A Textbook of Plant Taxonomy

Theory & Objectives

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CHAPTER 1

EVOLVING PERSPECTIVES IN PLANT TAXONOMY: FROM PRACTICAL BEGINNINGS TO MOLECULAR ADVANCEMENTS

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ABSTRACT:

Since the dawn of time, humans have known about taxonomy, the study of categorizing and organizing all things based on morphological similarity. The basis for this categorization or grouping should be homology, which states that members of a group must have traits in common that they received from a common ancestor. Plant taxonomists have recently been searching for more accurate methods to comprehend the relationship between genera and families. And several more inquiries are also kept in mind. The study of taxonomy, which divides living things into groups based on similarities between them, has developed extraordinarily throughout time. Preliterature, Medieval (Dark Ages), Ancient Literature, Renaissance, Theory of Evolution, or Taxonomy Revolt are the six main eras that taxonomy has travelled through. The distinctive characteristics and innovations from each period helped to shape the discipline into what it is now. This narrative overview examines the development of plant taxonomy from a practical endeavor to a sophisticated science, stressing its historical aspects.

KEYWORDS:

Chromosome, Morphology,Molecular, Plant Taxonomy, Taxonomists.

INTRODUCTION

These have prompted taxonomists to delve further into the inner workings of plants, particularly their chromosome, DNA, and genome architecture. We referred to this as molecular taxonomy. Comparisons are made between the data from this research and those from other taxonomy tools, and all of these data have been utilized for cladistic analysis and phylogenetic interpretation. Furthermore, in order to understand the current trends in taxonomy, it is necessary to examine the evolution of categorization throughout history, including how it changed as societies, technologies, and tools changed. The systems of categorization reflect the demands, amount of knowledge, philosophical ideas, and accessible technology of each historical time. Taxonomy now is a mirror of the past. The primary goal of this narrative overview of the literature is to summarize and outline current trends and current information used in plant taxonomy[1], [2].

The study of taxonomy divides organisms into many classifications based on their physical characteristics. This categorization or grouping should be based on homology, meaning that the people who are grouped in the same group must have traits that have been passed down from a common ancestor. As a result, in order to understand current trends in taxonomy, it is necessary to first examine the history of categorization and how this field has changed as societies, technologies, and tools have advanced. The systems of categorization reflect the demands, amount of knowledge, philosophical ideas, and accessible technology of each historical time. Taxonomy now is a mirror of the past. Therefore, in the current narrative review of literature research, we sought to outline and explain the most recent information used in plant taxonomy.

Perspectives from the past

Since the dawn of humanity, classification of creatures has been based on necessity, shelter, food, and medicine. Plant taxonomy comprises at least six major historical eras that may be distinguished: Preliterature, Ancient Literature, Medieval or Dark Ages, Renaissance, Theory of Evolution, and Taxonomy Revolt. These historical eras each have distinctive traits and accomplishments of their own. We can see how plant taxonomy has progressed and developed if we rapidly walk over each of these times. People back then lived extremely closely to the soil and relied on hunting and gathering for their nourishment. They were familiar with a variety of edible and medicinal plants. They were helpful plant taxonomists; they defined the plants, divided them into beneficial and hazardous categories, recognized them, and assigned each one a name so it could be quickly referred to.

The ancient Greeks arrived at their findings throughout this time period by reasoning rather than through the examination of observations. The distinctions between internal and exterior organs were highlighted. Plants were categorized by shape into shrubs, trees, and under shrubs. Additionally, they were aware of annuals, biennials, perennials, and floral morphology. They also detailed a variety of medicinal herbs, which have been used as a primary source of knowledge for more than 1500 years[3], [4].

Renaissance

This time period was affected by the following: 1- The printing press was created; 2- People felt confident to do creative things; and 3- Navigation made it possible to gather plants from all over the globe. For this reason, this time period was one of active learning and discovery, and a lot of substantial works regarding plants and their medicinal purposes were also created. The first attempts to organize and arrange the variety of blooming plants were made by the ancients. Along with the naming of plants in accordance with Carl Linnaeus's proposal, the founder of plant taxonomy, several natural and well-defined genera and families were also developed. Adanson has established the phenetics of numerical taxonomy. Lamark developed an early conception of evolution, and de Candolle used internal features in addition to exterior ones when classifying organisms.

The Evolution Theory

Before Charles Darwin introduced his theory of evolution, a geologist by the name of Charles Lyell put out a hypothesis of geological gradualism that claims that "slow, continuous changes produced features we see today." Darwin thus believed that the planet was far older than 6000 years and that evolutionary change must have happened gradually over time as differences accumulated.

He offered convincing evidence that life has evolved, and he suggested that natural selection is the mechanism driving these changes. Alfred Wallace also created an evolutionary theory about the same period, and he presented both of these in London Linnaean Society meetings. Since then, taxonomists have been examining which traits are regarded as primitive and which as advanced.

They attempted to synthesize information from all branches of botanical research, including anatomy, genetics, physiology, paleobotany, chemistry, and palynology. As a result, taxonomy enters a new stage known as phylogenetic categorization, which takes into account the distances and connections among species. Phylogenetic trees have been proposed as a result of the assumption that contemporary organisms shared ancient ancestors.

Taxonomy uprising

From the overview of the history of plant taxonomy shown above, it is clear that categorization standards are totally arbitrary human inventions and a question of personal preference. As a result, taxonomists began to evolve along with the development of the microscope and cutting-edge methods. Internal structures are now more evident because to the development of scanning microscopes. The study of comparative genome organization in plants and DNA sequences improved the accuracy of identifying links between species. We may simply state that a new era in taxonomy has begun. Following Linnaeus, plant taxonomists attempted to identify and differentiate these groups in order to categorize the plant kingdom in accordance with the theory that, rather from being classified according to their vegetative and floral characteristics, plants belonged to certain natural groupings. These systems are referred to as natural classification systems. Lamarck's idea of the inheritance of acquired characteristics, which refuted the notion that a living thing's environment had an impact on it, served as the foundation for the natural system of categorization. Thus, while analyzing any specimens, ecological considerations have been taken into account and have an impact on taxonomical judgments. Lamarck was struck by the fossil record and saw the parallels between the creatures he examined. This made him believe that life was not predetermined. When conditions changed, organisms had to adapt their behaviour in order to live. Darwin's theory of natural selection, which claimed that changes made by an organism throughout its lifetime in order to adapt to its environment are passed on to the organism's progeny, is followed by this. This notion caused a revolution in scientific thought, and as a result, the time of plant systematics and the formation of species began.

DISCUSSION

From this point on, taxonomy judgments started to take into account the interior architecture of plants. Major plant phyla may be separated based on the kind of vascular bundles; tracheids versus vessels. Gymnosperms do not have vessels, which distinguishes angiosperms from them. As a result, wood anatomy was employed in phylogenetic investigations to forecast connections. According to their internal arrangements, several families have since been divided into various families. Unilacunarvstrilacunar nodal anatomy plays a part in angiosperm systematics as well. Nehemiah Grew, using a microscope in the 1640s, was the first to see tiny particles, which he refers to as pollen grains. Numerous scientists have since been drawn to the study of pollen grains and palynomorphs. Gunnar Erdtman, a Swedish botanist, wrote his dissertation in 1921 on the use of pollen to analyze Quaternary vegetation and climatic change. With the invention of microscopes in the middle of the seventeenth century, botanists began to pay much more attention to pollen morphology.

With the revolution in plant method analysis, a new age in plant taxonomy was inaugurated. Beginning with the construction of phylogenetic keys and the prediction of species connections, chemotaxonomy and protein sequencing. Chemical compounds replaced the origin of species and the presence-absence criterion for the majority of morphological features as the preferred method for classifying plants. In actuality, the first methods of categorizing plants were based on their chemical make-up and therapeutic benefits, but these methods could not be used to create systems of categorization amongst plants. Dahlgren was the first to characterize orders and families using chemical data. Cronquist's comprehensive approach of angiosperm categorization takes into account the chemical components of plants. Iridoids and glucosinolates, two groups of compounds, seem to be limited to dicotyledons and have various origins[5], [6].

The molecular biological data comes from the many sources of information utilized in taxonomy and systematics. In order to compare fragment patterns across species, restriction enzymes in the chloroplast genome were utilized to solve the dilemma of how to get this data. the high temperature tolerance polymerases to make individual base pair sequencing data easily accessible. Thousands of studies have been conducted since then to understand the phylogeny and evolution as well as the connections between taxa. The APGI, II, III, and IV are some of the taxonomic studies that have produced fruit. essentially reclassifies the whole plant kingdom. Many people disagree with the APG ways of classifying plants since they are seen as artificial classifications. Taxonomists now strive to create more natural categorization by using all the data and techniques available. It has been proposed that computerization, numerical analysis, and other programs will provide us with natural connections. adjusting our thinking as a result of new problems. There are several problems affecting our world, including climate change, habitat loss, pollution, and urbanization. Along with other elements, each of these has an impact on not just the biological balance but also the health of people, animals, and plants.

Plant taxonomy began in the past with something as basic as how humans used such plants. As plant identification, distribution, morphology, and physiology were highlighted, this branch gradually started to take the shape of scientific publications. The introduction of the microscope allowed scientists to see minute processes, allowing them to examine internal structure, development, and the many phases of cell division in plants. Evaluation of the development of vegetation in a specific region as the environment changed was the focus of historical paleobotany. It covered the gradual changes in a region's vegetation, the development of different species across geological time, and the evolution of life. As a result, plant taxonomy was in use. The assumption that the plants were suited to their surroundings was used to approach evolution. The fields of genetics and evolutionary biology took off when the fundamentals of heredity and natural selection were discovered. The emergence of identical physical characteristics in phylogenetically dissimilar species under similar environmental conditions attracted a lot of interest. Paleobotanists' research therefore provided a solid basis for plant biology[7], [8].

The structure of DNA and RNA, the building blocks of protein synthesis, was discovered by molecular biology in the second part of the 20th century, revolutionizing the study of plants at all levels. With the use of molecular tools, taxonomists, evolutionists, ecologists, physiologists, and developmental biologists are now identifying a variety of reactions and processes that were previously inaccessible. Today, it is feasible to pinpoint the specific genes that contribute to features with great accuracy. Additionally, using molecular methods, researchers may add or remove genes associated with certain features. With the use of these cutting-edge methods, we may also change the current taxonomy and phylogeny and, as human activity changes the distinctions and similarities among taxa, we can even create new species. Future environments could be quite different from those we have now. All signs point to the climate being more unpredictable than it is now. Many models predict that both temperature and CO_2 levels will increase. Additionally, a disproportionally higher nighttime temperature is predicted. Despite the complexity of the genotype and environment interaction now, future environmental changes that the plant will experience will make it much more so. We must keep in mind that the environment directly affects the genotype by activating and inactivating genes. Furthermore, it is unknown which subset of a person's genotype or environment will have the most influence on their ability to vary and adapt. Every expectation point to a potential rise in the influence of environmental variation. As a result, it is anticipated that as environmental changes accelerate, specialized species would go extinct.

We may infer from these earlier studies that taxonomy is a field of science concerned with identifying all possible relationships between living things. It also has to do with using these correlations as the foundation for categorization systems. In the race against time to record, comprehend, conserve, and make use of the world's dwindling stock of botanical diversity, plant taxonomy—along with its related studies of plant exploration, floristics, phylogenetics, and phytogeography—is a vibrant and rapidly developing field. Therefore, we may anticipate that taxonomists will need to review all the educational resources; morphological taxonomy must also be remembered. We must get familiar with molecular methods and work to understand how development works and how it might be controlled. Not only do we need to investigate phylogenetic structures and developments via the study of genomic structures, but this does not imply that the fundamental structure of plant taxonomy will change. A clear understanding of evolution will not be provided by molecular research alone. A natural categorization system results from evolution, and it will depict the evolutionary hierarchy. Classifications are based on characteristics that seem to have an ancestor[9], [10].

Because of the changing surroundings during the next several years, certain species will spread further than others and new ones will emerge, making ecology more crucial to taxonomy than it has ever been. Studying plant variety and the processes of internal and external adaptation in response to environmental changes is necessary. Species with broad niches will predominate, whereas those with small niches will go extinct. Both environmental changes and gene mutations made via molecular methods will result in the emergence of new species. We must thus continue to look at how our flora is changing, how well our plants can adapt to environmental problems, and how to define new, more durable taxonomic traits. It is necessary to create a gene bank for the specialized species. To comprehend the links between the species, we must collect all the data from all areas of taxonomy, except those resulting from genetic research and ecological changes.

Outlooks for the future

We can see from the evolution of taxonomy described above that this field of research has been impacted by human thought, civilization, and advancements in knowledge facilities. We must carefully consider how we might save the wild plant life in order to preserve our planet in the present situation. Taxonomists must examine the vegetation and look for strategies to preserve and spread the plants. We need to comprehend the interactions between the populations' taxa. We must adjust our ideas to the novel circumstances. For accurate identification, to identify the new species as the consequence of speciation, and to save other species from extinction, it is necessary to keep in mind the environmental circumstances and their impact on plant features. To better comprehend the state of the taxa, ecologists and taxonomists must work together. Breeding experiments must be conducted to determine whether or not speciation is occurring. Taxonomy must simultaneously assess electrical impulses between cells and their environment and employ physiological traits to comprehend links among the many species.

CONCLUSION

The development of plant taxonomy is a reflection of how people's perceptions of nature are changing through time. It emerged via the philosophical speculations of the Ancient Greeks, the botanical studies of the Renaissance, and the paradigm-shifting Theory of Evolution from practical observations of plants for nutrition and healing in the Preliterate period.Taxonomy advanced significantly when we reached the Taxonomy Revolt period, which was characterized by improvements in microscopy, molecular biology, and chemical studies. Classifications based on morphology were replaced by more accurate molecular and genetic methods. Particularly, molecular biology has completely changed the science by enabling us to examine the DNA of creatures in great detail and learn about their evolutionary links. Plant taxonomy has promising promises for the future. Taxonomists must adapt to comprehend how environmental changes, climatic disorders, and habitat fragmentation effect plant life as these issues become more and more prevalent. In order to discover and preserve plant variety, molecular approaches, physiological characteristics, and ecological factors will be crucial.

Taxonomy's importance goes beyond categorization in this period of fast environmental change; it becomes a crucial tool in protecting biodiversity and comprehending the complex interactions between species. To handle the complicated issues our world confronts, taxonomists of today must adopt multidisciplinary techniques that integrate genetics, ecology, and physiology. Plant taxonomy is, in essence, not a static science but a dynamic journey through time that reflects the changing relationship between humans and nature. Taxonomy still serves as our compass, directing us toward a greater comprehension of the complex tapestry of life on Earth as we continue to push the boundaries of biology.

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CHAPTER 2

EXPLORING THE SIGNIFICANCE AND SCOPE OF SYSTEMATICS AND TAXONOMY IN UNDERSTANDING AND CONSERVING EARTH'S BIODIVERSITY

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ABSTRACT:

This research explores the significant relevance and wide use of taxonomy and systematics in understanding and preserving Earth's different ecosystems. The discovery, description, and interpretation of biological variety are all included in systematics, the study of organismal diversity, which also provides predicted categorization schemes. As a key element of systematics, taxonomy entails classification principles and procedures, including description, identification, naming, and classification.

The fundamental framework of biology is provided by systematics and taxonomy, which enables us to categorize, identify, and comprehend the vast array of living forms on our planet. This essay examines the many taxonomic elements, including nomenclature, description, identification, and classification, and emphasizes their crucial responsibilities in the scientific community. The evolution and range of these fields from the traditional alpha taxonomy to contemporary DNA taxonomies and cyber taxonomies are also covered. This research also highlights the value of systematics and taxonomy in modern culture. These fields are essential to finding, protecting, and using Earth's biological resources sustainably. It is impossible to overestimate the significance of systematics and taxonomy in protecting our natural legacy and maintaining human survival in light of the growing risks posed by climate change, habitat loss, and species extinction.

KEYWORDS:

Biodiversity, biosystematics, Biological Resources, Evolution, Phylogenetic, Taxonomy.

INTRODUCTION

The study of organismal diversity is called schematics. In addition to using this data in the form of predictive classification systems, it includes the discovery, description, and interpretation of biological variety. Therefore, systematics is the study of the current variety of biological life on earth as well as its evolutionary past. The framework, or classification, that other biologists use to talk about different kinds of organisms is also provided by systematics. Our comprehension of the natural world and effective communication about it depend on systematics. The fundamental tasks of systematics include naming and categorization, which are the oldest human approaches to handling data about the natural world. For food, shelter, fibre, clothes, paper, medicines, tools, colours, etc., we rely on a variety of species. The search for prospective commercially important plants is guided by systematics knowledge[1], [2].

Humanity has been captivated and confused by the dizzying variety of living forms that inhabit our planet for generations. The disciplines of systematics and taxonomy were developed in response to the need to comprehend, categorize, and name these species. The field of systematics, sometimes known as the study of organismal diversity, entails a thorough investigation of the variety of life on Earth. The discovery, characterization, and interpretation of biological variety are all included, and it eventually results in the creation of predictive categorization systems. Systematics' fundamental goal is to reveal the complex web of life on Earth. The scientific field of taxonomy, which is an essential part of systematics, deals with the concepts and methods of categorization.

Description, identification, nomenclature, and classification commonly remembered as DINC are its four fundamental parts. While identification entails connecting an unidentified organism with a recognized one, description entails meticulously cataloguing an organism's traits. Classification places these things into a systematic hierarchy based on similarities and distinctions, whereas nomenclature formalizes the naming of species.

Taxonomy and systematics are not only academic disciplines; they provide the groundwork for all biological sciences. These fields provide a methodical way to identify and label the many living forms that live on our planet. It would be very difficult to discuss, research, and preserve the natural world without systematic organizing and naming standards.

The field of systematics and taxonomy has significantly expanded in recent years. These fields have adapted to new tools and methodologies, moving from traditional alpha taxonomy, which mainly depended on morphological traits, to contemporary DNA taxonomy and cyber taxonomy, which harness the power of genetic data and digital technology. Our knowledge of interspecies connections has been fundamentally changed by molecular systematics, which also sheds insight on the evolutionary processes that have moulded life on Earth. Furthermore, systematics and taxonomy have enormous practical implications for society and are not only topics for scholarly publications[3], [4].

These disciplines are essential for locating, protecting, and sustainably using Earth's biological resources at a time of climate change, habitat destruction, and alarming biodiversity loss. Systematics and taxonomy directly support the preservation of our planet's natural history by aiding the identification of rare and endangered species as well as providing direction for conservation efforts for these species.

DISCUSSION

This study of the importance and range of systematics and taxonomy highlights the important roles that these disciplines play in our comprehension of the variety of life on Earth. These fields act as the compass that directs us as we go through the many ecosystems that make up life on our planet. We shall analyze taxonomy's components in more detail, look at its history and use, and underline its importance in modern society in the parts that follow.

The most fundamental and all-encompassing branch of biology is systematics since it serves as a reference framework for all of biology. Systematics is fundamental because it allows for the identification and naming of species, which are necessary before they can be addressed in a scientific context.

Because it collects and summarizes all information on an organism's properties, including those that are geographical, morphological, physiological, genetic, ecological, or molecular, systematics is the branch of biology with the broadest scope [5], [6].

Taxonomy

Science's field of taxonomy is concerned with the concepts and methods of categorization. Based on certain similarities and differences, taxa are identified, described, classified, and given new names in this biological field. The word "taxonomy" literally means "order by rules" or "lawful arrangement of things." Description, Identification, Nomenclature, and Classification (commonly referred to as DINC) are the four major parts of taxonomy. Systematics is significantly more comprehensive than taxonomy, which is sometimes mistaken for it.

The Taxonomy's Elements

Description

The written record of a taxon's characteristics is called a description. Characters are the characteristics. Both qualitative and quantitative characteristics are possible. Character states refer to the combination of two or more versions of a character. For instance, fruit type (achene, capsule, berry), petal colour (red and white), and leaf shape (ovate, elliptic, lanceolate).

Identification

The act of identifying an unknown taxon with a recognized one is known as identification. To put it another way, identification is the conclusion that a taxon is identical to or similar to another well-known element. Finding the taxon to which a specimen belongs, such as identifying medicinal plants, edible and deadly mushrooms, is the process of identification. Taxonomy's major purpose is identification, and through using nomenclature, it serves as a vital communication tool. Plant identification is done with the use of a taxonomic key. Taxonomic keys consist of a succession of two opposed assertions and are dichotomous. Each sentence serves as a lead. A couplet is composed of two leads.

Nomenclature

The official naming of taxa in accordance with established norms is known as nomenclature. The nomenclature is made up of the criteria for applying group names to organisms as well as the names themselves. A globally recognized standard, such as the International Code of Nomenclature for Algae, Fungi, and Plants, is used to determine the proper name of a known plant. Once the plant has been identified, a scientific name with broad application must be given to it.

Classification: The procedure of classifying is two-steps. Grouping things based on similarity and difference is the first step. Step 2 is to rank these groupings according to a hierarchy (a layered list of categories). Thus, classification is the grouping of a plant (or collection of plants) into groups based on its shared traits and distinctive characteristics. These groupings are then nested into categories in accordance with their levels. As a result, comparable people might be classified as belonging to the same "species," "genus," "family," and so on. In order to make it simpler to relate to its constituent parts, classification entails creating a logical system of categories, each including any number of species. The grouping of plant groups with specific boundaries by rank and position in accordance with arbitrary standards, phenetic similarity, or evolutionary links is known as classification[7], [8].

Traditional taxonomy description, identification, naming, categorization of species, and phylogenetic evolutionary history are all included in the field of research known as systematics as shown in figure 1, Information on plants and plant parts is collected, analyzed, and synthesized to study plant systematics.

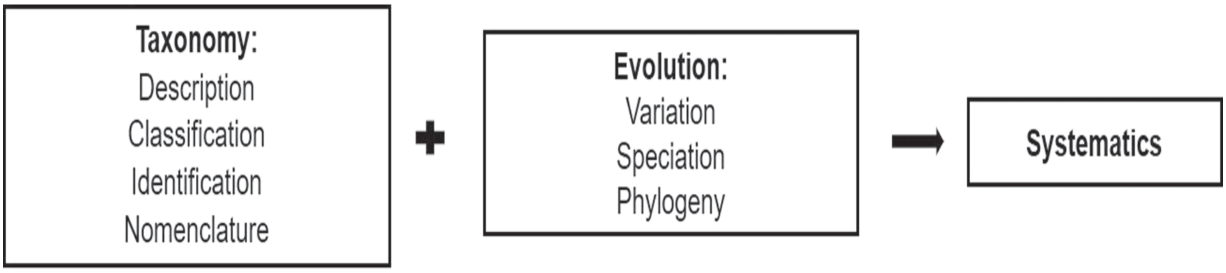

Figure 1. Evolution and taxonomy are both a part of systematics.

Since Linnaeus's first publication of his taxonomy of sexual traits, our understanding of the biological world has advanced significantly. Every year since Linnaeus's publication of Species Plantarum, hundreds of new species have been identified and described. New technologies and methods have made it easier to make discoveries. In recent years, there has been an increased emphasis on finding new species and publishing checklists, revisions, monographs, and Floras. More floristic and inventory projects have been started than at any other time in taxonomy's history. Both training programs and several joint research projects have been established. The inclusion of new categories of comparative data, techniques for phylogeny reconstruction, and methods for categorization have all made significant strides in the last fifty years. The area of systematics has undergone a revolution thanks to the use of molecular data, tree-building algorithms, and statistical analysis.

Progress and Scope

Although continually evolving and adapting, taxonomy has deep historical origins that enable it to remain grounded in the past despite its tremendous modernity. Over the last fifty years, new kinds of comparison data that are useful for plant systematics have been generated in addition to inventorying. Cytological information, particularly chromosomal count and fundamental karyotype, was prioritized in the 1950s. Secondary plant compounds, particularly flavonoids, numerical taxonomy, and phenetics were the dominant concepts in the 1960s. Isozyme-based population-level concerns from the 1970s and 1980s still provide useful solutions for resolving certain categories of systematic issues (such as hybridization). In the early 1980s, the use of computer technology that allowed for greater flexibility in managing data was introduced.

