

- Every plant should have only one correct scientific name.
- The scientific name should must be in Latin.
- Binomial nomenclature system must be used for naming the plants.
- The scientific name should be underlined or published in italics.
- The authors name may be given in abbreviated form at the end of scientific name. E.g., Pisum sativum L (L stants for Linnaeus).

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- If the generic name and specific name are exactly same,it is known as tautonomy. According to ICBN tautonyms are not valid in plant nomenclature. E.g.: Malus malus.

3.3. Classification

Assigning the plants to specific groups on the basis of their similarities and dissimilarities is called classification (Aldhebiani, 2017). In recent system of classifications data from different fields of botany is taken into account for this purpose, Kazlev (2002). Carolus Von Linnaeus, who is known as the father of taxonomy proposed certain specific principles of classification for the first time. In course of time they were refined by other taxonomists. Since floral characters are more stable characters than the vegetative characters, they are more useful in classification. All characters which can be correlated must be taken into consideration. It is always preferable to depend on more number of similar characters while deciding the position of a tax on, than depending on any single character. As far as possible any classification should reflect the evolutionary trends. Generally evolutionary trend in morphological characters listed below:

Primitive characters: Trees, shrubs, Perennials, Simple leaves, Solitary flowers , Bisexual flowers , Monoecious condition , More number of floral whorls, Actinomorphic flowers, Hypogynous flowers, Chlamydeous flowers, Polypetalous corolla, Free stamens, Free carpels, Superior ovary, Simple fruit, Presence of endosperm.

Advanced characters: Herbs, Biennials, Annuals , Compound leaves, Inflorescence, Unisexual flowers, Dioecious condition, Less number of members in floral whorls , Zygomorphic flowers, Perigynous and epigynous flowers, Monoclamydeous and achlamydeous flowers , Gamopetalous corolla , United stamens, Fused carpels, Inferior ovary, Multiple fruit, Absence of endosperm.

Types of classification: In order to classify billions of different living organisms on earth, they are classified into kingdoms based on their nutrition, habit, and habitat, anatomy of their body, and the number and type of cells they made with. These are: Protista (the single-celled eukaryotes), Fungi (fungus and related organisms), Plantae (the plants); Animalia (the animals), and Monera (the prokaryotes). Organisms of each kingdom are then further divided into smaller groups based on shared characteristics such as appearance, mobility, reproduction, and functionality. The grouping of system within each kingdom is carried out on six levels. These are phylum, classes, order, families, genus, and species. The availability of such groups makes it easier for scientists to study certain groups of organisms (Missmaggie, online reference; Softschools, online reference). Starting from Theophrastus who is known as the father of botany to the present day, several taxonomists have proposed different systems of classification based on different criteria. On the basis of the criteria taken into consideration all these systems can be grouped into three types. They are

1. Artificial classification
2. Natural classification
3. Phylogenetic classification

Artificial classification: These are the systems based on one or few comparative characters like morphology, nutritional habits. Etc., it is called as folk classification.

Eg. 1. Classification of plants on the basis of form into herbs, shrubs tress etc., by Theophrastus in his book Historia plantarum.

Sexual system of Linnaeus in which the floral characters are given importance for the first time.

Natural system of classification: these are the systems in which plants are grouped on the basis of their natural relationships taking into consideration all possible morphological characters.

Eg. Classification of de Jussiew, de Candole and Bentham and Hooker.

Phylogenetic system of classification: These are the systems proposed after the publication of Origin of Species and the announcement of theory of evolution by Charles Darwin. Hence they are also called Post Darwinian classifications. They reflect the genetic and evolutionary relationship among the taxa and show them in the form of a phylogenetic tree. Classifications made by Eichler, Engler and Prantil, Rendle, Bessey, Hutchinson and others come under this category. More recent phylogenetic

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classifications made by Takhtajan (1980). Cronquist (1981), Goldberg (1986) and Thorne (1992) have used data from different branches of Botany apart from the vegetative and floral characters. Hence they are also known as Multidisciplinary or Synthetic systems. (Morrison, 1993).

3.3.1. Units of Classification

Any system of classification is made up of different units, which are arranged in a hierarchical sequence. It is worth noting here that the taxonomic group of any rank, e.g. family, genus, species, subspecies, etc., is called 'taxon' (plural taxa; backformation from taxonomy). The word taxon, which was first used by a German Biologist Adolf Meyer in 1926 for animal groups, was proposed in 1948 b Herman J. Lam. for the plant system (Goswami, online reference). Irrespective of its rank in the sequence every unit is called taxon. Species is the basic unit of classification. All those plants which are identical in all respects are regarded as on species. Different species with related characters are grouped into one genus. Different genera with common characters are grouped into a family. Different orders which are related to each other are grouped into a series. Group of related series is considered as a class. Different classes with similarities are grouped into a division. A group of divisions constitutes the kingdom which is the largest taxon occupying the top most position in the taxonomic hierarchy. Every unit of classification can be subdivided as subclass, suborder etc.

Systematic position of Gossypium herbaceum (Cotton)

Kingdom	:	Plant kingdom
Division	:	Phanerogamae
Sub-division	:	Angiospermae
Class	:	Dicotyledonae
Sub-class	:	Polypetalae
Series	:	Thalamiflorae
Order	:	Malvales
Family	:	Malvaceae
Genus	:	Gossypium
Species	:	herbaceum

Conclusion

For the successful classification, it is a challenge to a taxonomist to choose the data carefully and collect them in sufficient quantity to clarify the relationships among leaving organisms. In solving any taxonomic problem, how to do sampling is a paramount consideration. Another concern is how to measure the collected data. This relates to the nature of the taxonomic questions being addressed. After collecting and measuring the data, the latter must be synthesized in some pattern numerically and/or graphically to allow relationships to be defined (Stuessy 2009). Rouhan and Gaudeul (2014) highlighted the major historical steps in the elaboration of taxonomy that plays a crucial role for society and provides baseline data for all fields of biology. They put the emphasis on the challenges that plant taxonomy faces nowadays. The example of these challenges they presented is the very incomplete taxonomic knowledge of the worldwide flora (the so-called taxonomic impediment) which is seriously hampering conservation efforts that are particularly pivotal as biodiversity enters its sixth extinction crisis. We agree with Pyšek et al. (2013) on their view that in order to improve the accuracy of species identification and further refine taxonomic classification at the level of genotypes and populations in the laboratory and field, a better integration of classical alpha taxonomy. (The discipline of detecting, describing, and classifying new species, as well as revising the classification of previously described species) and modern genetic taxonomic approaches should be achieved. In other words, modern taxonomy needs to integrate both classical and new concepts and approaches.

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