The advent of cladistic theory and the reconstruction of phylogenies using cladograms, which significantly aid in inferring the evolutionary history of species, marked a significant shift in the area of taxonomy. But in the 1990s, analysis of DNA sequences and fragments brought about the fascinating new data, which completely changed the area of systematics. Our present knowledge of connections among plants and their patterns of diversification through time, place, and form has been completely transformed by molecular systematics and the advent of phylogenetic analysis techniques. Since Linnaeus introduced the binomial naming method in the 1750s, a body of work has collected in the field of taxonomy during the last 270 years. Floristic inventorying, the inclusion of new kinds of comparison data, and quantitative ideas and techniques of phylogeny reconstruction and categorization have all made significant strides during the last 50 years.

The area of systematics has altered as a result of advancements in the utilization of molecular data, tree-building algorithms, and statistical analysis. Multiple international projects are presently digitizing and making accessible the vast quantity of taxonomic data.

The systematists incorporated more data sources to examine relationships and used cutting-edge technologies to analyze the data. Because increasingly bigger data sets required to be analyzed, computer software was quickly improved as molecular systematics rose to prominence. Then, morphology used the new programs more effectively than previously. As a result, molecular cladistics has helped morphological cladistics as well. In order to comprehend the evolutionary processes, taxonomy goes beyond the naming of species. This is made possible by the use of numerous disciplines, such as cladistics, phylogenetics, and genomics. The field of population and conservation genetics, as well as molecular systematics, have all been transformed by next-generation sequencing (NGS). Phylogenetic matrices based on three to four genes and including several hundred taxa were formerly regarded as huge; however, with the advancement of NGS technology, matrices based on hundreds of genes and involving thousands of species are now easily doable.

Goals and Purposes of Systematics

Discovering all the branches of the evolutionary tree of life, recording all the changes that have taken place throughout the development of these branches, and describing all species—the tips of these branches are the main objectives of systematics. The primary goals of systematics are to:

1. Name and characterize every living thing on the planet, therefore completing our inventory of the biota.
2. To provide a categorization of these creatures that reflects their evolutionary connections.
3. To comprehend the evolutionary patterns and processes that led to the tremendous variety of life.
4. By preserving and sharing this information, to provide an integrating and unifying focus, a channel of communication, for all branches of biology.

Alpha to Omega: Taxonomy's Phases

Taxonomy is often separated into these four stages:

1. Alpha taxonomy is one: The traditional or alpha taxonomy is descriptive and mostly depends on morphology. It deals with the gathering, naming, and description of taxa.
2. Beta taxonomy: The beta taxonomy is concerned with how taxa are organized into taxonomic groupings or categorization categories. Its focus is on the categorization process, which involves classifying natural groupings based on specific similarities and differences.
3. Gamma taxonomy: The study of intraspecific populations, speciation, and evolutionary rates and trends are all included in gamma taxonomy. This kind of research aims to interpret biological variety.
4. Taxonomy of Omega: The contemporary taxonomy, or omega, incorporates data from a number of biological fields, including cytology, palynology, phytochemistry, etc. to provide details on the connections between species. It is sometimes referred to as a "perfected taxonomy" since it emphasizes having a large data set for deciphering the links.

Taxonomy is sometimes described to as a synthetic science since it uses information from other disciplines including anatomy, embryology, palynology, phytochemistry, cytology, and molecular biology. However, a fundamental grasp of the classification of species is necessary for every biological discipline, and the data generated by taxonomic study serves as the cornerstone for all other branches of biology. Taxonomy is thus the brick that makes up the home of biodiversity.

Biosystematics

To comprehend the innate connections of plants, especially those of the rank of genus and below, the term "biosystematics" was coined. In biosystematic research, the taxon and its populations are thoroughly sampled, and the chromosome counts of several populations within geographic races, species, and genera are recorded.

Chromosome numbers, shapes, and behaviours during meiosis are often signs of genetic variations with taxonomic importance. The capacity of the various populations to hybridize is another element of the biosystematic investigation that offers information on the existence or lack of breeding barriers across groups. Delineating natural biotic units and applying a nomenclature system to these units that is capable of transmitting exact information about their specified bounds, relationships, variability, and dynamic structure are the main goals of biosystematic investigations. The ecotype, ecospecies, cenospecies (or coenospecies), and comparium are the four biosystematic categories that are most often recognized[9], [10].The fundamental unit in biosystematics is the ecotype. Although it is tailored to a specific habitat, it may cross with other ecotypes of the same ecospecies to create totally viable hybrids. A collection of plants known as an ecospecies is made up of one or more ecotypes. A collection of plants known as a cenospecies (sometimes spelled coenospecies) represents one or more ecospecies. The biosystematic unit known as a comparium is often compared to a genus. One or more cenospecies are included. The field of genecology is thought to have a taxonomic application, which is known as biosystematics. It is the study of how species differ in terms of their genotypic and phenotypic makeup in response to the settings in which they live.

Comprehensive Taxonomy

Combination, interdisciplinary, multidimensional, collaborative, or integrative taxonomy are terms used to describe a multisource approach that benefits from complementarity across disciplines, i.e., distinct areas of study. The rigour of species delimitation is increased by using many disciplines to tackle taxonomic difficulties, which helps prevent failure intrinsic to single disciplines. Despite numerous obstacles, progress is being made because species taxonomy is reemerging as a sound scientific discipline that incorporates technological advancements like virtual access to museum and herbarium collections, quick DNA sequencing techniques, geographic information systems, and a variety of internet functions. An improved and more reliable biodiversity inventory has been produced via integrative taxonomy.

Taxonomy of DNA

The study of genetic diversity for the confinement and separation of species is known as DNA taxonomy. It makes use of the idea of evolutionary species and offers a fresh framework for the development of taxonomic knowledge. Simply put, it involves identifying species using DNA. It is an efficient method for identifying species and quickly assessing biodiversity.

E-Taxonomy (Cyber Taxonomy)

Because taxonomic data is so large, it is being extensively digitized to make it simple for anyone to access this information anywhere in the world. Cyber taxonomy entails using standardized electronic technologies (databases, e-publications) to retrieve information. The main platform for taxonomic research and instruction is the internet. The infrastructure for the storage and retrieval of taxonomic data has been made more universally accessible. Cyber taxonomy has dramatically accelerated communication and increased accessibility to new descriptions and species diagnoses. An interactive "cyber taxonomy" with quick access to online descriptions and publications of new species has been envisioned for the future, where anybody may obtain current taxonomic material from anywhere. Additionally, evolutionary biology and systematics also make extensive use of digital image-based morphometrics.

Reversal of taxonomy

Reverse taxonomy is the study of an organism's DNA and naming without considering its morphology. In this procedure, the taxon is first allocated to a certain group based on the analysis of the molecular data, and then it is described at the genus/species level. It is useful when a tax cannot be precisely assigned to any taxonomic category using conventional techniques.

Science and social relevance

The discovery, description, and classification of more than 2 million species by taxonomists—a process that is still ongoing represents taxonomy's greatest gift to science and mankind. For humanity to survive, it is essential to comprehend the biological diversity, to preserve it. Systematics is essential to civilization because it helps to identify the creatures that are necessary for an accurate evaluation and categorization of biodiversity. Taxonomists recognize species in the field, watch for extinction threats or the introduction of alien species, and track biodiversity shifts through time. They conduct inventories to examine the flora and fauna of different regions and provide recommendations for their conservation. Systematics establishes the proper connection between species and aids in taxonomic differentiation. It not only sheds light on the beginning of life as we know it, but it also maintains current biodiversity knowledge via appropriate documenting and archiving. It offers a practical way to handle the vast quantity of information that exists in the world. The problem of climate change and global warming is growing, and this puts the biotic flora under tremendous threat of extinction. Their ability to survive is being hampered by the rising struggle for resources among species. A number of unidentified species are always under danger from practices like farming and deforestation. Thus, systematics is crucial to conservation biology. It aids in locating uncommon and threatened taxa, allowing us to create conservation plans for them.Systematic research also provides a comprehensive picture of the extraordinary variety of life on earth. The distribution of species on the earth and the biological interactions between species are better understood with the use of biogeographic data. Additionally, it helps in the identification of biodiversity hotspots and the development of strategies for their preservation in their natural habitats (in situ) or in habitats that have been purposefully produced (ex situ). The floristic biota may be gathered and inventoried in regions that are at danger of being destroyed. For the efficient use of financial resources, systematics is also crucial. To enhance the available germplasm and create resistant variants, it might be helpful to comprehend the wild species that are closely related to commercially significant agricultural plants. The understanding of the ecological effects on organisms may also help to enhance land use patterns. Correct taxonomic identification helps minimize pest infestation and harm brought on by a rise in weed populations. It also improves our knowledge of critical processes like the coevolution of diseases, pests, and pollinators in plants. With the use of systematic investigations, dispersal processes, ecological alterations in plants caused by climate changes, and habitat preferences may be readily comprehended. Additionally, systematics offers insights into the evolutionary processes by assisting in the study of the speciation process. This gives information on how the connection between ancestors and descendants has changed through time. These phylogenetic analyses provide light on the evolutionary process that led to the emergence of life on Earth.

CONCLUSION

Systematics is the study of the evolutionary history and biological variety that exists on Earth. Science's field of taxonomy is concerned with the concepts and methods of categorization. Description, Identification, Nomenclature, and Classification are the four major parts of taxonomy. Integrative taxonomy refers to the process of solving taxonomic issues using methods from many disciplines. Systematics is essential to conservation biology since it aids in identifying uncommon and endangered species, allowing us to create conservation plans for them. Systematics offers insights into the evolutionary processes by assisting in the study of the speciation process.The two disciplines of systematics and taxonomythe foundational tools for comprehending and categorizing Earth's biodiversityemerge as being of immense significance and relevance. They give a roadmap for understanding the fascinating diversity of living forms that live on our planet and provide a methodical strategy to doing so.

We have looked at many different aspects of taxonomy during this inquiry, including the thorough description of creatures, the application of genetic data in DNA taxonomy, and the incorporation of technology via cyber taxonomy. We have followed the development of taxonomy from its historical origins with Linnaeus to become a multidisciplinary science that currently includes genetics, ecology, and digital technologies. Importantly, we have emphasized the crucial part that taxonomy and systematics play in modern civilization. The study of biodiversity is more important than ever as ecosystems disappear and climate change picks up speed. We can identify, categorize, and preserve the biological resources on Earth using systematics and taxonomy, which enables us to safeguard the precarious balance of life on our planet. In essence, systematics and taxonomy are the stewards of our natural legacy rather than only academic endeavors. They help us comprehend the complexities of our planet, preserve its treasures, and responsibly use its resources. These disciplines will continue to direct our investigation of Earth's biodiversity as we advance and motivate us to take care of the astounding variety of living things in our immediate environment.

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CHAPTER 3

UNRAVELING THE COMPLEXITY OF TAXONOMY: FROM FOLK KNOWLEDGE TO PHYLOGENETIC CLASSIFICATION IN ETHNOBIOLOGY

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ABSTRACT:

Natural diversity produces a wide range of human populations, making it necessary to classify species for our knowledge. Ethnobiology examines the complex interactions between people and the natural environment by delving into the fabric of traditional knowledge. Taxonomy, the study of categorization, is a crucial tool for organizing and understanding the variety of life. Ethnobiology is a critical branch of the biological sciences that has become more important at a time when both traditional knowledge and biological diversity are being rapidly lost. It makes a substantial contribution to the evaluation of biodiversity and long-term conservation efforts.The foundation of biological study is taxonomy, which provides a standardized framework for classifying and identifying species and improving effective communication. The history of taxonomy is examined in this study, including its anthropocentric roots and its development into a discipline that looks for phylogenetic links among species. In order to ensure the correctness, dependability, and quality of plant information, taxonomists play a critical role in identifying, characterizing, and naming taxa. The systematization of plant variety, however, requires a multifaceted approach that takes into account categorization principles, botanical nomenclature, and the art of description and identification due to the enormous diversity and spread of plant species worldwide.

KEYWORDS:

Anthropocentric, Biodiversity, Ethnobiology, Taxonomy.

INTRODUCTION

Nature creates just people, nothing else. She makes them in such vast quantities that we are forced to categorize them in order to be able to keep them in our brains. Ethnobiology examines the folk knowledge of human interactions with creatures. This sorting called classificationtaxonomy. Traditional civilizations have traditionally been reliant on their immediate surroundings for the majority of their needs, including food, housing, clothing, tools, utensils, medicines, and instruments. Due to the fast loss of both traditional knowledge and biological variety, ethnobiology is presently regarded as a priority field in the biological sciences. As a result, it may contribute significantly to evaluations of biodiversity and sustainable conservation[1], [2].

A plant may have multiple local names, and a vernacular term may be used to refer to different plants, even if folk classifications are structurally ordered according to generic principles. Common names cannot therefore be used in place of scientific names, and in order to ensure best practices and high standards of scientific works in ethnobotany, the following procedures for recording plant species should be followed: first, a voucher specimen identified by the local informants should be collected and placed in a herbarium to be used as reference to this record; second, the herbarium specimen should be identified by a competent botanist; and third, the correct syllables should be used when recording plant species.

Therefore, the taxonomy, which is a fundamental prerequisite for any biological research, is essential to ensuring the correctness, dependability, and quality of plant information in order to achieve the best practice in ethnobotany[3], [4].

The science of taxonomy is in charge of organizing diversity

It offers a synthetic way to categorize and identify creatures, facilitating effective communication. The ideas used to organize biodiversity and the methods used to identify its components combine to form the field of taxonomy. Classifications are anthropocentric constructions designed with specific interests and assumptions as an inductive method of organizing the universe. They group objects and create classes intention based on their properties in such a way that other objects extensions of the same kind will also belong to those classes. In taxonomy, taxa are the classes or natural types of a kind, while organisms are the objects. Taxa are ideas or propositions that are characterized by shared traits or connections among their constituents. They may be generated but lack physical existence, changed but lack evolution, and banned but do not become extinct.

Taxonomists' duties include defining, describing, and naming taxa

Organisms are recognized based on how well they fit to certain taxonomy. Therefore, the main purpose of taxonomy is to define taxa and establish a hierarchy of classifications. These classifications may be created with a variety of objectives. Some are purely operational, straightforward, and stable in design, while others prefer the empirical content, synthesizing collective knowledge, or placing trust in projections.

Last but not least, some categories are theoretical and show things doing things or the outcome of natural processes. It is not unexpected that several classification schemes have been suggested for plants given their enormous diversity, vast distribution, and long history of usage by humans for a variety of purposes around the globe.

The three linked components of the systematization of plant variety are considered in this chapter's introduction to botanical taxonomy: (1) the principles of categorization; (2) botanical nomenclature; and (3) description and identification.

Natural systems are polythetic

They are based on many characters, grouping plants with a large number of correlated attributes. In contrast to artificial systems, which are based on a single or small number of characters chosen a priori, such as in Linnaeus' sexual system or in herbals, where plants are frequently arranged according to their uses and effects. Therefore, it is anticipated that a natural categorization will be more informative and helpful than an artificial one, as well as have a greater predictive value. However, these pre-evolutionary systems were not essentialist, in contrast to what has been widely accepted since the middle of the twentieth century. They connected other members based on how much they resembled the exemplars (or kinds) in general. As a result, groups were created based on these models rather than being defined by the fundamental characteristics of Platonic types.

The explanations for classifications changed, not taxonomic procedures, which shows that evolutionary principles had minimal impact on. Darwin was aware that categorization was a logical process that synthesized a lot of information in a limited number of words and that taxonomic categories were convenience-driven creations.

He disagreed with the natural systems of his day, nevertheless, since they did not classify things based on genealogical links. According to him, taxonomy should be founded on descendants from a common ancestral stock, not on degrees of resemblance. Although a kind of phylogenetic categorization was already attractive to Darwin, it would take more than a century for it to become widely accepted in the field of botany[5]–[7].

DISCUSSION

Evolutionary writers pay special attention to various areas of the plant given the intricate mosaic of traits. Some characters often get weights, and the author's classifications are very subjective. Because of this, evolutionary systems also deal with a lot of subjectivity and are often defended based on the expertise and authority of those who support them rather than on their usefulness or objectivity. A mathematical taxonomy evolved as a response. Some writers argued for classifications that were objectively based on the degree of resemblance since plant traits could be examined but ancestral connections could only be inferred; they were urging for repeatability and greater objectivity in systematics. The classification of plants was rapidly altered by the phylogenetic method. Only monophyletic taxa (sometimes referred to as "holophyletic" by some) must be taken into account when classifying organisms in a phylogenetic framework. A common ancestor and all of its progeny make form monophyletic groupings (or clades, then cladistics); as a result, these groups may be identified by synapomorphies, or traits that are similar due of their shared ancestry. So, in order to classify species phylogenetically, it is first necessary to formulate ancestral connection theories. These hypotheses are often represented in phylogenetic trees, which are branching diagrams made up of internal nodes for possible ancestors and terminals for creatures. Although several criteria are often taken into account to rebuild this connection, phylogenetic classifications are also based on a single attribute of its members that was also specified a priori: shared exclusive ancestry.

Phylogenetic and evolutionary systems agree that only

Groupings descended from a common ancestor, which prevents the detection of polyphyletic groups, as well as groups identified by homoplasies convergences or reversions, or traits that arise more than once independently. However, evolutionary systems also recognize graded paraphyletic groupings, which are neatly dissociated from the immediately nesting clades due to their level of dissimilarity. Evolutionary systems also recognize clades. Symplesiomorphies, or the lack of synapomorphies, traits that were present in some of their progeny but descended from their common ancestor, are used to identify grades. Members of the same grade may have a more recent ancestor with people from another group even if they are not necessarily closely connected to one another. Phylogenetic methods lessen the subjectivity of assigning marks based on how similar two groupings are by only allowing monophyletic groups. The phylogeny of a group may be reconstructed using a variety of hypotheses, methods, and data sources, but nothing can ensure that the whole phylogeny will be disclosed. Achieving findings that are near to the right ones requires adding data and developing analytical techniques, and advancements in our understanding of plant interactions have a direct impact on the taxonomy of these groupings. Most plant phylogenetic analyses conducted before the 1980s had few endpoints and relied heavily on morphological data and parsimony. When given a choice between two hypotheses, the parsimonious criteria states that the simpler one should be chosen; in terms of phylogenetic trees, this implies less homoplasy. Nature is not always straightforward, and parsimony may sometimes be contradictory since it is a philosophical standard rather than a scientific one. Regardless, morphology is a very complicated source of information, and many writers often interpret it in various ways. Furthermore, it is difficult or maybe impossible to compare the morphology of distant populations since traits are often influenced by the environment, providing skewed evidence of links. In fact, morphology-based trees are often poorly resolved, and the few clades that do exist are seldom supported[8], [9].

By the middle of the 1990s, molecular evidence had already surpassed morphological evidence, and it quickly replaced morphological evidence as the primary source of information in phylogenetic research, whether in conjunction with it or alone. This change, which enabled significant advancements in plant systematics, was made feasible primarily by developments in molecular sequencing and computer technology. Since DNA is the foundation of heredity, the most conclusive proof of ancestral ties is found in molecular data. The scientific community may quickly access nucleotide sequences that are kept in computerized databases like GenBank, which presently has more than 135 million DNA sequences. Although nucleotide sequences are not always accessible for all taxa and comparisons are not always clear or unambiguous, the job of identifying the four-character states of a nucleotide sequence is simple. Parsimony analyses are being displaced by model-based studies as a result of the overwhelming presence of molecular data. The use of more trustworthy models of nucleotide substitution was promoted by theoretical and empirical developments in molecular evolution. Currently, the majority of plant phylogenetic studies rely on DNA sequences, which are ultimately paired with morphology or, in a genomic approach, whole-plastid DNA. These studies also include maximum likelihood and/or Bayesian inference methods, which are often linked to the findings from parsimony analysis.

The Fundamentals of Nomenclature

Our categorization rules specify how plants should be arranged. However, taxonomy would suffer if there wasn't a mechanism in place to control the use of scientific names apart from these rules. To better support taxonomy, botanical nomenclature is continually being improved. Its purpose is to provide plant names with clarity, universality, and durability. Every six years, a nomenclatural segment that takes place a week before the International Botanical Congress discusses new ideas. Although the naming code has undergone progressive alteration, the Melbourne code is an illustration of how such changes might be revolutionary. First of all, the new nomenclature is called Code of Nomenclature for Algae, Fungi, and Plants rather than International Code of Botanical Nomenclature. More notably, since 2012, diagnoses of new names may be written in English in addition to Latin as long as they are published in a journal with an ISSN or book with an ISBN and in PDF format. A Latin diagnosis or description was required for the legitimate publishing of new plant names in the past, and a publication would need to be printed and circulated in at least two public libraries. These modifications, which started to take effect before the Melbourne code was published, would undoubtedly speed up the description of new species while promoting floristic investigations, especially in megadiverse but understudied locations. Conventional classification of taxa into categories replaces the lack of ranking criteria in nomenclature. Only the extent of inclusion distinguishes different categories. Unless there is redundancy across taxa, higher categories are more inclusive when taxa share organisms. These taxa have bigger circumscriptions and more generalized information;therefore, their intentions are greater than those of lower levels. Since they do not share organisms, taxa of the same rank are exclusive. Always keep in mind that rankings were created for convention and practicality; they are only comparable based on designation, not on any biological or natural basis. Some scientists are only accepting species and clades, like with the Phylocode or "cladonomy," since the usage of categories has been questioned as a cause of instability. However, in the present Linnean nomenclature, categories are still necessary for the application of names since they contain informative value and are mnemonic tools that have been widely and effectively used for a long time.

It have only one accurate name, and these names must be legitimately publicized. The classification of alternative names is aided by the nomenclatural concept of publication priority and is taxonomically directed by the kind of approach. Since 1958, in order to publish a new name, writers have had to provide a holotype. The specimen or image chosen or utilized by the creator of the species (or a taxon below species) to which the name is linked is known as the holotype. Isotypes are copies of a holotype. However, types were not always required, and names were published in classical literature without a direct reference to a type specimen. In some of these situations, the holotype may be assumed; however, in others, a lectotype from the original material (syntype) must be declared as the nomenclatural type. When the holotype is absent, a lectotype must also be assigned among the isotypes. However, a neotype must be assigned to the name if there is no original material accessible. Finally, when the name's type is inadequate, an epitype may be assigned to help with the name's exact application. The type approach is undoubtedly essential to nomenclature practice. It is crucial to emphasize that types are simply assigned to taxon names by convention and do not exist for the taxa themselves[10].

In botany, species names with identical general and particular names are invalid. Names must be regarded as accurate by their authors in the original publication in order to be considered legitimate. The valid last epithet in that rank and the accurate name of the genus or species are combined to form the proper name of a species or infraspecific taxon. Like in zoology, the author names in botany are followed by the author(s) of the right combination. In zoology, the author(s) of the basionym (initial combination of a species) of a later combination appear between parenthesis. A name may be erroneous if it is unnecessary, meaning that its type has already been given to another name, or if it is a posterior homophone, meaning that it has previously been used for another taxon of that rank. An alternative new name must be given to a posterior homonym since a scientific name may only be given to one taxon.

From Descriptions to Identification: Taxonomic Works

Iterative classification is a procedure. Taxonomists may constantly uncover fresh evidence to support their own taxonomic beliefs, and they may differ regarding specific taxonomic concepts. Evidence may come from a variety of sources, and disagreements may have a variety of reasons. For instance, whereas one taxonomist may regard two morphological variations to be diverse enough to be recognized as separate species, another taxonomist may see them as components of a single species' morphological variation; in this case, the two species would be considered synonyms. The discovery of unanticipated ancestral ties may necessitate taxonomic modifications since a taxonomy based on phylogenetics must represent ancestral relationships. These changes may modify the circumscription of taxa and may change the name of a species. For instance, it is not necessary to modify the nomenclature at the species level in order to form a new family or revive an existing one to include members of a clade. A tighter association between one species and those of another genus, however, will call for its transference and, as a result, a new combination. Changes could also be needed for greater clarity and applicability, such as when a name is discovered to be redundant or a later homonym. Currently, new phylogenetic data are the main cause of taxonomy modifications. Contrary to taxonomic stability, which may just indicate ignorance and not necessarily right, this is an indication of scientific advancement. Taxonomists are in charge of critically assessing fresh data and putting it into categories. It's crucial to update identifications consistently since this procedure often entails taxonomic rearrangements and nomenclatural alterations.

Giving scientific names to species of as-yet-unclassified taxonomy constitutes identification. There are various methods for identifying plants. Taxonomists, the group's experts, are often given this responsibility since they can use their expertise most effectively to make a quick and precise identification. Taxonomists aren't always accessible, thus alternative methods must be used instead. In these circumstances, plant identification may also be accomplished by examining particular monographs, thorough technical publications, and scientifically correct works. A thorough monograph will typically include analytical keys for taxa identification, an introductory section outlining the morphology of the group, detailed descriptions, and high-quality illustrations, as well as comments on taxonomy, phylogenetics, nomenclature, ecology, and geographic distribution (typically with maps of occurrence). In these treatments, species are either organized according to their connections, which favours comparisons of closely related taxa, or in alphabetical order, which favors direct individual inquiries.

When the relevant taxonomic and nomenclatural data are available is mentioned, the authors and the combination's first source are included after the proper name of the species. After the information for the right name, according to the publication date, the other homotypic synonyms are presented in order, starting with the basionym, with authors and references. Similar to this, heterotypic synonyms are given below the proper name heading, each beginning on a different line and often arranged according to the date that their base name was first published. The sorts of heterotypic names are listed at the conclusion of each heading, along with a statement about whether the writers of the work have looked into them. Standardized, concise, unambiguous, and exact plant descriptions are preferred. However, even when it appears evident, the kind of measurements must always be mentioned. For instance, verbs, study, and conjunctions may be removed. The following collecting information must be included in a taxonomic investigation to qualify as a scientific work: location, date, phenological condition, collector and number, and herbaria of duplicates. But some monographs are based on a huge number of samples. In these situations, it is advised to highlight a sample of the species' variation and distribution and include a complete list of extinct species at the end of the work, only with the collection reference first collector and number and its identification the species number, shown from its order in the treatment. Since Lamarck, the characteristics required for classification and identification have been separated, allowing for the creation of artificial, practical diagnostic keys intended to facilitate the quick identification of taxa in both natural and phylogenetic classifications. The user successively follows pairings of assertions that contrast and are preferred mutually exclusive as they best suit the characteristics of the specimen being recognized until they reach a tax on. It is preferable to have more qualities per statement, provided that they are straightforward and simple to notice. Traditional dichotomous keys might have a number or an indentation. In numbered keys, a pair of statements are next to one another, and the next statements are denoted by numbers. Statements in an indented key are arranged sequentially, progressively moving from the left, without the need for numbers to denote further statements. Others may be thoroughly detailed and displayed as a graphic. Some keys relate to representative examples of the traits.

Verification of identifications is always required. The specimen may be first compared to the species' description, image, and remarks. Later, the specimen can be compared to specimens in herbaria, preferably those that have been recognized by a taxonomist with expertise in the group. Access to exsiccates of various species and kinds is also available at synoptic virtual herbaria. A checklist may assist the user in determining if the taxon has been recorded in the area in the absence of a monograph or flora, but its absence from the list does not rule out the potential of a new occurrence. The record of our biodiversity is found in taxonomic works.

First, publications serve as the new taxon's birth certificate. They also keep track of new material as it is gathered and compile it into monographs, making plant knowledge accessible to others and allowing it to be passed down through generations. Despite this, taxonomy research is becoming less important to the scientific community. This is thus because such efforts take a lot of time, and publications are mostly used for consultation and seldom ever result in citations. However, taxonomy works well on the Internet, where there is no space constraint, allowing for the ongoing accumulation of data, the availability of colour pictures without extra expense, and the updating and linking of information to a wide range of relevant topics. Phylogenetically arranged websites for plant systematics exist, such as the Angiosperm Phylogeny Website, where flowering plant orders may be found using a phylogenetic tree or an alphabetical index. The majority of the tree's orders are connected to other family-based trees. Users may get updated information about a tax on, such as its diversity, internal arrangements and relationships, characters, and maps, by clicking on the family name. An extensive network of information is connected by scientific nomenclature. They serve as keys for the complete body of literature on the taxa they represent and are like seeds that travel across time and space. Taxonomic names have the ability to easily spread this information to any nation, regardless of the language, and ensure the accumulation and transmission of knowledge throughout generations, from naturalists to the contemporary phylogeneticists.

CONCLUSION

Our concept of the variety of life and our location within the natural world has undergone a remarkable history, moving from traditional knowledge to contemporary phylogenetic categorization in ethnobiology. This investigation of taxonomy's complex history illustrates how crucial it is for categorizing and understanding the many species that inhabit our planet with us. Taxonomy has been an important study from the earliest human civilizations that were dependent on their local environment for survival to today's rapidly changing globe characterised by the loss of conventional knowledge and biodiversity. In response to the difficulties given by an ever-expanding amount of information about the species we cohabit with, it has changed and grown. In addition to serving as a system of categorization, taxonomy is a symbol of human inventiveness, adaptability, and our never-ending search for knowledge. It depicts how our interaction with the environment has changed through time and acts as a link between our ancestors' perceptions of nature and the most recent advances in biological study. Taxonomy is still a crucial tool for scientists, environmentalists, and policymakers as we continue to investigate, catalogue, and classify the astounding variety of life. It offers a universal language that cuts across boundaries, allowing for efficient communication and teamwork in our combined efforts to maintain and safeguard the Earth's ecosystems. The importance of taxonomy is increased in light of continuous environmental problems. It aids in the evaluation of biodiversity and provides information for effective conservation plans. It supports us in our efforts to preserve the natural environment by illuminating the genetic ties that link species together and unravelling the complex web of life. The transition in ethnobiology from traditional knowledge to phylogenetic categorization is a prime example of how taxonomy is a dynamic field that is always changing, adapting, and inspiring. Taxonomy will surely be crucial to our efforts to comprehend, appreciate, and preserve the amazing variety of life on Earth as we go further into the twenty-first century.

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CHAPTER 4

HARNESSING TAXONOMY: THE FOUNDATION OF BIODIVERSITY UNDERSTANDING AND CONSERVATION

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ABSTRACT:

This study examines the crucial function of taxonomy as the basis for an understanding of biodiversity and efficient conservation. Systematics' essential area of taxonomy, which deals with the categorization, identification, and naming of species, functions as both a process and a result. By organizing and synthesizing biological data, taxonomic information greatly advances scientific study. It also plays a key role in social initiatives like sustainable development and biodiversity preservation. To close the current gaps in taxonomic data accessibility and distribution in India, the research suggests creating an integrated plant taxonomic information system. This system would provide a thorough platform for scholars, decision-makers, and the general public to access and successfully use taxonomic information. It would consist of multiple databases, including a virtual herbarium, bibliographical database, and botanical gardens network.There are several definitions of systematics, but Simpson's definition, which is suitable, calls it "the scientific study of the kinds and diversity of organisms and of any and all relationships among them." This description highlights the main goal of systematics, which is to understand biological variety and its evolutionary roots by exploring the complicated web of relationships among organisms, species, and higher taxa.

KEYWORDS:

Biodiversity, Biological Data, Information System, Phylogenetic, Taxonomic.

INTRODUCTION

The word "classification" has two meanings in taxonomy: it may refer to both the process of classifying and ranking organisms according to their connections and the resultant hierarchical taxonomy. Identification, which assigns specific specimens to previously categorized groups, and nomenclature, which controls the name of these groupings, are two complimentary tasks that are intrinsically tied to taxonomy. The importance of taxonomy extends beyond scientific inquiry, having an impact on broader socioeconomic and environmental issues. The Convention on Biological Diversity acknowledged taxonomy's significant contribution to advancing sustainable development in 1992, praising both its theoretical and practical applications. With the help of taxonomy, large biological datasets may be organized and the world's living things can be catalogued and understood. Additionally, it clarifies population dynamics, species development, and individual variability, shedding insight on the complex evolutionary processes[1], [2].Fundamentally, taxonomy is a subfield of the broader field of systematics. Numerous scholars have given numerous definitions of systematics. However, Simpson's definition of systematics as "the scientific study of the kinds and diversity of organisms and of any and all relationships among them" is the one that is most often used. To put it another way, systematics is the study of biological diversity and its causes, with a focus on understanding the evolutionary relationships between organisms, species, higher taxa, or other biological entities like genes, as well as the evolution of the traits of taxa like intrinsic traits, ecological interactions, and geographic distributions. The development of techniques, especially numerical ones, for different facets of phylogenetic inference and biological nomenclature/classification is another priority of systematics. Taxonomy uses the word classification, which also has a second meaning in everyday speech. It alludes to both a process and a finished item. It is the act of classifying and ordering living things according to their relationships, and its end result is the hierarchy of taxa. Both the act and the outcome of categorization contribute to its significance in biology and society. Identification and nomenclature are two related processes that make up classification. It entails assigning a specific specimen to a previously identified and classed group. Nomenclature refers to the naming of groupings of organisms and the regulations controlling the use of these names. Swingle distinguished between taxonomy and systematics, arguing that the latter dealt with phylogenetic categorization while the former was more inclusive of taxonomy and nomenclature. Still, many scientists confuse taxonomy with systematics. As a matter of fact, Crowson draws the following conclusion: "The phrases classification, systematics, and taxonomy are now routinely viewed as synonyms, an illustration of the confusion and the carelessness in the use of words which is pervasive in so much contemporary literature[3], [4].

Taxonomic Information's Value

The Convention on Biological Diversity, which recognized the critical function of taxonomy in advancing sustainable development, was signed by 150 head of state and government representatives in 1992. Both theoretical and practical ramifications stem from the influence of taxonomic knowledge. We may categorize the value of the data produced by taxonomists into two categories for discussion's sake: scientific and social.

The function that taxonomy performs as the "data processing system for biology" is one of the most significant contributions. In order to organize all of the biological data, or knowledge about life, that is currently accessible, taxonomy enables the building of a framework using the millions of bits of information that taxonomists have acquired from the natural world.

To put it simply, taxonomy inventories or catalogues the combined biomass of plants and animals. The study of systems also aids in understanding evolution, knowledge that is used in other branches of biology. Systematic research reveals the microprocesses of evolution, such as individual variability, population variation, reproductive isolation, modalities of speciation, etc. Systematic investigations also contribute to the discovery of evolutionary patterns or phylogenetic linkages, which inspire theories about the emergence of life and the evolution of ecological zones throughout the course of the earth's history[5], [6].

Social Worth

Taxonomic data has the most social significance when it comes to preserving biodiversity, protecting natural resources, and promoting the idea of sustainable development. According to Herdberg, "In a world with fast expanding population constraints and quickening exploitation it is vital to use biological resources shrewdly on a sustained yield basis, and to this purpose we must have all sufficient knowledge about its flora. Systamatics assists in identifying new plant resources for the economy, such as food, medicines, and industrially beneficial plants, to add to our body of current knowledge.

Therefore, it has the potential to significantly improve our agriculture-based economy, secure global food security, and promote good health. The taxonomic information may be used for biological management of invasive plants, finding a solution for land reclamation, phyto-remediation, etc. Systematists serve an essential role by providing advice on potential ecological effects on species via Environmental Impact Assessment (EIA) studies before to any industrial projects, the construction of any dams, canals, etc.

Participants in Taxonomic Information

The taxonomists themselves, scientists, ecologists, environmentalists, agriculturists, industrial sectors, policy makers, engineers, governmental organizations, and everyone else who needs knowledge about biodiversity are the consumers of taxonomic information. India's current taxonomy information infrastructure is utterly inadequate.

The numerous information sources are dispersed and mostly restricted to certain institutions. Timely retrieval hinders research and development since there is no national platform for sharing these crucial taxonomic data. The creation of the Environmental Information System (ENVIS), a decentralized information network with 76 network partners, of which 46 are subject-specific and 30 are on state-related issues, is the only initiative that can be seen as coming from the Ministry of Environment and Forests (MoEF). Since there is no comprehensive national floral or taxonomic inventory, this information network primarily meets the needs of those seeking broad environmental information.

The field of systematic biology is more reliant than any other on the historical literature of published descriptions of species; the validity of assigning credit for new discoveries still depends on publication in print. Due to its dispersed nature, researchers are now having trouble recovering the published literature from the past, therefore adequate access to it is crucial.

DISCUSSION

Information systems are a subset of communication systems that choose, organize, store, and transmit information to users in accordance with the goals established by information programs. All the parts that gather, process, and distribute data or information make up an information system. It typically consists of people, communication systems, hardware, and software. Data input, data processing into information, data storage, information, and the creation of services and goods are all activities related to an information system. A defined information program that outlines the goals to be met, the infrastructure needed, and the funding sources for the information system's setup should exist before any information system is put up.

A significant step towards the successful transmission of the enormous quantity of taxonomic data being created at the cost of the public exechequer may likely be made by an information system on plant taxonomy combined with taxonomic details, identification tools, traditional knowledge, and economic views. It will not only close the information gap between the information-rich and information-poor segments of society, but it will also boost the country's intellectual capital in the sciences.

The Government of India also noted in the Fourth National Report for the Convention on Biological Diversity that "Integrated database development at all organizational and management levels to effectively utilise the data sets as one of the important tools for decision support systems and establishment of a national information system" is one of the areas that require urgent attention from all concerned stakeholders in the Indian context. The system will serve as a standard platform for the gathering, processing, storing, and disseminating of taxonomic data, and the national phytodiversity digital repository will not only lessen "taxonomic impediments" to study but also promote conservation and sustainable development.

Information system's model

Botanical Survey of India (BSI), together with its 11 regional centres, will serve as the supreme body under MoEF. It will collaborate with the network's other partners, including the botany departments at various universities, the National Botanical Research Institute in Lucknow, the GB Pant Institute for Himalayan Environment and Development, and ag schools. The primary server will be kept at BSI Headquarters. Each regional database will have a server class computer in each of the regional centres. By adopting a server grid technology that is centrally monitored and uses VPN (Virtual Private Networking), all servers will be pooled together to access databases in the appropriate locations. Through a central server or dispersed network with metadata on a web portal, the public may have access to the database. In order to collect, process, manage, monitor, and coordinate the taxonomic data produced by the various centres in the states under its control, the regional centres will be essential. To put it another way, BSI will serve as a national clearinghouse for taxonomic information. There will be various centralized databases in the information system. A database is a group of connected data that is kept in one place without redundant storage in order to serve several purposes. In reality, it is a collection of data that has been logically organized, with the least amount of redundant information possible and the most acceptable amount, and has been indexed in the best possible way for the application the user is interested in. The operational environment and the decision-support environment are two different categories for the database environment. While the decision-support environment is primarily focused on user flexibility, the operational environment is mostly focused on online performance and data integration. The databases listed below may be created using pertinent data[7], [8].

Electronic Herbarium

The herbarium is an important tool in floristics and is often used interchangeably with conventional taxonomy. An herbarium's primary function, like that of other museum collections, is to provide tangible evidence of living things, knowledge of which is crucial for understanding, conserving, and making use of the variety of plants. Baseline information regarding the scope and distribution of plant variety is provided through herbarium collections. Additionally, they provide a nearly permanent record of taxonomic ideas and how they have evolved for a certain taxon. Future herbariums will be drastically different, and the idea of a "virtual herbarium" already exists. It essentially consists of an interactive online front-end connected to a common database of scientific names with distant Internet access to scattered specimen and other taxon or specimen-related information in the herbaria.

Database of scholarly works

All the works generated by Indian scientists and researchers in the fields of taxonomy, systematics, ethnobotany, and other relevant fields will be included in a bibliographic database. Through this platform, classic and rare retrospective taxonomic literature may be digitized and made accessible. To organize the massive information flow, family-specific bibliographies containing the bare minimum of bibliographic components may be created. Primary research output being made open access (OA) is the most contentious subject, and it may be discussed at all levels to reach an agreement. In fact, the Working Group on Libraries of the National Knowledge Commission, which was established by the Government of India, makes the following recommendation: it is crucial to develop more digital resources that may be shared in order to provide equitable and universal access to knowledge resources. It is necessary to promote the idea of a "information commons," or "resources shared by a community of producers and consumers in an OA environment." It highly advises that peerreviewed research publications that are published and subject to copyright limitations that are the outcome of publicly financed research in India be made accessible via open access channels.

Network of Botanical Gardens

It will serve as a database for all the BSI-affiliated orchidaria and experimental botanical gardens. Other information services, such as translation, referral, document delivery, current awareness, selective information dissemination, press clipping, bibliography, and various peer-to-peer communication services like blogs, forums, etc., can also be integrated in addition to database services. The development of a cross-platform common search engine that pulls relevant data from all relevant databases for a given query might have an impact on information retrieval. Major international databases like the International Plant Name Index (IPNI), Index Fungorum, Algaebase, etc. should be connected to this national database.

Biodiversity, the rich tapestry of life on Earth, represents the culmination of millions of years of evolution and adaptation. It encompasses the staggering variety of species, ecosystems, and genetic diversity that collectively constitute our planet's natural heritage. Understanding and conserving biodiversity are among the most critical challenges facing humanity in the 21st century, as it underpins ecological stability, human well-being, and the very future of life on Earth.At the heart of the quest to comprehend and preserve biodiversity lies the science of taxonomy. This article delves into the profound importance of taxonomy as the bedrock upon which our understanding of biodiversity is built and how it serves as an essential tool for effective conservation. We explore the multifaceted contributions of taxonomy, its societal and scientific value, and propose the establishment of an integrated plant taxonomic information system as a means to enhance its accessibility and utility. Taxonomy, within the broader field of systematics, plays a pivotal role in elucidating the relationships among organisms, species, and higher taxa. It provides a systematic framework for classifying and naming organisms, thereby allowing scientists to categorize, study, and communicate about the incredible diversity of life on Earth [9], [10].

Scientific Contributions of Taxonomy

1. **Organizing Biological Data:** Taxonomy serves as a sophisticated data processing system for biology. It allows scientists to organize and catalog the vast amount of biological information collected from the natural world. This structured framework forms the basis for comprehensive studies in ecology, evolution, and genetics.
2. **Revealing Evolutionary Processes:** Taxonomy enables researchers to explore the microprocesses of evolution, including individual variability, population dynamics, and modes of speciation. By uncovering patterns of evolution and phylogenetic relationships, taxonomy contributes valuable insights into the origin and development of life on Earth.

Societal Value of Taxonomy

1. **Conservation of Natural Resources:** Taxonomy plays a pivotal role in the conservation of natural resources and the protection of biodiversity. It helps identify new economic plant resources, facilitating sustainable agriculture and promoting food security.
2. **Environmental Impact Assessment (EIA):** Taxonomists provide essential input in assessing the ecological impact of industrial projects, dams, canals, and other infrastructure developments. Through Environmental Impact Assessment (EIA) studies, they advise on potential ecological consequences.

3. **Biodiversity Conservation:** Taxonomy's role in understanding biodiversity is indispensable for conservation efforts. It aids in biological control strategies, land reclamation, and phyto-remediation projects.

Stakeholders of Taxonomic Information

The beneficiaries of taxonomic information span a broad spectrum of society, including scientists, ecologists, environmentalists, agriculturists, industrial sectors, policymakers, engineers, government bodies, and the general public. However, the current state of taxonomic information infrastructure in India, as an example, faces challenges, including fragmentation and limited accessibility.

Proposed Integrated Plant Taxonomic Information System

To address these challenges, we propose the establishment of an integrated plant taxonomic information system. This system would serve as a comprehensive platform for the collection, processing, storage, and dissemination of taxonomic data, enhancing accessibility for all stakeholders. A digital repository of plant specimens, accessible through an interactive web front-end, would replace or complement traditional herbaria. This "virtual herbarium" would provide remote access to distributed specimen and taxon-associated datasets. A central repository for taxonomic publications would integrate classical and rare retrospective taxonomic literature, making it available for researchers and the public.

CONCLUSION

It is impossible to overestimate the significance of taxonomy as the foundation for understanding and conserving biodiversity within the larger framework of systematics. Scientific research, sustainable development, and environmental preservation are among its many contributions. Taxonomy is the hub at which information from the natural world comes together and is synthesized, enabling us to understand and value the diversity of life on Earth.From a scientific standpoint, taxonomy offers the essential framework for arranging and understanding biological data.

It helps scientists to catalogue and classify the astounding variety of species that populate our planet by establishing a systematic framework. In addition, taxonomy has made incalculable contributions to evolutionary biology by revealing the complex webs of life's evolutionary history via the analysis of phylogenetic connections.

The importance of taxonomy may be much more apparent in a social setting. It is crucial to conservation efforts since preserving our planet's ecosystems depends on our ability to comprehend biodiversity. In addition to helping with biological control operations, land reclamation initiatives, and sustainable agriculture, taxonomy also helps identify new economic plant resources. Additionally, via Environmental effect Assessment (EIA) studies, taxonomic data assists in making critical judgments on the ecological effect of industrial and infrastructural development. A reliable and accessible taxonomic information system must be established in order to fully realize taxonomy's promise for biodiversity knowledge and conservation. Researchers, decision-makers, and the general public would all benefit from this integrated system's ability to close current gaps in data transmission and exchange. Such a system would facilitate conservation efforts, encourage sustainable development, and lessen the "taxonomic impediment" by building a digital archive of national phytodiversity and integrating numerous botanical resources.

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CHAPTER 5

NAVIGATING THE EVOLUTION OF PLANT TAXONOMY: FROM PAST TO FUTURE

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ABSTRACT:

Since the beginning of time, taxonomy the study of classifying and ordering living things based on their physical traits has been an essential component of human knowledge. This article explores the evolution of plant taxonomy historically, illuminating how people have attempted to categorize and comprehend their environment. The development of plant taxonomy reflects our ever-expanding knowledge and shifting views, from traditional systematics to the contemporary age of molecular biology and ecological issues. The article addresses the significance of categorization in biology and how it has influenced how we see the world around us. It underlines how taxonomy, like other scientific fields, changes as more information is gained. Scientific names and taxonomic rankings are essential for creating a uniform framework for classifying, categorizing, and preserving plant species. It is investigated how taxonomic categorization is changing from morphologically based to including ecological aspects, chemotaxonomy, and protein sequencing. Notably, the natural system of categorization signalled a dramatic departure in taxonomic thought, driven by Lamarck's hypothesis of the transmission of learned features. The utilization of molecular biological data, a potent tool for comprehending phylogeny and evolution, and its effect on contemporary plant taxonomy are discussed in depth in this article. The future of plant taxonomy will be crucial in preserving the biodiversity of our world in the face of environmental problems, habitat degradation, and climate change. In order to evaluate and preserve plant populations, taxonomists and ecologists must work together. Understanding speciation and adaptability may be aided through breeding trials and physiological research. For accurate identification and to stop extinctions, taxonomists must also take into account how environmental factors affect plant features.

KEYWORDS:

Angiosperm, Chemotaxonomy,Environmental, Plant Taxonomy.

INTRODUCTION

Since the dawn of time, humans have known about taxonomy, the study of categorizing and organizing all things based on morphological similarity. We must examine the history of this branch of taxonomy in order to forecast its future. We can comprehend how humans needed to arrange and categorize everything in their surroundings according to their requirements and purposes if we look at the history of plant taxonomy science. This discipline of research evolved gradually as a result of the expansion in information, resources, methods, and techniques for exams and analyses. Taxonomy's goals are carried over into classification, which is the grouping of related items into related groupings[1], [2].

All living things must reduce the quantity of information their perceptions can gather in order to keep an overview of the complicated world around them. Modern biology, ecology, pharmacology, and all other branches of science could not advance until Carolus Linnaeus's 1735 universal categorization of all living things became a reality. In terms of science and conservation, a species without a name doesn't exist. In turn, the specimens record the physical characteristics of the plant and its geographic distribution. Plant taxonomy will be our major focus while discussing the science of taxonomy in this study.

The process of classifying a plant among all other plants in the world and assigning it a scientific name is known as taxonomy. The categorization reveals which species are connected to our plant and so indexes more details about it, such as illnesses that affect its relatives, toxic substances, or medications it carries. Like other aspects of biology, taxonomy evolves as more knowledge becomes accessible. A ranking adjustment in taxonomy based on newly discovered information that takes the shape of a change in scientific name or taxonomic position is always beneficial and sometimes causes us to alter our thoughts. The organization of plants into groups of things or occurrences that are connected to one another by the existence of certain genes that provide some features in common may be broadly defined as classification. The principle of classification is one that is "inherent in the human mind"; it is a principle that "pervades all of science" and without which all knowledge would be a disorderly and shapeless mass that is too large for the memory to comprehend and too heterogeneous for the understanding to use[3], [4].

Lamarck's idea of the inheritance of acquired characteristics, which refuted the notion that a living thing's environment had an impact on it, served as the foundation for the natural system of categorization. Thus, while analyzing any specimens, ecological considerations have been taken into account and have an impact on taxonomical judgments. Lamarck was struck by the fossil record and saw the parallels between the creatures he examined. This made him believe that life was not predetermined.

With the revolution in plant method analysis, a new age in plant taxonomy was inaugurated. Beginning with the construction of phylogenetic keys and the prediction of species connections, chemotaxonomy and protein sequencing. Chemical compounds replaced the origin of species and the presence-absence criterion for the majority of morphological features as the preferred method for classifying plants. In actuality, the first methods of categorizing plants were based on their chemical make-up and therapeutic benefits, but these methods could not be used to create systems of categorization amongst plants. Dahlgren (1975) was the first to characterize orders and families using chemical data.

The molecular biological data comes from the many sources of information utilized in taxonomy and systematics. Watson and Crick (1953) launched this data source more than 60 years ago. In order to compare fragment patterns across species, restriction enzymes in the chloroplast genome were utilized to solve the dilemma of how to get this data. The high temperature resistant polymerases used in the polymerase chain reaction (PCR) method provide quick access to particular base pair sequence data. Thousands of studies have been conducted since then to understand the phylogeny and evolution as well as the connections between taxa.

The APGI, II, III, and IV are some of the taxonomic studies that have produced fruit. essentially reclassifies the whole plant kingdom. Many people disagree with the APG ways of classifying plants since they are seen as artificial classifications. Taxonomists now strive to create more natural categorization by using all the data and techniques available. It has been proposed that computerization, numerical analysis, and other programs will provide us with natural connections. There are several problems affecting our world, including climate change, habitat loss, pollution, and urbanization. Along with other elements, each of these has an impact on not just the biological balance but also the health of people, animals, and plants.Plants may initially be separated into two categories. These are both seed-producing and non-seed-producing plants. The division of plants that produce seeds is known as phanerogams. Cryptogams are the name for the subdivision that does not produce seeds, as shown in figure 1.

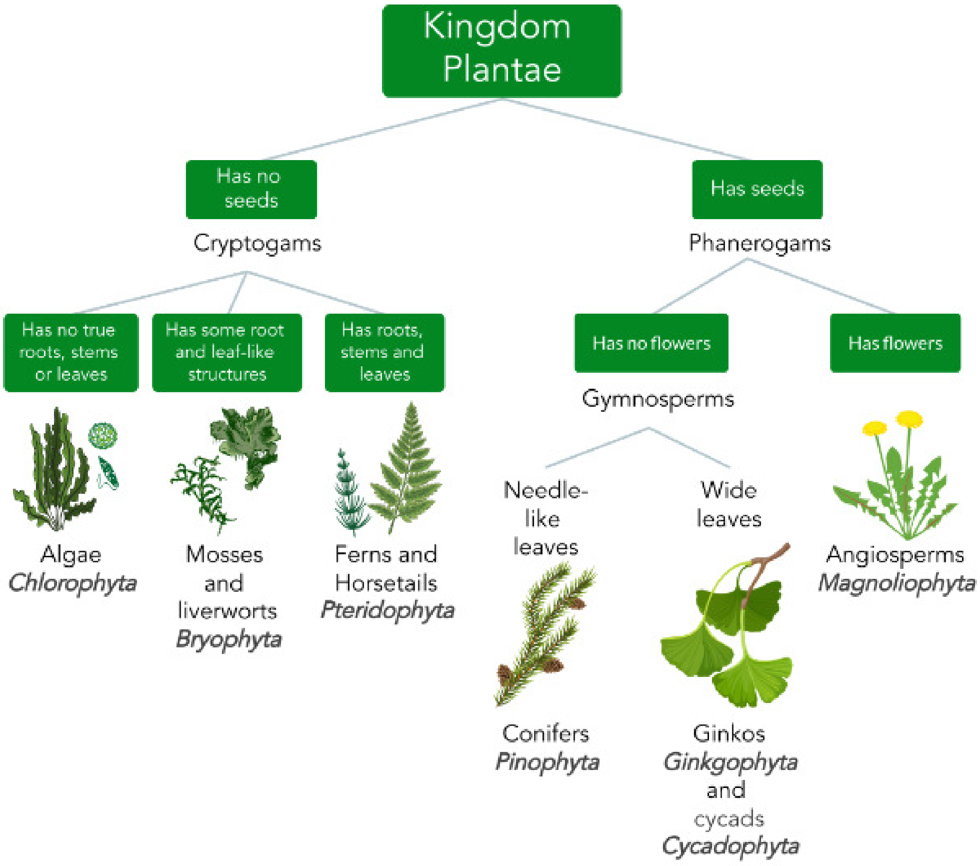

Figure 1: Illustrate the kingdom plantae.

Plant taxonomy's future

We can see from the evolution of taxonomy described above that this field of study has been influenced by human thought, civilization, and advancements in knowledge facilities. We must carefully consider how we might save the wild plant life in order to preserve our planet in the present situation. Taxonomists must examine the vegetation and look for strategies to preserve and spread the plants. We need to comprehend the interactions between the populations' taxa. We must adjust our ideas to the novel circumstances. For accurate identification, to identify the new species as the consequence of speciation, and to save other species from extinction, it is necessary to keep in mind the environmental circumstances and their impact on plant features. To better comprehend the state of the taxa, ecologists and taxonomists must work together. Breeding experiments must be conducted to determine whether or not speciation is occurring. Taxonomy must simultaneously consider physiological traits and the electrical impulses that connect cells to their environment to comprehend connections among the many species[5].

DISCUSSION

Our interest with the natural world has inspired us to seek order and understanding amid the many living forms that exist all around us throughout human history. In this quest for information, plant taxonomy the study of identifying, classifying, and describing plants has been essential. Plant taxonomy has developed in response to our growing understanding of the botanical world from the oldest periods of human civilization, when our ancestors walked the Earth, to the cutting-edge discoveries of the current day.

This extraordinary trip into the development of plant taxonomy spans millennia of human inquiry and intellectual exploration. A long-ago practice founded on the need to recognize and use plants for food and healing, helped to create the organized discipline that exists today. We'll see first-of-their-kind ideas like Lamarck's theory of the inheritance of learned features and its influence on early efforts to comprehend the links between plant species have a profoundly revolutionary effect. Plant taxonomy evolved through time to take into account ecological considerations, chemotaxonomy, and protein sequencing, ushering in a new age of categorization. The emergence of the natural categorization system permanently changed how we see the interconnectivity of plant life. The integration of genetic information, the development of the Angiosperm Phylogeny Group (APG) classification systems, and the continuous discussions and difficulties encountered by taxonomists will all be made possible by the development of molecular biology. But our adventure continues into the future and doesn't finish there. The importance of plant taxonomy has never been greater in light of climate change, habitat loss, and the urgent need for biodiversity protection. To comprehend and protect plant populations, taxonomists and ecologists must cooperate. Breeding research and physiological analysis

Molecular investigations within the flowering plant clade suggest that extant groups cover the evolutionary tree more evenly than the living angiosperms and gymnosperms, which are related in a distant way. The angiosperm tree may now be used by evo-devo researchers to choose species for study whose lineages split shortly before and after significant evolutionary breakthroughs. At the root of the core eudicots, an immense clade that includes the rosids, asterids, and Caryophyllales, in addition to a number of lesser groupings, one of the most profound changes to floral design may have taken place. Floral structure seems to have solidified at the base of the core eudicots in a whorled arrangement of organs.

The first and second whorl organs of core eudicots typically have unique sepal and petal morphologies, demonstrating a strong distinction in perianth organs. In the core eudicots, the evolutionary history of petals. He comes to the conclusion that core eudicot petals were initially generated from bract-like structures that entered the flower by carefully examining perianth anatomy across the eudicots, with special attention on basal lineages. This theory suggests that petals produced from stamens, seen in several core eudicot families, are secondary derived features, not the plesiomorphic condition originally thought [6], [7].

Some angiosperm species have flowers that are monosymmetric (also known as zygomorphic, or bilaterally symmetric), with only one plane of symmetry, whereas others have blooms that are polysymmetric (also known as actinomorphic). Within flowering plants, the development of monosymmetry from polysymmetry seems to have taken place repeatedly independently, often as a consequence of co-evolution with particular pollination vectors. In this sense, Ranunculales, the sister group to all other eudicots, is mapped into the phylogenetic tree, other floral characteristics.

The authors next investigate the relationship between various character states and floral symmetry using numerical methods. They come to the conclusion that none of the many occurrences of floral symmetry limitation in the Ranunculales relies on any specific pre-existing merism, or floral organ number. However, Ranunculales groups with stable floral ground plans and known floral organ numbers and placements in each whorl were the only ones in which monosymmetry was allowed to develop. Antirrhinum and allied species from the asterid clade of the core eudicots, in which TCP and MYB transcription factors are known to play key roles, are now the taxa where monosymmetric flowering mechanisms are well characterized. Strangely, Lotus, a member of the distantly related rosid family, has homologs of TCP genes that regulate floral symmetry, and have documented evidence of Ranunculaleshomologs of TCP genes that likewise regulate floral symmetry. Therefore, homologous sets of genes seem to be in charge of comparable, albeit non-homologous, floral symmetry characteristics in very divergent species [8], [9].

The current understanding of the role of TCP genes in Ranunculales floral symmetry is mostly based on comparisons of gene expression data with findings from model species like Antirrhinum. However, by using virus-induced gene silencing (VIGS), these and other functional concerns in non-model plants may soon be directly answered. This method has the advantage of producing quick results; typically, effects on target gene expression can be seen just a few days after viral infection, allowing for the performance of gene knockouts in many plant species for which there is no practical genetic transformation protocol. Both of these characteristics are crucial for evo-devo investigations since many plant groupings that hold crucial evolutionary positions have lengthy life cycles or cannot be altered using existing techniques.

Transforming mutants of model plants with gene orthologues derived from the relevant non-model species is another technique for examining the function of genes from non-model plants. This method to look at the protein function conservation across orthologues of the transcription factor CRABS CLAW (CRC), which is involved in the growth of the carpel, the female reproductive organ in angiosperms that encloses the ovules. the extant angiosperms, about 160 MYA, the CRC orthologues from Arabidopsis and Amborella, representing a very basal angiosperm lineage, have partially conserved a common activity in the control of the establishment of abaxial-adaxial polarity in the carpel. These authors go on to say that novel functions, adopted by CRC orthologues in the core eudicots to regulate nectary development and by CRC orthologues in grasses to regulate carpel identity and leaf development, may have evolved independently of changes to the genes' coding sequences. Some people have issues with the strategy of switching genes or their coding sequences across taxa. While a lack of complementation in such experiments is not always indicative of a change in the roles of orthologous genes, rather than just of genetic drift, it is not impossible for the complementation of a mutation in one species to occur using an orthologous gene from another, even when the functions of the two orthologues have diverged. Such heterologous experiments, however, may aid in providing exact answers to a number of topics in evolutionary and developmental biology, despite these interpretative difficulties[10].

CONCLUSION

Since the beginning of time, taxonomy the study of classifying and ordering living things based on their physical traits has been an essential component of human knowledge. This article explores the evolution of plant taxonomy historically, illuminating how people have attempted to categorize and comprehend their environment. The development of plant taxonomy reflects our ever-expanding knowledge and shifting views, from traditional systematics to the contemporary age of molecular biology and ecological issues.The article addresses the significance of categorization in biology and how it has influenced how we see the world around us. It underlines how taxonomy, like other scientific fields, changes as more information are gained. Scientific names and taxonomic rankings are essential for creating a uniform framework for classifying, categorizing, and preserving plant species. It is investigated how taxonomic categorization is changing from morphologically based to including ecological aspects, chemotaxonomy, and protein sequencing. Notably, the natural system of categorization signalled a dramatic departure in taxonomic thought, driven by Lamarck's hypothesis of the transmission of learned features.

The utilization of molecular biological data, a potent tool for comprehending phylogeny and evolution, and its effect on contemporary plant taxonomy are discussed in depth in this article. It draws attention to the difficulties and disagreements that taxonomists must deal with, as seen by the APG (Angiosperm Phylogeny Group) categorization schemes. It is also explained how computerization, numerical analysis, and sophisticated programs may be used in taxonomy. The future of plant taxonomy will be crucial in preserving the biodiversity of our world in the face of environmental problems, habitat degradation, and climate change. In order to evaluate and preserve plant populations, taxonomists and ecologists must work together. Understanding speciation and adaptability may be aided through breeding trials and physiological research. For accurate identification and to stop extinctions, taxonomists must also take into account how environmental factors affect plant features.

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CHAPTER 6

A BRIEF REVIEW ON PLANT TAXONOMY AND ITS COMPONENTS

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ABSTRACT:

Fundamental biological ideas like taxonomy and systematics may help us recognize, categorize, and comprehend the wide variety of living things on our world. Even though the meanings of both words have changed throughout time, they both are essential for classifying and arranging living things. The systematic grouping and ranking of organisms based on similar traits is called taxonomy, often known as the science of classification. This process facilitates the sharing of biological knowledge. On the other side, systematics digs further into the investigation of the connections between taxa, using a variety of methodologies including genetics, phylogenetics, and more recently, molecular technologies. In order to show how taxonomy and systematics complement one another in the biological sciences, this article examines their differences. It explores the development of categorization throughout history, from early folk systematics to contemporary scientific taxonomy, illuminating the innate human need to classify and comprehend the living world. The significance of categorization in understanding evolution, disseminating biological knowledge, and protecting biodiversity is also underlined. The study also addresses how categorization is hierarchical, from kingdoms to species, and how this structure enables researchers to analyze and organize the enormous diversity of living things on Earth. Finally, it discusses how speciation leads to the development of new species within a genus.

KEYWORDS:

DNA Barcoding, Plant, Taxonomy, Systematic,Phylogenetics

INTRODUCTION

Our comprehension of the astounding variety of life on Earth is based on two interrelated branches of biology called taxonomy and systematics. Due to people's urge to understand the natural world, many disciplines have developed throughout ages. While some people may use the words "taxonomy" and "systematics" interchangeably, they have different meanings that help us grasp biological variety more comprehensively. The Greek word for "taxonomy" is "putting in order," while the word for "systematics" is "putting together." These descriptions provide a flavour of what these disciplines are all about. In order to facilitate better communication and reference, taxonomy is the systematic grouping and ranking of species based on similar traits. On the other side, systematics dives further into the connections between these groupings, using a variety of tools and techniques to reveal the links to taxonomic development. The origins of categorization may be traced to the ancient era, when early people' existence depended on their capacity to distinguish between distinct plants and animals. The more scientific methodologies we use now were built on the "folk systematics" of the time[1], [2]. A dynamic and synthetic area, taxonomy has evolved through time to include information from other scientific disciplines, including as anatomy, genetics, molecular biology, and ecology. Classification is the glue that binds the intricate web of life together. It enables them to divide living things into kingdoms, phyla, classes, orders, families, genera, and species, with each level displaying distinct common traits. These hierarchical divisions make it easier to study and comprehend the enormous variety of species present in the universe.To identify and characterize species, people employ the ideas of systematics and taxonomy. However, there has been much discussion over the official definitions of the words systematics and taxonomy. Greek terminology translates the words taxonomy and systematics as "putting together" and "putting in order," respectively. Radford defines systematics as the investigation of the phylogenetic, genetic, and phonetic relationships among species. Phylogenetics, taxonomy, and classification are the three subdisciplines of the field of biology that deals with categorizing living things. This part of biology is concerned with the variety and relationships of living things, including both modern and ancient creatures. As a result of the significant advancements made in molecular phylogenetics over the last several decades, plant systematics is one of the most active fields in biology. The scientific study of plant variety and connections, if any, is known as plant systematics. Plant systematics studies natural variation, speciation, evolution, reproductive biology, as well as a number of other biological phenomena in addition to the standard taxonomic tasks. Molecular systematic refers to the branch of systematic that employs information acquired from differences in protein and/or cytoplasmic chloroplast, mitochondrial, or nuclear DNA to clarify evolutionary connections between plants. In molecular systematic research, the nucleotide sequences of protein-coding genes, non-coding spacer regions, or ribosomal RNA are widely employed.

Systems vs. Taxonomy

The study and description of biological variety, the research of the causes and effects of this variation, and the manipulation of the data gained to generate a system of categorization are all parts of taxonomy, which is perhaps the oldest of all disciplines. Taxonomy was defined in 2014 as "the science that investigates, describes, names, and classes all organisms." Because it makes it simpler to categorize species, taxonomy greatly simplifies the communication of biological knowledge. Even before the great contributions of the Greeks and Romans, plant taxonomy was one of the first scientific fields to emerge. Historically, the classification of plants was mostly based on their overall morphology. But nowadays, data from scientific fields like as anatomy, genetics, cytology, chemistry, reproductive biology, ecology, physiology, and molecular biology is utilised. As a result, taxonomy is the foundation of all other disciplines and is a particularly dynamic and synthetic subject.

Classification

Man has used categorisation in his daily life from the dawn of the living world. Man's tendency to categorize living things into categories may be traced back to ancient periods, when being able to distinguish between different kinds of plants and animals was crucial for survival. Early group identification at the time was mostly based on the stark physical similarities and differences between individuals. This is referred to as "folk systematics," and it offers categories that develop out of need in both uncivilized and primitive civilizations without the help of science. Folk systematics' core taxa often, but not always, match those of species defined by science. Classification, according to Stace, is "the production of a logical system of categories, each containing any number of organisms, which allows easier reference to its components." He did describe categorization as an object as "that system itself, of which there are many sorts."

According to how they receive their nourishment, the kinds of cells that make up their bodies, and the quantity of cells they possess, the billions of diverse species that inhabit the world are divided into kingdoms so that they may be studied. Protista, Fungi, Plantae, Animalia, and Monera are these. The subsequent classification of organisms into smaller groups is based on similar traits including appearance, movement, reproduction, and usefulness. There are six tiers in the grouping system used throughout each kingdom. Phylum, classes, order, family, genus, and species are some of these. The existence of such groupings facilitates the study of certain groups of organisms by scientists. The kingdom of plants is very complex and intricate. It is crucial for humans to consume plants since they are necessary for survival and some of them may live for up to 2,000 years. Because animals cannot get energy directly from the sun, other species also consume plants. In order to release oxygen for ourselves and other creatures during photosynthesis, plants remove carbon dioxide from the atmosphere. A significant supply of medication comes from plants. Some plants catch insects to feed, while others assist keep an eye on pollution levels. Botanists are researchers who focus on plants[3], [4].

DISCUSSION

Each Family of plants, which is the highest level of categorization often utilized, has several botanical characteristics in common. At this level, a layperson can often recognize the similarities between plants. According to the botanist whose categorization is used, several plant Families exist. It is important to note that in categorization, family, order, class, division, and kingdom are the categories that are taken into account at the higher level. Sambamurty examined the angiosperm taxonomy in 2010. The plants in each subfamily of the Family are grouped together according to their notable botanical distinctions. Smaller botanical variations are used to divide subfamilies into tribes, which often include a wide variety of plants. Botanists are sometimes the only ones who can distinguish the subtler botanical variations that are utilized to separate the tribe into subtribes. A Genus' members are often simple to identify as belonging to the same species. Sections are often employed to assist organize extremely vast genera, some of which may include hundreds of species. Taxonomic rank below the Genus and above the Species is the Section. If existent, the rank of the Series is below the Section and the Subgenus is higher than the Section. When a genus contains a lot of species, Sections may be further split into Subsections, which is beneficial.

An individual plant is defined at the species level, where the name often refers to some characteristic of the plant, such as the colour of the flowers, leaves, or seeds, the size, shape, or location of the plant's discovery. The genus and species names are used to designate a single plant since they relate to both of those names together. Additionally, a logical connection between genus and species was found. The term "species" was then defined a priori and was thought to be immutable and unchangeable. Speciation is the process through which new species develop from more ancestor species. The most commonly recognized explanation describing how species evolve is the geographical theory of speciation, sometimes known as the allopatric theory of speciation. Either theory states that the initial stage in speciation is reproductive isolation brought on by physical or geographic population separation[5], [6].

The Species may sometimes be further broken down into Subspecies, which comprise plants that aren't quite unique enough to be categorized as Varieties. The lowest taxonomic rank, "Form," is given to the hierarchical level with the smallest amount of diversity. Each Form is made up of plants that vary somewhat from the other forms of the same species in terms of its botany, such as the colour of their flowers or the shape of their leaves. Gardeners and horticulturists often misuse the phrases variety and cultivar. A cultivated variation of a plant, or cultivar, is a specific plant that has developed either naturally or via intentional hybridization and may be replicated to create more of the same plant. The most frequent use of the word "cultivar" is to describe a collection of plants chosen for their propagation-friendly traits. In nature, variations are common, and the majority of them are true to type. Cultivars are not always accurate to their descriptions. The majority of cultivars have developed via cultivation, although a small number are unique wild choices. Some cultivars could be crossbreeds between two species. Other cultivars are the result of sports or plant mutations. Popular beautiful garden plants, such as rose varieties, are created via careful breeding and blossom shape and colourselection. Few wild plants are currently utilized as food sources, and agricultural food crops are nearly entirely cultivars that have been chosen for qualities like better production, flavour, and disease resistance.

On the basis of their general likeness to one another, groupings of organisms are constituted in this manner. The 'phenetic' system of categorization refers to this mindset. Such categorization methods often use data from plant structure and anatomy, cytology, morphology, genetics, and biochemistry, among other sources of data. But it quickly became clear that there are many of issues with estimating phenetic correlations. Particularly pertinent were the observations that different classifications can arise from utilizing various clustering approaches, as well as the discrepancy between classifications based on various organs or life history phases. Numerous articles aiming at demonstrating the links between creatures based on their evolutionary ties have been sparked by the creation of species. It's interesting to note that his theory of evolution did not immediately change the methods used to classify plants; instead, it took some time before it became the most used approach. Phylogenetic classifications are thought of as 'natural' since they essentially represent the phylogeny of the plant, in contrast to artificial categorization schemes designed to improve identification. A fascinating aspect of this system is that no specific taxonomic approach is implied. Cladistics is now the most well-liked phylogenetic categorization paradigm in biological taxonomy and is usually acknowledged as the most effective way to describe evolutionary connections. Cladistics is described as "a method of classification that groups taxa hierarchically into discrete sets and subsets" by Kitching et al. According to the authors, this categorization scheme may be used to organize any sort of comparison data, however it has mostly been used in the context of biological systematics. The cladistic theory and the quick development of DNA technology made it possible to infer phylogenies and provide genuine natural categories based on genealogy.

Plants have historically been categorized according to their phenotype. However, this traditional technique of categorization encountered problems due to a lack of specialists and the instability of phenotypes, which are quickly influenced by environmental influences. When the first sizable studies of flowering plants based on DNA sequences were published in the early 1990s, the advent of sequencing technology offered a possible answer to these issues. These were made feasible by significant advancements in computational power and DNA sequencing technologies in the late 20th century. The capacity to sequence DNA has revealed a lot more information about a plant's taxonomic position and aids in the exact identification of new species. As a result, morphology and ecology are increasingly employed in addition to DNA to prove an organism's uniqueness in the biological world. According to the history and general knowledge on molecular phylogeny, the availability of quick DNA sequencing technology and the development of reliable statistical analysis methodologies gave this area a fresh boost. The authors contend that although being extensively used even today, conventional morphology-based methods of organism categorization have certain drawbacks. They claimed that, despite their limitations and relative recent rise in popularity, the use of molecular markers may supplement the conventional morphology-based approach for phylogenetic investigations[7], [8].

Nomenclature

There has been a lot of interest in the finding and naming of living things throughout history. The system of naming organisms via the creation, interpretation, and implementation of the rules that underpin this system is referred to as nomenclature. In the hierarchy, the species rank is of great significance and serves as the benchmark for all others. This significance is reflected in the rigorous procedure for naming new species, which includes the determination of a type specimen, the development of a new binomial, and the formation of a new authority for new names at the species level. Higher rank type specimens may be traced back to a particular species. A formal publication called International Code of Botanical Nomenclature, whose rules were developed at the International Congress held in Cambridge in 1930, was the first to publish uniform and globally recognized principles for naming plants. These principles were drafted over the course of several International Congress meetings. But these regulations were themselves descended from earlier ones, the first of which came from the Paris Congress in 1867.

The massive extinction of priceless plant species throughout the ages, together with its detrimental effects on socioeconomic and environmental values, has prompted the conservation of plant resources for future use. Therefore, accurate plant material identification is crucial for the efficient conservation of plant resources. The difference between species also aids in characterizing the genetic diversity in plant species germplasm collections that are in risk of extinction and, as a result, helps to assess which groups are the most genetically unique and need to be conserved. A accurate diagnosis is required to safeguard and conserve them via in situ conservation activities due to the significance of many wild relatives of crops in crop development and breeding programs for their resistance genes to diverse biotic and abiotic challenges. The identification of plant genetic resources is also highly helpful for their Ex situ conservation, which is crucial for maintaining biological diversity outside of natural environments. In this regard, plant species identification also aids in maintaining and managing germplasm collections, ensuring that the identity and integrity of accessions held within a collection do not change due to unwanted gene flow or genetic drift after regeneration by seed, and checking the true identity of material entering genebanks.

As previously stated, just those traits necessary to separate this species from all others are used to identify a plant species. A character, which in actuality comprises morphological and anatomical attributes but may also include biochemical, physiological, and cytological traits, is any aspect of an organism that can be measured, quantified, or evaluated. The traits that are continuous within a species but different across species are the most helpful for identifying the species. These qualities must to be fast and simple to document as well. The discussion brought up the point that recognizing a plant is not at all straightforward since, in addition to knowing which aspects to look at, it is necessary to embrace a full vocabulary of phrases intended to offer accuracy in the observation of certain qualities.For purposes of diagnosis, species may be seen as collections of individuals that are organized into populations and who have a set of distinguishing characteristics that are unique to the group. A thorough explanation of these traits is necessary when naming a new species. But although if "species" has a definition, the actual task of identifying species is not made any easier. The cynical definition of a species as a collection of people sufficiently different from other groups to be recognized by taxonomists to be worthy of special rank has resulted from the difficulties in defining species in many instances. Since there is no established criteria to determine this, taxonomists evaluate if they are sufficiently distinct based on the information they have[9], [10].

Typically, a number of characteristics may be used to distinguish between similar plant species. The more probable identification outcomes there are, the more characters and character states are needed for diagnosis. Because of this, it is important to arrange character state comparisons when there are several species to identify so that diagnosis may be made accurately and efficiently. The early techniques of species diagnosis, diagnostic keys, data matrices and online identification tools, computer-assisted plant diagnosis, computer-stored keys, and computer-constructed keys are some of the approaches that may be used to accomplish this process. Because it demands expertise and effort, this approach is time-consuming and challenging. Automatic species identification is now feasible because to the emergence of pervasive technology like mobile computers and digital cameras. The authors suggested that most plant automated identification systems, which concentrate on the characteristics of leaf shape, venation, and texture and are promising for the identification of certain plant species, disregard leaf tooth, a trait often utilized in traditional species identification. As a result, they put forward a unique automated species identification technique that makes scant use of leaf teeth traits.

Traditional identification techniques may vary greatly across individuals of the same species, are often too flexible to be utilized for species-level identification, aren't always accurate, and depend on the plant's developmental stage. As a result, they are not always correct and trustworthy. Therefore, the most appealing method for identifying plant species is to employ molecular methods. The development of several molecular methods that produce molecular markers has made it feasible to distinguish between different plant species with accuracy. These methods vary in their laboratory requirements, costs, levels of variation they can detect, and species-specificity, and they either take advantage of changes at the DNA level or in the proteins that are encoded by it. Therefore, the group of plants under research, the degree of accuracy needed, the facilities available, the expertise and cost all play a role in the method selection. For more accurate findings, each one of these methods may be used alone, or they can be combined.

The discovery and naming of plants have always sparked a lot of curiosity. All plants and, of course, all other species are investigated, characterized, named, and categorized by the scientific discipline known as taxonomy. Plant taxonomy include the description of plant variety, the investigation of the causes and implications of this variation, and the manipulation of the data acquired to create a classification scheme. Taxonomy considerably facilitates the sharing of biological information about plants by making the classification of plants easier. Categorization, nomenclature, and identification are the three main tasks of taxonomy. Historically, plants have been divided into groups using artificial systems based on one or a few easily distinguishable characteristics or by utilizing as many morphological characteristics and general characteristics as possible. However, the lack of experts and the phenotypic instability, which is swiftly altered by outside factors, make the use of conventional classification methods challenging. With the introduction of the fields of phylogenetics, cladistics, and systematics, artificial systems have evolved to a system of modern biological classification based on the evolutionary connections between organisms, both living and extinct. The development of several molecular techniques that result in molecular markers has made it possible to accurately identify plants in terms of plant identification. The ability to sequence DNA has made it possible to determine much more information about a plant's taxonomic position and to precisely identify new species.

CONCLUSION

Systematics and taxonomy are essential tools in the field of biology. While systematics delves more deeply into the complex interactions among species, taxonomy offers the foundation for classifying and disseminating biological knowledge. Together, they aid in our understanding of the planet's astounding variety of life.The need to categorize and order the natural world has spurred the growth of these areas from the dawn of humankind. Modern taxonomy and systematics are still developing, combining state-of-the-art methods like molecular biology to improve our comprehension of evolutionary links. Scientists can examine and catalogue the enormous variety of living forms because to the hierarchical structure of categorization, from kingdoms to species. This organized approach not only supports scientific study but is essential for biodiversity preservation and our attempts to live in harmony with nature. These disciplines are crucial in the effort to solve the riddles of life on Earth because they provide the foundation of our larger knowledge of biology.

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CHAPTER 7

PLANT TAXONOMY: TRACING THE ROOTS OF BOTANICAL CLASSIFICATION

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ABSTRACT:

The history of the ancient discipline of classifying and categorizing plant life, known as plant taxonomy, goes back to the dawn of human civilization. This study sets out on a journey through the history of plant taxonomy, from its modest origins founded in folklore to its contemporary development propelled by cutting-edge scientific methods. Our investigation begins with a look at folk taxonomy, in which early people classed plants according to their practical and therapeutic qualities. As communities developed, a need for a more organized system of plant identification arose. This led to the creation of herbal taxonomy, in which plants were categorized according to their physical traits as well as their applications. We first encountered early taxonomists in the pre-Linnaean period, who were equipped with crude microscopes and excellent observational abilities. Their pioneering work served as the basis for modern taxonomy, which shifted the emphasis from mainly therapeutic uses to a methodical analysis of botanical traits.

KEYWORDS:

Botanical, Genetics, Modern Taxonomy, Plant Taxonomy, Phylogenetic.

INTRODUCTION

One of the oldest disciplines that evolved with human civilisation is taxonomy. Identification, nomenclature, and categorization are all parts of the science of taxonomy. The word "taxonomy" has an organized, systematic meaning in Greek. Taxonomy was not created in a lab by a scientist, inventor, scholar, or philosopher in a specific nation or region; rather, it has been everywhere and for as long as civilization. Taxonomy is a disciplined, civilized science that demands zeal, ardour, sensitivity, untapped knowledge, and endurance. Taxonomy is a complete science in and of itself, encompassing all branches of biology including morphology, phenology, embryology, ecology, reproductive biology, biochemistry, cytology, genetics, as well as other scientific disciplines such as geology, geography, mathematics, statistics, information technology, etc.Plant taxonomy, the ancient science of arranging and classifying plant life, has a history as old as human civilization itself. From the early days of human existence, when our ancestors sought to identify and understand the plants around them, to the modern era of molecular biology and advanced genetic techniques, the field of plant taxonomy has undergone a remarkable evolution[1], [2].

The term "taxonomy" itself, derived from the Greek word's "taxis" (meaning arrangement) and "nomia" (meaning method), reflects the fundamental purpose of this science: to bring order and method to the diverse world of plant species. But plant taxonomy is not merely a branch of biology; it is a comprehensive science that draws upon a multitude of disciplines, from morphology and genetics to geography and information technology. In this exploration of plant taxonomy, we will delve into its historical development, beginning with its roots in folk taxonomy the early human practice of categorizing plants based on utility and medicinal properties. As societies evolved, so did the need for a more structured system of plant identification. This gave rise to herbal taxonomy, where plants were classified not only by their uses but also by their appearances and characteristics. The pre-Linnaean era witnessed the pioneering work of early taxonomists who, armed with rudimentary microscopes and observational skills, laid the foundation for modern taxonomy. The classification of plants transitioned from primarily medical applications to a systematic focus on botanical characteristics[3], [4].

Plant taxonomy is the branch of taxonomy that focuses on the naming and identification of plants. Systematics refers to the identification, proper naming, and classification in accordance with any recognized system. Some botanists believe that the terms taxonomy and systematics are synonymous. The goal of plant taxonomy is to acquire information on the world's plant species and how they might be categorized. Due to the extent of the earth's flora, it is impossible to obtain information without organizing it in a systematic fashion. Making an exhaustive inventory of all the plants in a region, then the whole world, is necessary to achieve the first goal. The initial stage in taxonomy is the collecting and preparation of herbarium for further research. identifying is the second phase, which is carried out via description, the creation of pictures, and the creation of identifying keys. Taxonomy's main goal is to categorize all types of plants, and its secondary goal is to organize them according to recognized categorization schemes.

DISCUSSION

Identifying includes determining the taxon. As being the same as or identical to a recognized taxon are plural taxa. This means classifying a plant into a certain taxonomic category and then to the species thereafter. This may be done with the use of existing literature, such as flora, monographs, and herbaria. When all attempts to link a plant to an already known and identifiable plant are unsuccessful, a new species is created. According to their apparent commonalities, plants are arranged in taxonomic groupings, divisions, classes, orders, families, genus, and species via classification. It involves creating a logical structure of categories, each of which may include any number of species. Any contemporary method of categorization is built on the basic premise that groupings are connected genetically, bringing together closely related groups. Any handy or artificial association may serve as the basis for categorization, in addition to natural features. classified artificially or according to evolutionary relationships phylogenetic grouping[5], [6].

Fundamentals of Taxonomy

The fundamental focus of modern taxonomy is morphological distinctness and affinity, although it is also significantly affected by research from cytologists, geneticists, anatomists, etc. It's a practical science, taxonomy. Principles that have evolved with the rise in plants themselves, beginning with the time of descriptive taxonomy in the nineteenth century, control the function's direction, character, and scope. The majority of taxonomic work throughout the descriptive era and for beginning students of descriptive taxonomy was often based on gross morphological characteristics.

1. Plant connections are based on upstream and downstream genetic lines, which must form the basis of phylogenetic taxonomy. This will naturally develop into a branching structure, not a reticulate one.
2. All of the plant's organs may not undergo evolution at the same time or in the same direction. While one organ may be developing, another may be standing still or regressing.
3. While some evolutionary processes advance, others regress.

4. In general, evolution has been steady, and when a specific advancement or regression has taken hold, it has lasted till the end of the phylum.
5. Generally speaking, structures with more comparable pieces are more basic, while those with fewer parts that are different from one another are more sophisticated.

In any phylum, the chlorophyllous plants come first before the non-chlorophyllous plants. Typically, parasites and saprophytes among lesser plants are descended from independent forms, while saprophytes among blooming plants are descended from independent forms.

The same evolutionary phenomena have often been repeated as separate occurrences in different parts of the plant kingdom i.e., loss of chlorophyll, loss of petals, stamens and carpels; acquisition of fleshy texture in fruits and of various types of thorns, change from simple to compound leaves, from erect to prostrate habit and from hypogynous to perigynous insertion of floral parts, and lateral union (symphysis) of petals, stamens and carpels. It is often ideal to compare the most basic or primitive members of each group, rather than those that are simplified by reduction or those that are most highly specialized, when establishing the degree of connection between two families or other groups.

Broad dicta

1. Evolution sometimes entails deterioration and degeneration rather than continuously moving higher.
2. Generally speaking, heterogeneous structures (with fewer and diverse pieces) are higher than homogeneous structures (with numerous and comparable parts).
3. Not all of the plant's organs are necessary involved in evolution at any one time, and one organ may be progressing while another is regressing.
4. Occasionally, an organ or group of organs may become more complicated, and other times they will become simpler.
5. In general, evolution has been constant, and when a certain advancement or retrogression has begun, it persists till the end of the phylum. Dictionary with particular emphasis on the overall structure of flowering plants

One of the first fields of botany, known as "Folk Taxonomy" before the fourteenth century, plant taxonomy has evolved significantly since then. The classification of helpful plants under folk taxonomy marks the beginning of taxonomy; herbalists distinguished the plants based on their monetary worth. As a result, herbal taxonomy was made possible.

The early taxonomy was driven more by curiosity in medical applications than by systematic ones. The plants are then separated into several groups based on their exterior appearance, such as herbs, shrubs, under shrubs, trees, annuals, biennials, and perennials.

Taxonomy prior to Linnaeus

As long as human civilization and the emergence of language, taxonomy has existed. Knowing the names of practical plants has always been crucial for passing on learned knowledge to other community members. When we refer to ancient taxonomy, we often refer to Western history, beginning with the Romans and Greeks.

But the early indications come from the East, not the West. Westerners did not become aware of Eastern taxonomic studies until the Middle Ages; therefore they were unable to have an impact on the development of Western sciences. Medicines made from minerals, plants, and animals were all included in Divine Husbandman's Materia Medica, a pharmacopoeia. In Egypt about 1500 BC, wall murals depicted therapeutic herbs.

Initial taxonomists

The taxonomy works were sufficiently innovative by the end of the 16th century to take the place of the Greek writings. The invention of lenses, which allowed for comprehensive examination of certain plant structures and was useful in comparative research, was the cause of this. The gathering of specimens was included into taxonomy, shifting the focus away from medicinal to taxonomic considerations.

Biological Phase

With the development of molecular tools, microscopy, cytology, and other sciences, as well as the growth of biosystematics, taxonomy has recently undergone extraordinary transformation. It is a systematics idea that views a species as the outcome of evolution. It takes into account all of the known traits of organisms and all of the available data from various branches of biology. Sir Julian Huxley created the idea of new systematics in 1940. The study of biosystematics is used to find, characterize, identify, categorize, and classify various life forms as well as document their diversity, life cycles, habitats, functions in ecosystems, and spatial and geographical ranges.

Different Classification System Types

Classification is the orderly grouping of a plant or group of plants into discrete groups in accordance with a specific and well-established design and nomenclature system. Classification may be artificial, natural, or phylogenetic (phyletic), which includes phenetic and cladistic, depending on their goals.

Classification Methods

Similar to how words are classified in dictionaries, plants are placed in this categorization in alphabetical (ABC) order. No character was taken into account.The plants were grouped together in this categorization based on a few natural characteristics that could connect them. The following forms of classification may be further broken into. This is more or less arbitrary since the plants are categorized based on one or a small number of characteristics, which don't reveal anything about the affinities or relationships between the plants. The first categorization schemes were artificial, and they predominated from 300 B.C. until about 1830.

Natural categorization system: In this system, the plants are categorized in accordance with their associated characteristics, which include all other significant characteristics except those connected to reproductive organs and structural relationships. It aids us in identifying a plant's name as well as its connections to and affinities with other plants. All of the categorization schemes used today are natural.The phylogenetic method of categorization divides plants into groups based on their genetic and evolutionary connections. It allows us to identify any taxon's ancestors or derivatives. These take the shape of phylogenetic trees or shrubs that demonstrate the groupings' purported evolution[7], [8].

One of the first fields of study among practically all disciplines is taxonomy, which deals with categorization, nomenclature, and identification. Plant taxonomy is the branch of taxonomy that focuses on naming and identifying plants in relation to other organisms. The goal of plant taxonomy is to acquire information on the world's plant species and how they might be categorized. Identification entails determining if a taxon (Plural taxa) is similar to or identical to another taxon. Plants are organized into taxonomic groupings (division, class, order, family, genus, and species) based on their recognized commonalities in classification. The fundamental focus of modern taxonomy is morphological distinctness and affinity, however studies from cytologists, geneticists, anatomists, etc. have a significant impact. Swingle put up 36 evolutionary taxonomy principles, and plant taxonomists have all agreed on them. He developed a technique to assess a plant group's level of primitiveness or evolutionary progress using a series of dicta, or declarations of guiding ideas[9], [10].

Classification is the orderly grouping of a plant or group of plants into discrete groups in accordance with a specific and well-established design and nomenclature system. Classification may be artificial, natural, or phylogenetic (phyletic), which includes phenetic and cladistic, depending on their goals. It is a naturally occurring categorization scheme with a wide range of applications. It is widely used in many nations, including India, for the organization of plant species in the Kew Herbarium. According to the established evolutionary sequence, gymnosperms should not be placed between dicots and monocots.

CONCLUSION

The development of plant taxonomy may be traced back to human curiosity and advancement in science. Plant taxonomy has continually evolved to suit the changing demands of our knowledge of the natural world, starting with the crude folk taxonomy of ancient times and ending with the sophisticated methods of contemporary molecular biology.

The importance of plant taxonomy has never been greater than it is now, when we must urgently address issues like climate change, habitat loss, and the critical need for biodiversity protection. For recognizing and preserving the great variety of plant life on Earth, it is a cornerstone.

The underlying goal of taxonomy, which is to provide us the knowledge we need to grasp, safeguard, and cohabit peacefully with the botanical web that supports life on our planet, has not altered despite the field's continued evolution to include genetic data, ecological insights, and cutting-edge technology.

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CHAPTER 8

EXPLORING PHYTOGEOGRAPHY: UNRAVELING THE EARTH'S BOTANICAL TAPESTRY

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ABSTRACT:

Geobotany, another name for phytogeography, explores the complex global network of plant species distribution. The study of biogeography examines not only the current geographic distribution of plant life but also the historical imprints that it has left on the planet. Records of plant occurrences, from their existence to absence, are mapped onto geographical units, whether they political areas or exact geographic coordinates, and provide the essential data in phytogeography. It includes a thorough understanding of how plants are distributed, from the range of particular species to the larger forces that influence whole plant communities and floras. Understanding the fundamental principles driving the spatial organization of plant species is the ultimate objective of phytogeography, which goes beyond just cataloguing plant species. This study examines the complex field of phytogeography and sheds light on its different aspects, such as the distribution of genetic diversity, historical biogeography, and patterns of distribution of plant species in general. In exploring the many phytogeographical zones, we look for distinctive plant relationships and ecological adaptations that have developed through time. Although phytogeography and zoogeography have some similarities, this article's primary emphasis is on plants. It explores their migratory histories as well as how temperature and geography affect their futures.

KEYWORDS:

Biogeography, Biodiversity, Geobotany, Genetic, Phytogeography.

INTRODUCTION

The branch of biogeography known as phytogeography, often known as geobotany, is focused on the geographic distribution patterns of plant species or, more broadly, plants on Earth. A branch of research known as phytogeography examines the spatial relationships between plants in both the present and the past as well as how those relationships have affected the surface of the world. Observation recordings indicating the presence or absence of a species with operational geographic units, such as political units or geographic coordinates, are the fundamental data components of phytogeography. Phytogeography is concerned with all facets of plant distribution, from the variables governing the makeup of whole communities and floras to the controls on the distribution of individual species ranges at both large and small scales[1], [2].

Recording plant species and, if feasible, explaining their distribution in the area are the two main objectives of phytogeography. Using this information, phytogeographic or floristic provinces and components are often created. In contrast, zoogeography is more focused on the distribution of animals than plants. By itself, the word "phytogeography" indicates a wide definition.

The section on phytogeography contains patterns of general plant species distribution as well as phytogeography, genetic variation distribution, and historical biogeography. Patterns of biodiversity are not well addressed. The extensive area of plant geography includes the study of plant nativity, distribution, adaptation, and relationship. The phytochoria, also known as bio-geographical zones, biomes, and flora provinces, show various plant associations from various angles. The study of the region's phytogeography may shed some insight on the current ecological state of the area since the climatic and edaphic conditions are the main determinants of plant movement. Zoogeography and phytogeography share many of the same topics and methods, although zoogeography is more focused on the distribution of animals than it is of plants. Periodicals that use the word provide insight into how practising scientists really use it. Patterns of biodiversity are not well addressed.

Descriptive (also known as static phytogeography) and interpretive (also known as dynamic phytogeography) are the two main subfields of phytogeography. The real description of floristic or vegetational groupings that may be found across the globe is the focus of descriptive phytogeography. Earlier plant geographers sought to categorize the planet into floristic and botanical zones by describing floras.

The dynamics of plant and animal migration and evolution are the subject of interpretive work. It discusses the causes of the diverse distribution of plant species around the globe. It is a borderline science that involves the synthesis and integration of information and ideas from a number of specialist fields, including palaeontology, genetics, taxonomy, evolution, and ecology[3], [4].

DISCUSSION

The climatic factors dominate in determining plant dispersal. Throughout geological history, temperature variations have had an impact on plant migration. The numerous taxa are divided into the following groups according to the amount of ground surface that the plants occupy:

1. Wides,
2. Endemics.
3. Different species.

Wides refers to plants that are widely dispersed over the globe in distinct climatic zones and the many continents. Endemic to a region refers to a taxon whose range is restricted to that region. A distribution is said to be discontinuous or disjunct when it occurs in two or more locations on different continents or in seas that are hundreds or thousands of kilometres apart. Early in the study of plant geography, broad patterns of plant distribution emerged. Biogeography is the study of how organisms are distributed unevenly around the world. Biologists have been working on this problem for more than 200 years. In a time when we need to be able to forecast how species will respond to anthropogenic environmental change, it is still an important study subject.

However, general biogeographic explanations continue to be problematic due to the intricate interactions between modern ecology, earth history, organismal extinction, and evolution. There is a lengthy history of phytogeography. Alexander von Humboldt, a Prussian naturalist known as the "father of phytogeography," was one of the topic's initial proponents. Modern plant geography has been defined by the quantitative approach to phytogeography that von Humboldt promoted[5], [6].

India's Phytogeographic Regions

Any location's vegetation will vary depending on the temperature, geology, other biotic variables. The vast size of the Indian subcontinent offers a variety of climates and vegetation to match.

1. Western Himalayan range
2. Eastern Himalaya
3. The Indus plain
4. Fourth Gangetic plain
5. Central India

Occidental Himalaya

The tallest Himalayan mountains border India's northern region. Himalaya is a treasure trove of plant variety and riches, making it one of the world's most significant botanical areas. Thus, the Indian Himalayan Region (IHR) may be separated into two main opposing regions: the Western Himalaya and the Eastern Himalaya, based on physiography and flora. Jammu and Kashmir to Uttarakhand make up the Western Himalaya area. True tropical vegetation may be found close to the sea level while moderate arctic flora can be found at higher elevations. Again, based on phytogeography, the Western Himalayan Region (WHR) may be split into western, central, and eastern phytozones. Kashmir, an area of Punjab, Himachal Pradesh, Garhwal, and the Kumaon region of Uttarakhand make up the Western Himalaya.

This region is moist in the outer southern ranges and dries up to produce cold desert in the interior northern region. The Western Himalayan Zone receives 100 to 200 cm of rain on average every year. In contrast to its eastern cousin, the Western Himalayan range is larger and colder, with less precipitation and drier, desert climate conditions. In this area, snowfall happens in the winter. The Western Himalayan range has plants that can withstand cold and drought. Coniferous trees including pine, deodar, fir, spruce, and junipers predominate in the woods[7], [8].

Alpine region

The alpine zone is located above 3000 m asl and continues up to snowline, or around 5000 m asl. Evergreen conifers and a few low, broad-leaved trees make up the vegetation. The cushion habit, diminutive nature, and gregarious tendency of the vegetation in this area define it. Shrubby woods are prevalent in the lower alpine area and may include (a) birch-fir forests, which are rather thick and mix with evergreen shrubby Rhododendron at higher levels, or (b) birch-Rhododendron forests, which are more abundant and include Abies, Betula, Rhododendron, and Juniperus.

The herbaceous species Primula, Polygonum, Gentiana, Cassiope, Meconopsis, Saxifraga, Potentilla, Geranium, Aster, Astragalus, and others that make up alpine meadows are dominant in the higher alpine zone. Snow covers everything year round at a height of around 5000 meters and higher, and plant growth is nearly nonexistent. Snow line or ice line are terms at this elevation. With the rise in altitude, populations of Draba, Braya, Cortia, and Leontopodium continue to grow.

Oriental Himalaya

NEFA (North-East Frontier Agency, presently Arunachal Pradesh), upper Assam, Darjeeling, and the Eastern Himalaya are all connected by Sikkim. This area's vegetation is distinct from that of the Western Himalaya. Eastern Himalaya is a far more diverse region than Western Himalaya because it is characterized by broad-leaf evergreen and semi-deciduous forests. The main variations are the result of altered climatic elements, such as significant monsoon rains, less snowfall, hot temperatures, and humid conditions. One of the world's richest vegetation groups, the eastern Himalayan region has a variety of plant species that are indigenous to other nations, including China, Japan, Myanmar, Malaya, and Europe.

Punjab Plains

A portion of Rajasthan, Delhi, Gujarat, and Punjab are all included in the Indus Plains. Pakistan presently occupies a portion of this plain. The average annual precipitation in this area is less than 70 cm, while in some places it is barely 10-15 cm. The dry, hot summer and dry, cold winter that characterize this region's climate. Almost everything, except developed terrain, has salty soil. Due to prolonged drought, a large portion of the land has turned into a desert. It mostly encompasses the arid regions of Rajasthan and Punjab. There is no irrigation on the property. The majority of the vegetation in this area is xerophytic, consisting of bushy, prickly, and thorny plants.

Ghastly Plains

One of India's most abundant and fertile vegetational regions is the Gangetic Plains. This region stretches from Delhi to the Bengali Sundarbans, travelling through the states of Bihar, Orissa, and Uttar Pradesh. This region has yearly rainfall ranging from 50 cm to 150 cm. Dry deciduous (Scrub), wet deciduous vegetation, and swampy mangroves of the Sunderbans make up the region's vegetation. Because of their comparable types of flora, the Indus and Ganges regions are often referred to as the Indo-Gangetic plain. Upper Gangetic Plain, Lower Gangetic Plain, and Sundarbans are the three divisions of the Gangetic Plain.

Deccan

The whole southern peninsula of India, including Satpura, the southern Godawari River, and the area east of Malabar, is included in the Deccan phytogeographic region. The primary catchment area for many of south India's major rivers, including the Narmada, Tapti, Mahanadi, and Godawari, is the Deccan highlands. About 100 cm of rain falls on average each year in this area. It is where the thorny and degraded shrub areas, as well as deciduous woods, are found. There are a few tiny pockets of evergreen woodland. The zone's northern part is home to the valuable timber-producing species teak (Tectonagrandis) and saal (Shorearobusta), as well as other related trees. The southern part is often drier and is made up mostly of thorny woodlands with affinities to Acacia, Albizia, and Hardwickia. In this area, shrubs including Zizyphus, Bauhinia, Woodfordia, Capparis, Lagerstroemia, etc. are often seen. The following two subdivisions may be made within this region:

This phytogeographical zone, which includes the Brahmputra valley, the Jaintia, Khasi, and Garo hills, the Mishmi hills, a portion of the Himalayas, the Santosh River, the Naga, Cachar, and Mizo hills, as well as the Mizoram, Meghalaya, Nagaland, Manipur, Tripura, and Assam regions, is particularly rich in plant diversity. In India, this area has the most yearly precipitation. One of the rainiest areas on earth, Cherapunji often receives more than 1000 centimetres of yearly precipitation. In this region, lush woods and luxuriant pteridophytic flora have developed due to excessive moisture and high temperatures. This zone is characterized by abundant tall, evergreen angiosperm flora with large leaves and occasional conifers. The area is home to several Ficus, Artocarpus, Sterculia, Michelia, and Morus species. Canes, climbers, and green shrubs are also typical in addition to these bamboos. Alnus and Betula are prominent trees in this zone's northern woodlands. Magnolia, Prunus, Michelia, and Rhododendron. In the Garo hills, saal (Shorearobusta) is also present. In this region, there are several species of ferns and orchids. The tropical insectivorous pitcher plant Nepenthes khasiana is an endangered and native species to this area. The only native Nepenthes species to India is this one. These bay islands are the peaks of underwater mountains. In the seaside area, the climate is humid. Beech woods, semi-evergreen forests, deciduous forests, and mangrove vegetation are all prevalent in the Andaman Islands. Common plants in mangrove vegetation include Rhizophora, Mimusops, Calophyllum, etc.

Tall trees are widespread in the evergreen woods in the interior. The most evergreen woodland is largely characterized by Dipterocarpus. Calophyllum, LagerstroermiaDipterocarpus, and Terminalia are a few notable tree species. A portion is also being farmed. Sugarcane and paddy are significant crops[8], [9].

Endemism

Every natural taxon has a specific natural origin from which it travelled to other locations; this location is known as the taxon's native place. If taxa are discovered outside of their native locations due to human or other activity, they are referred to as imported species. The climatic factors dominate in determining plant dispersal. Throughout geological history, temperature variations have had an impact on plant migration. The numerous taxa are divided into the following groups according to how much of the earth's surface the plants occupy: 1. Wides, 2. 2. Endemics, 3. different species. Endemism is the biological condition of a species that can only be found in a certain area, location, or kind of environment. If a species only occurs there and nowhere else, it is said to be endemic to that place. Endemism, which refers to a species' limited distribution within a specific biogeographic region, a single island, a mountain peak, or even a single rock outcrop, is the origin of a species. A native species may exist in regions other than the one under consideration and is not always endemic. Endemism, from an ecological perspective, refers to a species that is wholly indigenous to the local biota. The great conservation significance of a given biogeographic region is shown by its high nativity and endemism. These two characteristics are crucial for determining the evolutionary history and the conservation significance of any habitat or ecosystem. Due to their extreme sensitivity, endemic species are very susceptible to becoming extinct or becoming endangered.

On the basis of environment, historical events, and genetics alone, it is challenging to explain the emergence of endemic species. As previously mentioned, a high degree of endemism is often associated with an area's age, isolation, and habitat diversification since these characteristics have an impact on both the development of new endemics and the survival or generation of relic endemics. While endemics restricted to a single population may either be paleao or neo-endemic, those with many disjunctive populations are most likely relicts. A primary source for evaluating the state of nativity and endemism may be the floristic description of a specific geographic region, although taxonomic biases and scant and elusive field data pose significant challenges.

A region with unusually high biodiversity and endemic species concentration is known as a biodiversity hotspot. It is characterized by a grave danger from humans to its variety. A technique for locating areas of the globe where conservation funding should be focused in order to alleviate biodiversity loss is the identification of biodiversity hotspots. The phrase "biodiversity hotspot" was first used by British scientist Norman Myers in 1988 to describe a biogeographic area with very high levels of plant endemism and severe habitat loss. Myers later broadened the word to include a larger global reach. Myers' hotspots were adopted by Conservation International (CI) as its institutional model in 1989. In 1999, the organization performed a thorough worldwide evaluation that resulted in the introduction of numerical criteria for the classification of biodiversity hotspots.

The high degree of habitat fragility and high degree of species irreplaceability seen within broad geographic areas account for the biodiversity relevance of hotspots. This indicates that due to their rarity, these places and the animals that live there are both highly threatened and of substantial worldwide worth. Therefore, to stop additional biodiversity loss in these places, activities that take place inside global biodiversity hotspots should adhere to strict biodiversity evaluations. This method uses coarse-scale eco-regions at the global scale, rendering it ineffective for evaluation and decision-making at the site size. In order to pinpoint the precise distribution of biodiversity within these regions, further thorough evaluations are required. Biodiversity hotspots will comprise locations with a high relevance for biodiversity as well as degraded land and urban areas. Areas known as hotspots provide crucial ecological services. Although they only make up 2.3% of the Earth's surface, biodiversity hotspots are thought to provide 35% of the world's ecosystem services. Additionally, 2.08 billion people live in hotspots, contributing significantly to ecosystem services. Many social and/or cultural values are likely to be present in certain regions of biodiversity hotspots since they may contain a variety of human land-uses, both rural and urban, as well as protected areas under a range of different governance systems. This, however, is independent of the region's designation as a biodiversity hotspot. On the basis of scientific evaluations of new locations, fresh biodiversity hotspots are regularly introduced. For instance, the Forests of East Australia were recently classified as a hotspot after study revealed that the region met all Conservation International (CI) requirements. Changes in conditions, such as ongoing habitat loss, fragmentation, or the discovery of new species, may make previously unqualified locations eligible in a later reevaluation of biodiversity hotspots[10].

India's biodiversity hotspots

India, one of the 12 mega-diversity nations in the world, has more than 8% of the world's total biodiversity and occupies 2.4% of the planet's land area. The amount of endemism and species richness seen in a diverse range of taxa of both plants and animals served as the foundation for this designation. Due to the wide range of landforms and climatic circumstances, India has an enormously broad range of habitats, from tropical to temperate, alpine to desert. A very high variety of ecosystems that have been impacted by humans, such as agricultural and grazing areas, and one of the greatest diversity of domesticated plants and animals all contribute to this. One of the eight global locations of genesis for domesticated plants identified by Nikolai Vavilov is India. India, a nation that is mostly agricultural, has a mix of wild and cultivated habitats, which results in a particularly specialized biodiversity that is unique to the meeting point of two or more habitats. The branch of biogeography known as phytogeography, often known as geobotany, is focused on the geographic distribution patterns of plant species or, more broadly, plants on Earth. Phytogeography is concerned with all facets of plant distribution, from the variables governing the makeup of whole communities and floras to the controls on the distribution of individual species ranges at both large and small scales. Recording plant species and, if feasible, explaining their distribution in the area are the two main objectives of phytogeography. The phylogeography, genetic variation distribution, historical biogeography, and general plant species distribution patterns are all included in the phytogeography section. Early on in the study of plant geography, gross patterns of plant distribution emerged.

CONCLUSION

Phytogeography stands out as a crucial thread in the rich fabric of our planet's biodiversity, connecting the tales of plants and their habitats. This investigation has brought us across a variety of plant distribution spheres, from the Himalayas' towering peaks to the Indus River's parched plains, from the Western Ghats' lush vegetation to the Andaman and Nicobar Islands' distinctive ecologies. It has drawn attention to India's extensive variety of plant life, one of the world's mega-diversity nations.The importance of phytogeography goes beyond simple recording since it sheds light on the factors that have impacted the distribution of plant species throughout millennia. We learn about nature's mysteries, including how climate, geology, and biotic interactions choreograph the intricate dance of life, as we analyze the elements determining whether they exist or do not in certain areas. Additionally, this research emphasizes the usefulness of endemic species, those that are peculiar to a certain place, as markers of a region's importance for conservation. By preserving these unique plants, we maintain not just their evolutionary past but also the complicated web of life that they sustain. We need to be mindful of the vulnerability of these ecosystems as we continue to investigate phytogeography. These floral beauties are being threatened by human activities like urbanization and deforestation. Therefore, there has never been a more pressing need for conservation initiatives that are informed by phytogeographic knowledge. We learn more about the natural history of our world and become more conscious of our duty as stewards of this amazing biodiversity as we unravel the Earth's floral tapestry. The field of phytogeography acts as a lighthouse, showing the way to safeguarding the richness of our planet's biological heritage.

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CHAPTER 9

EXPLORING PLANT BIODIVERSITY, CONSERVATION, AND HERITAGE: A JOURNEY THROUGH PHYTOGEOGRAPHY, INVASION, AND PLANT EXPLORATION IN INDIA

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ABSTRACT:

This thorough essay takes readers on an engrossing tour of numerous aspects of plant biodiversity, conservation, and India's rich botanical history. The importance of plant discovery in the past and now is examined, with a focus on how it improves ecosystems and human lives. This article focuses on the contributions made by India to the preservation of germplasm and the advancement of botanical knowledge, from the founding of the National Bureau of Plant Genetic Resources (NBPGR) through the idea of herbaria. The paper also explores the crucial problem of plant invasion, illuminating how non-native plants imperil native ecosystems and biodiversity. The effects of invasive species on the environment, people, and communities are examined, highlighting the critical need for conservation measures. A potent technique for agricultural improvement, plant introduction is also explained, demonstrating how it has changed Indian agriculture through time. It is important to acclimatize plant species to new settings, which is why the techniques involved in plant introduction are outlined.

KEYWORDS:

Conservation, Ecosystems, Plant Biodiversity, Preservation, Plant Genetic.

INTRODUCTION

Exploration is the process of looking for resources with the intention of finding them. When European explorers sailed and mapped a large portion of the rest of the globe for a number of reasons during the age of discovery, it saw its most spectacular rise in human history. The foundation of the plant introduction section in the division of Botany at the Indian Agriculture Research Institute (IARI), New Delhi, marked the beginning of the systematic plant exploration in India in the early 1940s. The National Bureau of Plant Genetic Resources (NBPGR), which supports the preservation of the germplasm collection of various crops, is what finally came from this. Plants are either directly or indirectly a source of food for humans. They supply a variety of essentials for living, including food, clothes, fuel, and shelter.

The practice of gathering and preservation was initiated in order to pass on to the next generation his knowledge and experience about the usefulness of plants. Herbariums were first thought of with this end in mind. The term "herbarium" was first used to describe a collection of dried medicinal plants in a book on medicinal plants. A modern herbarium is a modern filing system for data on plants that is mainly stored in the form of real specimens and secondarily in the form of notes, information, and images that have been recorded[1], [2].

Plant Discovery

One of humankind's oldest past times is the study of plants. Since the beginning of civilization, people have collected novel and practical plants from distant locations. As humans explored new regions and made their homes there, seeds and seedlings were often a part of the family. The native Americans, seed-carrying travellers, immigrants, explorers, and missionaries improved the colonists' diet with foreign grains and plants that had been brought over considerable distances while the early colonists survived on maize, squash, peas, wild fruits, and game. India has a very rich history of biological variety that thrives in every imaginable environment because to its immensely diversified geology, geography, and temperature. People have understood the value of plants from the dawn of time, and they have investigated and categorized them according to their usefulness, such as as food, medicine, or fibre, among others. One of the complementary medicinal disciplines is ayurveda, which heavily relies on herbs. Our earliest texts that discuss medicine and surgery are the Charak Samhita and the Sushrut Samhita.

Invasion of plants

After habitat fragmentation, plant invasion is the danger to biodiversity that is most serious. Any plant, animal, or fungal species that is not native to a certain area is considered to be an invasive species. By taking over a region, wilderness regions, specific habitats, or land along the wild-urban boundary, it might harm the local ecology by displacing natural controls like herbivores or predators.

Impact of the Invasion

Numerous human activities place a lot of stress on native species, disrupt their habitats, and alter how their ecosystems work. Competition from invasive species harms native species. It is possible for species that are closely related to endangered native species to mate with them. The negative impacts of hybridization have caused native species to dwindle and even become extinct.

Personal Effects

A person's performance may be impacted by invaders in a number of ways. For instance, invasive plants may hinder native plants' development and alter their structure by competing with them. Such variations in human development and aging may affect population size and destiny. The relationship between the person and the population may be established using basic life cycle descriptions as the basis for population models.

The ecological variety and population size of native species may be reduced as a result of invasive species. They are the primary cause of extinction after land modification. Through competitive exclusion, niche displacement, or hybridization with closely related native species, invasive species may drive local native species to extinction.

Therefore, in addition to their effects on the economy, alien invasions may also have significant effects on the global distribution, structure, and composition of the biota at the locations of introduction. This will eventually result in the homogeneity of the world's fauna and flora and the loss of biodiversity. Additionally, invaders may interact with habitat change, heightening the danger to biodiversity[3], [4].

Effects on the Population and Community

The loss of native plant species is mostly caused by introduced species, which ranks second after habitat degradation. The effect of invasions may be seen immediately and is easily observable when native species are replaced by non-native ones. The most striking effect of invading species may be extinction. Native species with small populations are most at danger of becoming extinct due to a variety of genetic and demographic factors. Threatened and endangered species are greatly endangered by invaders.

DISCUSSION

One of the most traditional and powerful methods for agricultural improvement is plant introduction. A cultivated species or variety is moved in a controlled manner to a new environment while adhering to the standard processes of assessment, multiplication, and distribution. It also refers to a plant's adaptability to a new environment. Primary introduction refers to the introduction of a plant variety without any changes to its genotype that is subsequently made available for commercial cultivation.

For instance, the Australian wheat cultivar "Ridley" is currently widely farmed in Himachal and Uttarakhand. In India, introduced varieties include the semi-dwarf rice cultivars IR-8 and IR 2, as well as the dwarf wheat cultivars Sonora-64 and Lerma rojo. One of the best methods for improving crops is plant introduction. The process entails the following steps: buying the germplasm, holding it under quarantine, categorizing, evaluating it, multiplying it, and dispersing it.

Purchasing of Plants or Genetic Material

The National Bureau of Plant Genetic Resources (NBPGR) or the International Bureau of Plant Genetic Resources (IBPGR) receive requests for the acquisition of plant material for the introduction of plants or new varieties. The material may be acquired via F.A.O. or directly from friendly nations on an exchange basis. It can also be bought or received as a gift from people or organizations.

Propagule are the plant parts used in that species' reproduction. Depending on the crop species, it might be seeds, tubers, runners, suckers, stolons, bulbs, root cuttings, buds, or seedlings. Depending on the kind, propagules are freed of other weed seeds and pollutants, treated with fungicides, properly packaged, and sent to ensure that they arrive at their destination in good health.

Quarantine

Plant quarantine is defined as "a strict isolation imposed to prevent the spread of disease for ensuring disease and pest-free plants." In the event of plant introduction, the receiving nation screens all propagules for pollutants. Insecticides, fungicides, or nematicides are used to treat the questionable materials before releasing them to the user. Preventing the entry of any pests or pathogens is the main goal of the quarantine procedure[5], [6].

Gardens of Herbaria and Botanical

A herbarium functions as a repository for knowledge on the variety of plants. People with specific collecting licenses gather plant samples from the wild, which are subsequently dried or otherwise conserved. To preserve their lifespan, they are then carefully maintained under archival conditions. To better understand the plants and their environments, these specimens and the information associated with them are conserved.

A collection of preserved plant specimens and related information used for scientific research is called a herbaria, plural of the word "herbarium." The phrase may also be used to describe the structure or space where a collection of preserved plants is kept, inventoried, and organized methodically for study by amateurs, professional taxonomists (scientists who give names to plants), and other botanists.

Herbarium Collections' Value

Herbarium specimens' major significance has historically been tied to taxonomy-related issues. While studying living plants would be ideal, it is also vital to refer to a collection of preserved plants when this is not possible. The herbarium houses a working reference collection used for plant identification, the creation of monographs (descriptions of individual species within a plant group, such as a family), floras (descriptions of all the plants in a nation or area), and the study of plant evolutionary connections. Herbarium collections are now essential for a wide range of studies, such as reconstructing plant phylogeny, invasive species spread and habitat preferences, rare plant population trends, identifying priority sites for conservation, pollination ecology, education, forensic investigations, ethnobotanical investigations, and phenology studies, to name a few. Every plant specimen in a herbarium, which resembles a library or a large catalogue, has its own distinctive information, including where it was discovered, when it blossoms, and what it looks like. DNA may be preserved for a very long time, therefore they can also be utilized to supply samples for scientific study. It is often taken from herbarium specimens and is typically employed for evolutionary investigations[7], [8].

National and international herbaria of note

Currently, there are roughly 3,990 accredited herbaria across the globe, together with over 10,000 curators and biodiversity experts that work there. An estimated 350,000,000 specimens, collected by all herbaria worldwide, represent the earth's 400 years of vegetation. In terms of the global herbaria's collection of more than 3.5 million specimens, which includes more than 23 thousand type specimens, India is ranked 19th.

Essential Indian Herbaria

Botanical Survey of India is in charge of the majority of herbaria in that country. With roughly 2 million plant species, the Central National Herbarium (CNH) is India's oldest herbaria. It is one of the world's biggest herbaria. This herbarium was started by William Roxburgh in 1795 at his office/residence. Roxburgh House is the current name of this structure, which is situated along the Hooghly River. The herbarium was moved to a newly constructed structure in 1883. It houses more than 15,000 type specimens.

Herbaria Preparation and Preservation

The herbaria's amazing and irreplaceable collection of dried, pressed plant specimens and the data that goes with them are invaluable sources of knowledge about plants and the environments they live in. Herbarium records should be properly gathered, produced, stored, and maintained since they provide the comparative information that is necessary for many plant investigations.

Equipment for the Field and Collection

The plant collector needs a variety of devices for the outing. A field book, a pocket lens, a pair of secateurs for cutting woody twigs, a khurpi for digging out subterranean stems and roots, a knife, a pair of forceps, a vasculum for storing the gathered plants and their branches, blotting sheets, and newspapers. It is best to gather the full, healthy representative specimens from almost all natural stages, including both above- and below-ground components. When the plant is in the late blooming stage and has both flowers and immature fruits, a single specimen may be picked. Collection has to come from many ecosystems and locations. Instead of collecting, take pictures of the area's unique and unusual plant species. In certain circumstances, identification of the plant requires the use of its roots and other subsurface components. One should go on excursions multiple times throughout a season to harvest plants.The plant specimens are typically maintained in specially designed herbarium cases after mounting them on herbarium sheets. The mounted plant specimens are kept in wooden or steel cabinets with shelves that are somewhat larger than the size of the herbarium sheets. "Filing the specimen" refers to preserving mounted plant specimens for future documentation[9], [10].

Plantation Gardens

A botanical garden is a space set aside for the collecting, cultivation, and exhibition of a large variety of botanically named plants. It could include collections of specialty plants, including cactus and other succulents, herb gardens, tropical plants, alpine plants, and other unusual species. The world's first botanical garden was established in Padua in 1545; as a result, "botanical gardens are institutions holding documented collections of living plants for the purpose of scientific research, conservation, display, and education. Botanical gardens are important centres for conserving endemic and endangered plant species. An arboretum is a display garden that focuses on woody plants (shrubs and trees); it may be a collection in its own right or part of a larger collection.

Role and Purpose

Many of these activities contribute to ex situ conservation, but botanical gardens also play a significant role in in situ conservation. The following are the main activities that are used for plant conservation:

(A) Plant cultivation in botanical gardens enables the growth of species that may be extinct in the wild, preserving and restoring species diversity.
(B) In order to preserve a live repository of genetic variation that can support several conservation and research initiatives, living collections of plants include species under different groups.
(C) The conservation of plant variety in situ is possible via seed banks and collections of live plants, and botanic gardens are essential to the viability and effectiveness of this method.
(D) Creating a connection between plants and human health while also promoting the preservation of indigenous and local knowledge in order to promote the sustainable use of plant resources for the benefit of all people as a component of sustainable development.
(E) By interacting with a variety of audiences, these gardens assist in raising awareness of the value of plant conservation and in disseminating information about how this might be done.

Education programs can help the public develop greater environmental awareness by helping them understand the meaning and importance of concepts like conservation and sustenance. Botanical gardens provide an excellent medium for communication between the world of botanical science and the general public. In recent years, the focus has been on creating an awareness of the threat to the Earth's ecosystems from human overpopulation and its consequent need for biological and physical resources.

CONCLUSION

Herbaria are collections of plant specimens gathered from all over the world; the plants are organized in herbaria are sequenced in accordance with some known system of classification; it serves as a fundamental source in plant identification and aids in teaching and research;

specimens with a distinctive seal are to be incorporated in the herbarium; accessioned herbarium sheets are sorted out rank-wise; special arrangements should be made with the specimens like type specimens. It also goes into depth on how herbaria and botanical gardens preserve plant variety and aid in scientific study. These organizations act as priceless repositories of plant specimens, advancing research into taxonomy, evolution, and conservation. This article's conclusion highlights the significance of comprehending and protecting India's plant biodiversity. The importance of plant discovery, the difficulties faced by invasive species, the advantages of plant introduction, and the value of herbaria and botanical gardens in preserving our botanical history are all acknowledged. These revelations help us to better understand the natural environment and our need to preserve it for next generations.

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CHAPTER 10

THE FOUNDATIONS OF TAXONOMY: FROM IDENTIFICATION TO HERBARIUMS

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ABSTRACT:

a vital area of biology that deals with identifying, naming, and classifying organisms. The successive steps of taxonomy are examined in this study, starting with identification and ending with nomenclature and classification. Modern taxonomy, in contrast to the classical method, takes into account a wide variety of facts, including as morphology, anatomy, palynology, embryology, cytology, paleobotany, physiology, and ecology. The importance of morphology in taxonomy, which provides the crucial language for describing and categorizing plants and creatures, is emphasized heavily. Since morphological information is so easily available, it serves as the foundation for taxonomy research. The article also discusses how taxonomic tools have developed through time, moving from conventional procedures to cutting-edge ones like phytochemistry, serology, histology, and molecular biology, including DNA barcoding. The importance of herbariums in taxonomy is covered in depth in this article. Herbariums store dried plant specimens, conserving their distinctive qualities for future study and reference. The study goes through several kinds of herbaria, their functions, and how crucial they are to conservation efforts. It also emphasizes the use of herbarium specimens for research, taxonomy, and the study of plant dispersal. This study describes the critical function of taxonomy in the biological sciences as well as the vital techniques and instruments used by taxonomists.

KEYWORDS:

Cytology, Molecular Biology, Morphological, Modern Taxonomist, Taxonomists.

INTRODUCTION

Taxonomy is the science of grouping organisms into different categories on the basis of their gross morphological characters. The grouping, or classification, may be based on homology of various organs. The individuals of the same group must share common morphological features that have been inherited from a common ancestor. The earlier taxonomic work was based on gross morphology of organisms, merely descriptive and has limitations and termed as Alpha taxonomy. Undoubtly gross morphological features have provided the foundation and framework for plant taxonomy as well as other fields of taxonomy. Morphology has been the most widely used taxonomic tool in the field of plant classification from ancient times. Morphological study deals with external structure and form (Morph) of plants, usually its component organs. Morphological features have been extensively studied by classical taxonomists in various ways to classify plants thus it might be said that there is a little scope to learn. Morphological evidences provide the basic tool for plant characterisation, identification and classification. However, morphological characters are easy to observe and do not need any specific instrumentation, thus it seems most frequently used tool in classical taxonomic studies by traditional taxonomists.Morphological features are traditionally used taxonomic tool as evidence at all taxonomic levels, particularly at the specific and generic levels. The gross morphological characters are habit of plant, root and stem habit and structural types, structure of bud, leaf and inflorescence, flower, perianth, androecium, stamen, gynoecium, types of carpel and fusion manner, types of ovules, fruit and seed. Flower modifications and alteration of stamens and attachment manner, position, size and shape of anther, ovary, style, stigma, number of carpels and their manner of fusion, perianth number and their attachment manner etc. contribute to the reproductive success of the species. The habit of plants herb, shrub or tree may be primarily useful in classification. A truly natural classification is to be attained, it must be based upon "the analysis and the harmonization of evidences from all organs, tissues and parts [1], [2].

DISCUSSION

The modern taxonomist has, therefore, must have a broader outlook than his predecessors a few years ago. The validity of relying of such a system of classification which is developed and build up simply on the basis of morphological features only have been criticized and challenged by the thinking botanists.

To study the modern trends in taxonomy we must go through the history of classification and how this branch has developed with the development of peoples, instruments and techniques. We must keep in our minds that taxonomy today is a reflection of the past, meanwhile the systems of classification reflect both needs, level of knowledge, philosophical concepts and available technology of each historical period.Now a day's taxonomy is progressing rapidly and these progresses have been brought about by the research work in various branches of science like optics, microscopy, molecular biology, cytology, cytogenetics, anatomy, embryology, biochemistry, paleobotany, etc. Thus we have entered in new era of taxonomy with major developments of tools and techniques. Modern taxonomists consider that the gross morphological characters are not always sufficient to provide means of differentiation in determining the genetically and evolutionary relationship among organisms. To achieve these taxonomical evidences from anatomy, embryology, palynology, cytology, palaeobotany, biochemistry molecular biology etc. are used as taxonomic tools. One of the most significant modern trends in plant taxonomy is towards a synthesis between the older methods, outlook and more recent developments in our knowledge of plants [3], [4].

Taxonomic Evidences

Embryology

Embryology is the branch of science that deals with the study of sporogenesis, gametogenisis, fertilization, formation of zygote and embryo, development of endosperm finally in the form of seed and its protective covering seed-coats.Recognition of the value of embryology in taxonomy as a taxonomic tool for solving taxonomic problems was delayed because of the time and trouble involved in embryological data collection.

The role of embryology as taxonomic tool in solving taxonomic problems was first brought into prominence by a German embryologist, Embryological characters, have acquired great significance in plant taxonomy, especially when external morphological characters are inconclusive and misleading as a result of convergence. Thus the embryological evidences have been utilized by taxonomist for solving taxonomical problems which are not possible at gross morphological level. Although embryological evidences have its significance almost at all levels, and have helped to resolve thedoubtful and disambiguous systematic positions of several taxa.

The embryological characters have proved to be of significant role in determining relationships within families, genera and species, but less useful at the rank of order, subclass, or class.The embryological characters have been utilized by plant taxonomists in analysis of evolutionary trends, delimitation of taxa and determining of systematic position of taxa, etc. An account of seeds and fruits morphology as important tool in plant taxonomy, especially after the invention of the transmission microscopes which opened new vistas in field of taxonomy.

Ovule

Development and structure of ovule, placentation, vasculature of integuments, and orientation of ovule has proved important, orthotropus ovule has been considered as evolutionary older. Form and extent of the nucleus i.e., whether it is broad and massive crassinucellate or ephemeral tenuinucellate, persistence or gradual disappearance of nucleus. The extent and origin of the sporogenous tissue in ovule i.e., whether single-celled or several-celled, presence or absence of wall layers, type of division of nuclear epidermal cells; mode of mega-sporogenesis, arrangement of megaspores, position of the functional megaspore, and development of embryosac i.e., whether monosporic, bisporic or tetrasporicembryosac and their types; number and distribution of nuclei in embryosac and presence and absence of endosperm; entrance or pathway of pollen tube to the ovule i.e., porogamy, chalazogamy or mesogamy and temporal relationship between pollination and fertilization in addition to formation of seed and seed coat have provided data of taxonomical significance[5], [6].

Endosperm

It consisted of presence and absence and mode of formation i.e., whether nuclear, cellular or helobial type, nature of food reserves; persistence or gradual disappearance of endosperm at the time of maturity in seed; some special cases and abnormalities in development such as apogamy, apospory, diplospory, adventive embryony, polyembryony and parthenogenesis, etc.Majority of angiosperms have anatropous ovule and polygonum type of embryo sac. Another characteristic feature of flowering plants is double fertilization and triple fusion, and post-fertilization development of polyploid endosperm, which also support the probable monophyletic origin of angiosperms.

Further the classification of the Angiosperms into two groups namely, Monocotyledonae and Dictoyledonae is based on cotyledons present singly or in pairs which is the characteristics of embryo. Certain groups have well marked their characteristic embryological features like endospermic or non-endospermic seeds and seeds with small embryo, etc. that can be easily used in identification of members of particular taxa. The delimitation of angiosperms in the first instance has been largely based on embryological characters.

Anatomy

Undoubtly morphology external features provides primary taxonomic evidence but internal structure of plants can provide more information in solving taxonomic problems. Anatomy is the study of internal structure, organization of plant cell and tissues. When morphological characters are solely unable to prove or no help in the preliminary identification of taxa, anatomical evidences may be helpful. Anatomical characters of vegetative and floral parts of plants have been successfully employed in solving angiosperm taxonomic problems and for resolving of phylogenetic relationships among them. Anatomical evidences have proved to be very useful in discerning evolutionary trends and interrelationships of taxa at and above the species level and at higher taxonomic categories.

The most useful evidence is in determining relationship between different genera, families, orders and other taxonomic categories. Thus anatomical studies of flowering plants can serve as an integral part of taxonomy. The application of anatomical data to phylogenetic problem is of great value in elucidating taxonomic relationships. Vegetative anatomy and floral anatomy have been proved useful in resolving controversial systematic position and classification of several taxa. The vascularization of floral parts, nodes, and integuments of seeds also give the clues of affinities[7], [8].

Wood Anatomy

Based on wood anatomy, several taxonomic problems have been resolved successfully. Wood anatomy also provides a phylogenetic tool in determining evolutionary relationship among taxa. Wood anatomy has helped to establish the systematic position of primitive vesselless angiosperms. It is believed that there is a progressive evolution in angiosperms from small tracheids to long narrow vessels with lignified thickening of various types. Wood anatomy reveals that Gnetales are not ancestral to angiosperms and Amentiferae constitute a relatively advanced group.

Nonporous wood is mainly found in gymnosperms thus it makes the characteristic feature of it while porous wood is found in angiosperms thus characteristics for angiosperms. Members of angiosperm families like Winteraeae, Trochodendraceae, Tetracentraceae, etc. show their primitive angiospermic relationship. Magnoliales are considered primitive on the basis of wood anatomy. The first time used anatomical characters in plant classification for the delimitation of taxa of various levels. Bureau's work on the family Bignoniaceae, in which anatomical features were made use of in the diagnosis of the genera. However, Radlkofer's monograph of the Sapindaceous genus Serjauia is really the flrst important contribution towards systematic anatomy, being based on the anatomical examination of numerous specimens of each species and a careful comparison of the relative value of the different features observed.

Floral Anatomy

Floral anatomy proves to be significant taxonomic evidence in identification and classification of angiospermic plants. The role of floral anatomy has been emphasised in solving taxonomic problems. It is also important in understanding the evolutionary relationship thus tracing the phylogeny of angiosperms. The behavior and numerical strength of vascular bundles in floralparts of plant have been utilized in taxonomic study. Once the vascular bundles are formed they become autonomous with regard to their behavior by virtue of their position. Vascular anatomy of floral organs mostly helps in ranking taxa of higher level such as genera and families in taxonomic hierarchy.

Palynology

Palynology is deals with the study of pollen grains (modern and fossil) and spores generally focusing on the wall structure rather than on internal or living features and its applications. The term Pollen is derived from Greek word “palynein” meaning to scatter. Since the first use of the term palynology by Hyde and Williams in 1945, it has emerged as an important discipline of fundamental and applied interests. Pollen grains are often easily disseminated by wind, insect, water etc. and found in everywhere e.g. in rock sediments, glacier ice, air over the poles and oceans. Fossil spores occur in peat and various sediments. Palynology has proved significant in the field of plant taxonomy.

The significance of pollen attributes in taxonomy has been realised during the last few decades with the revolutionary changes in field of microscopy. Now a days, palynological investigations have become a popular tool in plant taxonomy, especially with the invention of the high-resolution power microscopes such as scanning electron microscope and transmission electron microscopes. Outer special covering of pollen is called sporoderm, which provides another important character for consideration. Sporoderm or pollen wall is made up of biologically very resistant substance called sporopollenin. Pollen wall comprises of two layers, the outer is the ektexine/sexine and the inner is endexine/nexine. Ektexine presents various structural and sculptural elements which help in identification, classification, etc. Endexine does not present

Modern Approaches in Taxonomy

Numerical taxonomy or taxometrics/taximetrics is a kind of classification based on numerical comparison of large number of equally weighted characters scored consistently for all groups under consideration and in which individuals are grouped solely on the basis of observable similarities without regard to phylogeny. The criteria of taximetrics are overall morphological, anatomical, physiological or biochemical similarities and dissimilarities. Such classifications came to be known as Adansonian classifications. The numerical taxonomy (or Taxometrics) is defined as a numerical evaluation of the similarity between groups of organisms and the ordering of these groups into higher ranking taxa on the basis of these similarities.

Numerical taxonomy is a classification system deals with the grouping by numerical methods of taxonomic units based on their character states. It aims to create a taxonomy using mathematical or statistical methods like cluster analysis rather than using subjective evaluation of their properties. Numerical taxonomy developed in the late 1950s as part of multivariate analyses and in parallel with the development of computers. Its aim was to devise a consistent set of methods for classification of organisms. A French botanist, first time gave views regarding fundamental position of numerical taxonomy. The views were represented by certain principles. He put forward a plan for assigning numerical values to the similarity between organisms and proposed that equal weightage should be given to all the characters while classifying plants. They divided the field into phenetics in which classifications are formed based on the patterns of overall similarities and cladistics in which classifications are based on the branching patterns (Cladistics) of the estimated evolutionary history of the taxa. Numerical taxonomy or taxometrics/taximetrics, perhaps more appropriately referred to as phenetics, refers to the application of various mathematical procedures to numerically encoded character. In recent years numerical taxonomy and phenetics are considered as synonyms or interchangeable by many authors despite of the distinctions made by those authors[8], [9].

Principles of Numerical Taxonomy

A priori, every character should be given equal weightage in creating natural taxa.The overall similarity between any two entities is a function of the individual similarities in each of the many characters, which are considered for comparison. Distinct taxa can be recognized because correlation of characters differs in the groups of organisms under study. Phylogenetic inferences can be drawn from the taxonomic structure of a group and from character correlations, given some assumptions about evolutionary mechanisms and pathways. The science of taxonomy is viewed and practiced as an empirical science.

Chemotaxonomy

The use of chemicals found in plants naturally as taxonomic tool in plant classification or for solving taxonomic problems is called chemotaxonomy or chemosystematics. Thus in generalchemotaxonomy is use of biochemistry in taxonomic studies. Plants produce several kinds of natural products in varying amounts, and quite often according to their own biosynthetic pathways, these compounds also differ from one taxonomic group to another. The occurrence, distribution and biosynthetic pathways of the various types of chemical compounds present in plants prove to be of taxonomic significance. Chemotaxonomy is the based assumption that similar or related group of plants have similar chemical compounds. Thus plant chemicals play a key role in identification and systematic botany. It gives close relationship between chemical constituents of plants and their taxonomical status.

Taxonomy is the science of grouping organisms into different categories on the basis of their gross morphological characters. Morphology has been the most widely used taxonomic tool in the field of plant classification from ancient times. Morphological evidences provide the basic tool for plant characterisation, identification and classification. The modern taxonomist has, therefore, to have a broader outlook than his predecessor a few years ago. Now a day's taxonomy is progressing rapidly and these progresses have been brought about by the research work in various branches of science like optics, microscopy, molecular biology, cytology, cytogenetics, anatomy, embryology, biochemistry, paleobotany, etc. Morphological features are traditionally used taxonomic tool as evidence at all taxonomic levels, particularly at the specific and generic level. Embryological characters, have acquired great significance in plant taxonomy, especially when external morphological characters are inconclusive and misleading as a result of convergence. The embryological characters have been utilized by plant taxonomists in analysis of evolutionary trends, delimitation of taxa and determining of systematic position of taxa, etc.[10].

Majority of angiosperms have anatropous ovule and Polygonum type of embryo sac. Another characteristic feature of flowering plants is double fertilization and triple fusion, and post-fertilization development of polyploid endosperm, which also support the probable monophyletic origin of angiosperms. Vegetative anatomy and floral anatomy have been proved to resolving controversial systematic position and classification of several taxa. When morphological characters are solely unable to prove or no help in the preliminary identification of taxa, anatomical evidences may be helpful.Stomata are very useful anatomical tool in the field of plant taxonomy for resolving the appropriate position of several taxa.

CONCLUSION

The Fundamental elements of taxonomy, showing the importance of this discipline in biology. We've seen that taxonomy entails a thorough process of identification, naming, and classification, with contemporary taxonomists depending on a broad range of information outside of morphology.

The essay has a strong emphasis on the development of taxonomic tools, illustrating how advances in science and technology have made it feasible to go from crude procedures to sophisticated ones. The tools of the taxonomist's trade have expanded to include phytochemistry, serology, histology, and molecular biology, allowing for more exact and thorough categorization of species. Herbariums, excellent repositories of dried plant specimens, are the subject of a significant chunk of the article. In addition to preserving the history, these collections are essential for comprehending the present and future of plant biodiversity. Herbariums are vital resources for botanists, taxonomists, and scientists all around the globe because they provide a wealth of information for study, conservation, and teaching. This study conclusion highlights the dynamic and ever-changing nature of taxonomy as well as the ongoing significance of herbariums as stewards of botanical knowledge. In the biological sciences, taxonomy still serves as a fundamental subject that connects our knowledge of the natural world's past and present.

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CHAPTER 11

TAXONOMY UNVEILED: FROM NAMING TO HERBARIUMS

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ABSTRACT:

Understanding the natural world relies heavily on the scientific discipline of taxonomy, which encompasses the complex procedures of species name, identification, and classification. This article explains the taxonomy's successive stages, starting with identification and moving on to nomenclature and classification. Modern classification techniques go beyond the limitations of morphology, in contrast to classical taxonomy, and integrate a wide variety of data. Through the rigorous investigation and integration of information acquired from every aspect of organisms, including their behaviours, herbaceous or woody nature, root systems, leaf kinds, floral arrangements, and more, a genuinely holistic classification emerges. The cornerstone of taxonomy is gross morphology, which is supported by insights from anatomy, palynology, embryology, cytology, paleobotany, physiology, and ecology, each of which is discussed in more detail in the sections that follow. The study of an organism's structure and individual organs, or morphology, provides the basic vocabulary for defining, categorizing, and classifying plants. Due of its availability and observability, morphological data is the most frequently used data type in taxonomic research. Herbariums are the only source of morphological data used by taxonomists. The classification of plants based on their development habits and different kinds of root structures is covered in detail in the article, which specifically distinguishes monocots from dicots.

KEYWORDS:

Anatomy, Cytology, Herbarium,Morphological, Physiology, Taxonomic.

INTRODUCTION

The scientific discipline of taxonomy encompasses the naming, identifying, and categorizing of species. As a result, the first step in taxonomy, nomenclature naming, comes after identification. Modern categorization systems are based on a broad range of evidences, as opposed to the classical approach, which is often focused on morphological evidences. A really natural categorization is produced by the analysis and synthesis of data from all organs and parts, including habit, herb, shrub, and tree types, root, stem, and leaf types and arrangements, flower arrangement, inflorescence, etc. Gross morphology serves as the foundation of taxonomy, and it should be supplemented by information from anatomy, palynology, embryology, cytology, paleobotany, physiology, and ecology[1], [2].

The next subsections will cover each component in detail. Morphology is the study of the form and organization of living things, usually an organism and its component organs. Morphological evidence gives us the basic language for classifying, describing, and connecting plants. Morphological data is the most often used kind of data in taxonomic studies since it is easily accessible and observable. Only herbariums are used by taxonomists as a source for morphological information. Plants may be categorized by their growth patterns, such as herbaceous or woody plants. Based on the many root structure types they have, such as tap root systems, fusiform, napiform, and adventitious root systems, plants are categorized into two primary groups termed monocots and dicots. Dicots, which include plants like the bean, pea, and others that have two cotyledons each, may be identified by their tap-root systems. Monocots, which include plants like wheat, rice, and maize, among others, have just one cotyledon, and they are identified by adventitious roots.

Therefore, techniques, procedures, and information that are useful for categorizing and recognizing species are known as taxonomic tools or aids. They are required since almost all branches of biological sciences depend on the taxonomic study of plants, animals, and other species to accurately identify them and understand how they relate to one another. For the purpose of recognizing plants and animals, keys, zoological parks (zoos), herbaria, botanical gardens, museums, and zoos are essential tools. Taxonomists now depend more on modern and sophisticated technologies to assist their job than they did in the past as science and technology develop in every discipline. These include a variety of techniques such as computerized data analysis, numerical taxonomy, histology, cytology, serology, phytochemistry, and many more. The most recent contributions to this list include the GIS Geographical Information System, DNA barcoding and molecular techniques, nucleotide sequencing, etc[3], [4].

Herbarium

In an herbarium, which is a specimen repository, plant specimens are collected from all over the globe, preserved in dried form, and mounted on a standard size of herbarium sheet. Standard herbarium sheets are organized into groups according to any accepted categorization scheme and preserved in pigeon holes underneath distinctive generic covers for future reference and study. Succulent plants, including those in the Cactaceae family, and pulpy fruits lose their distinguishing qualities when dried. Thus, preservatives like 4% formalin solution or F.A.A. (Formalin-acetic acid-alcohol) are used to protect these plants. Many different types of dry fruits are dried and kept in large glass jars, including Lodoiceamaldivica (double coconut), coconut, Oroxylum, stiff gymnosperm cones, and prolonged, sclerenchymatous palm inflorescences, among others. It's an excellent method for categorizing information about plants, both in the form of actual specimens and, to a lesser degree, in the form of written annotations on labels attached to the sheets.

The materials in the herbarium serve as a permanent record of the flora of certain locations, even though the natural topography and vegetation of those areas may have changed or disappeared. The herbarium demonstrates what was formerly present under these circumstances. When it comes to habitat, common name, native location, uses, ecological notes like abundance frequency rarity of the species, associated plants, behaviour, etc., the labels on the herbarium specimens are adequate. These data for the particular species could originate from several collections in various locations, but when carefully inspected and evaluated, they provide helpful details for an essentially complete description of a variety of taxonomic traits, including distribution and morphological range of variation. An herbarium acquires fresh specimens via exchanges, presents from other taxonomists, contributions from its staff, taxonomists, explorers, etc. It is a repository of data and material[4], [5].

Different Herbaria

Herbaria come in a variety of forms depending on the plants they include, how they are used, where they are located, etc. There are different kinds of herbaria depending on the type of holder, such as government organizations, individuals, institutions, universities, and their interest in a particular plant type, such as fungi, algae, angiosperms, herbs, medicinal plants, woody plants, etc. and how they use these plants, such as the following:

1. Regional herbaria
2. Colleges, universities, and other institutions have herbaria.
3. botanical gardens with scented and healing plants.
4. Domesticated plants are housed in herbaria.
5. weeds, plant collections, etc.

Functions of Herbarium

The herbarium's mission is to gather all information on all plants that it may be interested in, including habit, habitat, phenology, distribution, ecology, and uses, in one place. A herbarium may concentrate on a specific area, such as a township, commissionery, district, state, or country, or it may aim to cover the whole continent. It could try to compile all the information on a single taxon, like a species, or on a small group of taxa, like those in a genus or family, or it might try to contain information on all the plant species.

The primary sources used to categorize the world's flora are observations made on herbarium material and associated data. The herbaria are particularly important to conservation groups and have recently become well-known as informational hubs for local, unique, uncommon, and threatened species. An herbarium may be used for a variety of beneficial things, such as the following:

Plant specimen repository

The primary and most important function of an herbarium is to preserve dried plant specimens, guarding against loss and damage while simultaneously preparing them for study. Maintaining type specimens is important for taxon identification, appropriate naming, and the presence of species- or intra-specific-taxons. Type specimens are the specimens that served as the foundation for a taxon's name. These are kept in safe storage at a number of reputed herbaria, sometimes in locations with restricted access. Most herbaria have an extensive collection of plant specimens and provide tools for identification simultaneously and on-site. Researchers may uniquely identify their collected specimens by contrasting them with the suitably categorized herbarium specimens. Herbarium specimens are the "original documents" since they include the necessary information for understanding taxonomy, evolution, and plant distribution. These samples may be used to create manuals, monographs, and floras. Herbarium contents form a significant percentage of floras, manuals, and monographs[6], [7].

Resources for instructing nascent taxonomists, botanists, graduate, and undergraduate students about classification, herbarium, and identification methods. Numerous herbaria now provide tools for planning field trips and even excursions to far-off places. Since big herbaria have collections from several locations throughout the world together with their characteristics, examining the herbarium specimens may offer information on the geographical distribution and range of distribution. Voucher specimens are samples that botanists, scientists, and other naturalists have collected and on which a particular study project has been conducted.

These are then stored in various herbaria and give information for further studies. Graduate and post-graduate students studying botany utilize the herbarium as a resource for research and instruction. When teaching a course when access to new material is limited, a teacher may include herbarium specimens into their lesson plan. In addition to serving as a source of information, it is essential for biosystematic research, namely for precise naming and identification. It provides research resources for anatomical, paleontological, and chemotaxonomical inquiries.

DISCUSSION

It supports research and could be examined to verify the identity of the specific plant used in a study. A reliable herbarium committed to long-term preservation must receive a voucher specimen. For further information about herbaria, see "Herbaria and Herbarium Specimens" in our online publication. Why is content for vouchers necessary? Plant classification is always changing. Species groupings and alignments evolve in response to new information becoming available. The names might undergo changes. Voucher specimens make it simpler to compare these modifications with past investigations. In essence, a herbarium is a collection of botanical specimens that have been arranged in accordance with a recognized classification scheme and are prepared for use in research or other scientific activities. After being mounted and kept in the herbarium, the collections are referred to as herbarium specimens. The fact that these herbarium specimens may be preserved for an extended period of time makes them valuable as a history collection, a reference collection for verifying the identity of freshly acquired plants, a teaching tool, and a source of research material. The cornerstone for taxonomic research is the herbarium, a well-known collection of protected plants.

Drying organic

Pressed plant specimens are difficult to dry and take a long time, especially in humid and rainy locations. The majority of the time, specimens are dried naturally by constantly changing blotting sheets, while artificial heat may also be used sometimes. It might take weeks or even months to dry completely. Plants that have just been picked are placed in a press without corrugated sheets and locked for four hours. During this sweating period, plants lose some moisture, become flaccid, and are more easily moved. The folded sheet holding the specimen is lifted and placed into a fresh, dry, folded blotter. The newspaper must be switched out periodically, and the plant must be carefully shifted from one newspaper to another. Blotters shouldn't be utilized in this scenario, especially after one or two revisions. Newspaper sheets are replaced every 4 to 8 hours at initially, then every few days, progressively extending the interval between changes until the specimens are fully dried. The duration of the whole drying process might range from 10 days to a month, depending on the specimens and the surrounding climate. Between two wooden plant press frames, all of these blotters and newspapers are packed, and two straps hold them all in place[8], [9].

Drying Using Artificial Heat

Drying with artificial heat assistance might take anywhere from 12 to 2 days. Following the initial sweating in the field press, the specimens are transferred to a drying press in a plentiful supply of corrugated sheets, often one alternate per folded blotter holding one specimen. The dryer—a cabinet in which a heat lamp, dry hot air blower, or electric bulb warms the air—is used to maintain the press. It dries the specimens by moving them across corrugated surfaces. Quicker drying results from accelerating the hot air's circulation within the cabinet using a hot air blower. Only so soon may specimens be dried using artificial heat before the plants become brittle, lose their structure, and lose some of their leaf colour.

The dried specimens are put on herbarium sheets of the standard size (42 x 29 cm). Items are mounted with saree glue, fevicol, fixatives, adhesive, or cello tape. Cones, seeds, and other bulky plant pieces are among the major plant components that are dried without pressing and packed into small envelopes called fragment packs. Instead of being put on herbarium sheets, succulent plants are collected in 4% formalin or FAA (Formalin Acetic Acid and Alcohol). Liquid paste or glue is used to connect the majority of contemporary specimens. With the exception of situations when strapping is the only operation, most specimens are strapped after being glued in some form, whether it be with linen tape, liquid plastic, white glue, or sewing with strong linen thread. Only heavy stems, overlapping leaves, rhizomes, tangled grass roots, enormous fruits, cones, or other surfaces where using glue or plastic would be difficult or uncomfortable are allowed to be sewn. To hide the threads on the back of the sheets, use linen or paper tape.

Labelling

A label is either printed or adhered to the bottom right corner. All relevant information about the plant, such as its location, altitude, habits, date of collection, collector's name, common name, complete scientific name, applications, and any further remarks, should be included on the label. Although any size may be used for herbarium labels, a size of 4 by 6 inches (10 to 15 cm) is recommended. After being correctly dried, pressed, and identified, plant specimens are then organized according to any accepted system of classification into the appropriate herbarium pigeon-holes using thin paper folders called "specimen covers" and thicker paper folders called "genus covers." Bentham and Hooker's categorizing system is used in India.

No matter how many plant species are found in a certain area, all plant species together are referred to as flora. In general, flora is a list of all plant species that may be present in a given location and is unrelated to how numerous any particular species may be. Flora's plant descriptions are organized using any accepted system of classification. Flora is the name given to the systematic study of plants.

The Latin word for "flower" is the root of the English term "flora," which refers to the fertility goddess of spring and blooming plants in Roman mythology, particularly wild blooms and non-cultivated plants. In a nutshell, "Flora is a systematic account of plant species present in a given geographic area at a particular time and provides keys and descriptions of plants for identification." Nearly all visible living creatures are referred to as "flora and fauna," often known as "biota." Flora mostly helps in species identification. It also provides details on the description, geographic range, and common name of a certain plant. The flora is a list of the local plants that contains their names, descriptions, and other details. A study in floristics is the term used to describe an investigation of the plants. The book Flora includes illustrative keys to help readers identify the many plants. An identification key, also known as a taxonomy key, is a useful tool for classifying unidentified plants.

The design of keys guarantees that the user receives important information in a structured manner. This allows the user to skip through the many species that lack certain traits and is designed to help them arrive at a correct identification in the fewest number of steps. Because of this, taxonomic keys are useful resources for pointing scholars toward the taxon's accepted name. However, not all taxonomic keys are created equal. They are often created for a certain plant species or environment.

Histological Techniques

Plant histology, or more precisely, plant anatomy, is the study of the composition and structure of plant tissues, notably those of wood and flowers, in relation to their distinctive functions. Histology's objective is to comprehend how tissues are organized at all structural levels, from cells and intercellular components to organs. Realistic interpretations of the morphology, physiology, and phylogeny of the structure of cells and tissues are provided. Thus, histology provides the most significant data for addressing the phylogenetic problems of plant species. The subject was discussed during the VIIIth International Botanical Congress (IBC), which took place in Paris, France, in 1954. A variety of techniques are needed to histologically analyze plants and their distinctive tissues. Only taxonomists employ histology instruments since it takes a lot of effort, talent, and time to use them properly. Various fixatives, the use of a microtome to create thin sections, staining, microscopy (light, fluorescence, and electron microscopy), and X-ray diffraction techniques are some of the methods used to complete this work. Phylogenetic classification, however, may benefit from the development of tools like improved microscopy, microtomy, and computerized equipment[10].

Cytological Techniques

Cytogenetics is a branch of biology that combines cytology with genetics. In-depth examinations of chromosomes and their behaviour are used by the systematic botany discipline of cyto-taxonomy to categorize and link plants to one another. The characteristics of chromosomes—their number/ploidy level, structure, and behavior—have a significant impact on taxonomy since they are the most often used and referenced trait in botany. The majority of chromosome counts are formed during metaphase and are expressed as the diploid number (2n) for somatic cells and the haploid number (n) for gametes. A key taxonomic characteristic is where the centromere is located on the chromosomes. Cytological proof is more crucial than other taxonomic evidence.

Chemical Plant Methods

Phytochemistry, sometimes referred to as chemotaxonomy, chemosystematics, or chemical plant taxonomy, is a taxonomic approach that uses the chemical properties of plants to categorize and resolve taxonomic problems. Chemotaxonomy is based on the idea that groupings of related or comparable plants share chemical properties. Phytochemistry is essential for plant identification and systematic botany. It illustrates the close relationship between a plant's chemical composition and taxonomic status. All living organisms generate secondary metabolites, which are created from primary metabolites. Secondary metabolites are useful for classification because their chemical structures and biosynthetic mechanisms are often specific to taxonomically related organisms. This categorizing technique is regarded to be better than the previous way because of how straightforward the working approach is. The chemical characteristics of plants will in the future provide the most contribution to our understanding of plant taxonomy. The best resource for man in his search for novel industrial and medicinal plants will be plant taxonomy. Lichenologists disagree, nevertheless, since certain lichens with the same shape but different chemical properties are referred classified as "chemical strains" rather than distinct species. Chemicals may be divided into three main groups according to chemotaxonomy: primary metabolites, secondary metabolites, and semantides. The term "primary metabolites" refers to the compounds that take part in the fundamental metabolic processes. Due to their widespread occurrence in nature, these compounds only have a little role to play in chemotaxonomy. However, these substances might sometimes be useful chemotaxonomic tools depending on their abundance. Since it is present there, sedoheptulose, for example, may be utilized to distinguish between species of the Sedum genus.

Serological Techniques

Serology is a branch of biology that focuses on the nature and interactions between antibodies and antigenic materials. Antigen is the substance that may cause the production of an antibody, and antibody is the highly specific protein molecule that is created by plasma cells in the immune system in response to the antigen. An organism produces antibodies in the blood (antiserum) in response to foreign cells or particles (antigens), which is known as "the study of the origins and properties of antisera." The most often used proteins as antigens in sero-taxonomy are those that provide crucial taxonomic information and are easy to handle.

Both structural and reserve proteins may be used to compare proteins in the field of systematics as long as they all originate from the same group and organs. The best proteins for taxonomic research are often pollen and storage proteins. As efficient antigenic materials for systematic investigation, stem tubers, algal cells, fern spores, fruits, and leaves are also acceptable.

Phyto-serology, which investigates the immunochemical interactions between serum antibodies and antigens, has also established itself as a credible method in systematics since it assists in the finding of homologous proteins. It takes use of the unique traits of animal-produced antisera against plant proteins to investigate plant linkages. Sero-taxonomy developed and became well-known in Germany, a country that has long served as a centre. Nuttal was a pioneer in the systematic comparison of the immunochemical specificity of serum proteins. Kowarski, Bertarelli, and Magnus were three additional early prominent serologists who examined proteins from various grass and legume species to point out similarities and differences. Serology in Germany suffered as a result of this conflict. Otto Moritz gave plant serology a key jumpstart in the 1950s, and it is now accepted as a valid method in systematics. The sero-taxonomy method involves injecting a crude protein (antigen) extract of a particular plant into the bloodstream of an experimental animal, often a rabbit or rat, in order to stimulate the production of antibodies. In reaction to the injected antigen, a specific antibody is produced in the animal's blood. Following isolation, the antigen-reactive serum is made to interact in vitro with both the antigenic proteins and proteins from other closely related taxa, the affinities of which are still up for discussion. Serological interactions between antibody and antigen result in precipitate production. Protein homology, which is utilized as a phylogenetic tool and taxonomy trait, is influenced by precipitation amounts. By using crude plant protein extracts in serological research, the taxonomy of some higher-level taxa has been resolved, and phylogenetic relationships have been determined.

CONCLUSION

The essay also presents the critical idea of taxonomic tools and aids, which includes methods, processes, and information essential for classifying and identifying species. Modern taxonomists increasingly use cutting-edge technologies including computerized data analysis, numerical taxonomy, histology, serology, cytology, phytochemistry, and more in an age characterized by technological development. Geographic Information Systems (GIS), DNA barcoding, molecular methods, and nucleotide sequencing are recent contributions to this toolbox.The dominant topic is the herbarium, a treasure trove of botanical specimens that have been painstakingly gathered, conserved in dry state, and mounted on uniform sheets. These herbarium sheets are a dependable source for reference and study since they are neatly arranged in pigeon holes, protected by recognizable generic covers. The essay emphasizes the critical function of herbaria in recording plant variety, safeguarding important information for the future, and supporting taxonomy research.Herbaria are seen in a variety of settings, including government agencies, private persons, institutions, universities, and more. Each is designed for a particular plant kind and style of use. The article explains the many roles that herbariums play, from the preservation of specimens to aiding in taxonomic study, instruction, and conservation initiatives. Finally, "Taxonomy Unveiled: From Naming to Herbariums" explores the complex world of taxonomy, tracing its roots from fundamental ideas to the vital tools and resources that help us comprehend life on Earth. While highlighting the herbariums' historic relevance as the keepers of botanical knowledge and biodiversity record, it emphasizes the dynamic nature of taxonomy and how it is developing with the incorporation of cutting-edge technology.

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CHAPTER 12

BOTANICAL GARDENS: CATALYSTS FOR SCIENTIFIC RESEARCH, CONSERVATION, AND PUBLIC ENGAGEMENT

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ABSTRACT:

The importance of botanical gardens in scientific study, plant protection, teaching, and public outreach makes them multifunctional organizations. These gardens become essential hubs for integrated plant conservation methods, especially for endangered species, in light of the alarming pace at which plant species are disappearing as a result of diverse human activities. This minireview provides a thorough overview of the duties and operations carried out by Kunming Botanical Garden (KBG), illuminating the global network of botanical gardens. Modern botanical gardens have developed into hubs of scientific inquiry, providing a variety of chances for researchers from other fields. Botanical gardens serve as research centres for taxonomic and systematic studies as well as plant ecology, phenology, physiology, and plant-animal interactions. We now have a far better grasp of how plant species adapt to shifting climatic circumstances because to recent study conducted in these gardens. Botanical gardens are a useful resource for ex situ conservation initiatives in addition to scientific study. Many of the plant species in their live plant collections are in risk of extinction in the wild. In order to build ex situ collections and protect the genetic variety of these threatened plants, botanical gardens place a high priority on the cultivation and upkeep of these species.

KEYWORDS:

Botanical Gardens,Conservation, Horticulture, Physiology, Plant Ecology.

INTRDOCTION

Conservation, propagation, horticulture, seed research, taxonomy, systematics, genetics, biotechnology, education, restoration ecology, public education, and other scientific activities are often carried out by botanical gardens. An unprecedented pace of plant variety loss is now occurring, which has a negative impact on ecosystem services. A third of the 300,000–450,000 species of vascular plants on the planet are currently in danger of going extinct because of a number of destructive human activities, such as overharvesting, overexploitation through destructive agricultural and forestry practices, urbanization, environmental pollution, land-use changes, exotic invasive species, and global climate change. Therefore, there is a greater need to create integrated conservation strategies for plants, especially for those plant species that are endangered in the wild.Botanical gardens are involved in citizen science and public outreach[1], [2].

These organizations actively include the public in scientific research, promoting a stronger connection between people and the natural world. Initiatives in citizen science, carried out in conjunction with volunteers, enable anyone to take part in efforts to monitor and conserve biodiversity. By educating the public about environmental concerns via outreach and education initiatives, botanical gardens want to change attitudes and instill a feeling of responsibility for the environment.We present the scientific research, in-situ conservation and use, citizen science, teaching, and public outreach happening at Kunming Botanical Garden in this minireview. Furthermore, we explain the upcoming problems and obligations these gardens face in order to illustrate the interconnected activities of botanical gardens across the globe. Modern botanical gardens play an essential role in educating the public, raising awareness, and increasing capacity while engaging both employees and visitors. These activities provide exceptional chances for gardening, conservation biology, and study on plant biodiversity in well-known public areas. It could be enough to increase people's knowledge of the environmental issues we face to affect fundamental behavioural shifts. Last but not least, we also wish to highlight particular efforts done at KBG to mark its 80th anniversary[3], [4].

The Roles That Botanical Gardens Play

Numerous scientific disciplines may benefit from using botanical gardens as study sites. In addition to acting as taxonomic and systematic research hubs, botanical gardens are crucial for gathering data on plant ecology, including phenological indicators of climate change, plant physiology and growth strategies, and interactions between plants and animals. Botanical gardens may provide a vast variety of species for the study of functional trade-offs between species features and plant performance. According to Cao et al.'s investigation of bamboos in the Xishuangbanna Tropical Botanical Garden in Yunnan, China, grasses' roots determine their maximum height. One of the most sensitive indications of how the climate is affecting the vegetation in mid-latitude zones is the monitoring of plant phenology variants, which has a long heritage in certain gardens. In truth, botanical gardens have made significant contributions to our knowledge of how different plant species are adjusting to the changing environment.

Additionally, botanical gardens are good sites for research on the ecology of pollination, the dispersal of seeds, and other plant-animal interactions. For instance, researchers were able to propose that any process for the conservation of these Chinese yews should include not only conservation of the trees but also conservation of these tree's avian dispersers and habitats for seed germination and seedling growth. This was made possible through the study of seed dispersal in an endangered species, Taxus chinensis, in an ex-situ conservation population introduced into the Nanjing Botanical Garden in the 1950s. Conservationists have been advised by research at botanical gardens to consider the possible dangers of hybridization in ex situ collections of vulnerable plant species. Open-pollinated seeds or seedlings may get contaminated by spontaneous hybridization in ex situ facilities, which has been demonstrated to compromise the genetic integrity of ex situ collections. Pollination ecology, comprising the breeding system, efficient pollinators, and other characteristics, should be carefully documented and monitored in order to successfully maintain and manage the ex-situ population of endangered species in botanical gardens. Moreover, the effectiveness of alien plants being successfully naturalized in botanical gardens is correlated with the richness of native pollinators. Additionally, the variety of native pollinators is linked to the success of alien species' attempt to become naturalized in botanical gardens[5], [6].

Plant conservation genetics offers practical methods to direct preservation and effective restoration, assess and track processes, and eventually reduce the danger of extinction of vulnerable plant species in the wild. Conservation genetics has mostly concentrated over the last several decades on the genetic effects of limited population size that may restrict the survival of populations and species.

The long-term survival of rare and common species, however, is under danger from genetic degradation, according to recent analyses on the genetic elements of plant conservation. It is widely agreed that in order to create a genetically representative ex situ collection, 50 populations of each species must be collected, with 50 individuals in each group. It is impossible to adhere to these regulations for particularly rare tree species that have already seen their natural population dwindle to a small number of individuals. The only hope to prevent the species from becoming extinct in the wild may be to cultivate it and create ex situ collections, which should be a top priority.

DISCUSSION

The primary contribution of botanical gardens is their living plant collections, which include more than 80,000 species and 6.13 million accessions, according to Botanical Gardens Conservation International. Our knowledge of endangered species has been tremendously aided by the long history of the protection of live plants in botanical gardens, particularly of species that are vulnerable in the wild. Ex situ conservation is defined by the Convention on Biological Diversity as the preservation of biological diversity components away from their native settings. Ex situ preservation, which is crucial for preserving endangered plant species, is often connected to botanical gardens. To construct and maintain plant stocks for ex situ conservation and sustainable use of the world's plant resources, as well as to create and support collections of native species, is one of botanical gardens' core goals[7], [8].

Identification and management of threats, long-term ex situ and/or in situ germplasm storage, management of research and development information, horticulture and living collections, conservation priorities, and environmental education comprise the fundamental framework for integrated plant species conservation in a botanical garden. Rare plant species are often grown in botanical gardens for the aim of ex situ conservation. About 20,000 vascular plant species, or 90% of all plant species maintained by all Chinese botanical gardens, have been gathered for conservation by the botanical gardens of the Chinese Academy of Sciences as of 2013. This reveals that CAS has preserved at least 60% of China's natural flora and given China a significant plant resource reserve for long-term economic growth. Incorporating the study and preservation of tree species that are threatened in the wild is another excellent use of botanical gardens. Ex situ seed conservation is thought to be as inexpensive as 1% of in situ conservation as a kind of insurance against extinction.

There are several methods for preserving live plants in different garden collections. It is difficult to determine an ex-situ collection's conservation value directly. For ex situ botanical populations of endangered species, it is crucial to comprehend efficient sampling structures that enable the acquisition of large diversity for live plant conservation collections. Many new species are grown in botanical gardens;however, the majority of these taxa are only found in a few collections and are typically only found in tiny populations with insufficient genetic diversity. In tiny populations, there is little genetic exchange, and stochastic processes leave them vulnerable to genetic influences that are harmful. Therefore, for the protection of specific plant species in their natural habitats, both in situ ecosystem management and in situ conservation play crucial roles. Because there are more native species present there, for instance, Xishuangbanna Tropical Botanical Garden plays a key role in conservation. With live collections, the botanical garden protects more than 10,000 plant species. Of course, contemporary botanical gardens should not overlook the traditional roles of a botanical garden, namely the development and use of plant resources.

Citizens' science and outreach

Botanical gardens across the world have many goals, including public education and garden displays, in addition to scientific pursuits like conservation and research. The practice of citizen science, in which everyday people participate in scientific study, has long been connected to botanical gardens. Modern citizen science now emphasizes "citizens as scientists" rather than "scientists using citizens as data collectors." In order to improve their capacity to monitor and manage natural resources, identify at-risk species, and safeguard natural conservation areas, decision-makers and NGOs are increasing the use of volunteers. For instance, volunteers were able to provide evidence of substantial losses in monarch butterfly populations in western North America during the previous 36 years. Investigating the spread of invasive plant species by locals via a citizen science program may increase awareness and lead to a change in behaviour. In reality, planning and carrying out public data-collection initiatives often results in scientific and educational outputs including biological research, biodiversity monitoring, and science teaching.

Cooperation between academic researchers and unpaid volunteers from the community has the potential to broaden the focus of study and improve the capacity for data collection. Local residents are more likely to provide useful information since they are better familiar with their areas. Collection-based botanical gardens display plant species and, as a result, have a unique relationship with the natural world. Studies on demography, reproduction, and ecological and genetic responses to habitat fragmentation are among the citizen science programs at botanical gardens. Environmental education or citizen science may influence people's knowledge, attitudes, and beliefs, claims new research on the connections between climate change and the purposes of botanical gardens. For instance, citizen scientists were able to assist kids in the transition from seeing the natural world to scientifically studying nature by doing pollination in botanical gardens.

Various human endeavours, including horticultural hybrid processes in botanical gardens and in situ/ex situ conservation trials, are reuniting formerly disparate populations and species. However, the resulting artificial gene flow might cause outbreeding depression, which would eventually result in the decline or extinction of plant species. Indeed, outbreeding depression has been linked to deleterious impacts on population persistence in recent research. Therefore, it is important to take precautions to prevent inbreeding and outbreeding in accessions produced in botanical gardens. Botanical gardens work to advance the knowledge of, interest in, and preservation of the variety of plant species. The species richness of botanical gardens themselves, however, has not been the subject of many investigations. The live exhibits of the world's botanical gardens, according to Pautasso and Parmentier, are unrelated to patterns of species-richness seen in natural ecosystems. The authors urge more funding for scientists in impoverished nations and botanical gardens in areas with a wide variety of plants. In order to track changing environmental elements in gardens, botanical gardens should also play important roles in the creation of plant information databases. Managers of various botanical gardens need faster access to information on plant variety. Conservation horticulture research is specifically designed for employees at botanical gardens. Horticultural activities are significant aspects of in situ and/or ex situ plant conservation in botanical gardens. However, many studies have disregarded the beneficial impact that botanical garden horticulture had on plant conservation in previous decades. Therefore, we recommend that horticulturists at botanical gardens work together with specialists in taxonomy, genetics, systematics, and environmental education[9], [10].

The personnel of these scientific centres should make use of their significant field expertise and knowledge to undertake these evaluations since they are essential to the effectiveness of conservation in botanical gardens. Otherwise, it may be difficult to accomplish the goals of scientifically conserving endangered plant species. Given the large visitor traffic on-site and online, citizen science offers a unique potential for botanical gardens. However, while designing a citizen science program, any conflicts between scientific research, educational activities, and participants' motivations should be taken into account. The following fundamental guidelines should be followed by citizen science initiatives carried out in botanical gardens: data gathered from the general public must be corrected by various specialists; data gathering techniques must be standardized; and volunteers must get feedback for their contribution to the botanical gardens.

Botanical gardens are excellent places to study plant variety and resource use. However, studies carried out in botanical gardens are often disregarded in mainstream plant science. Botanical garden researchers don't often get to positions of leadership in the field of plant science. It is necessary to perform capacity development and training initiatives to prepare future horticulturists and botanists in botanical gardens. Finally, given that we are now in the Anthropocene, it is important to debate the idea of "new conservation," and post-GSPC 2018 research possibilities in botanical gardens may potentially arise as a result of new technology. Having an extensive collection strategy for live collections is essential for a scientific botanical garden that places a strong emphasis on research and conservation. This would take into account things like plants having a natural origin, representative populations, suitable sample sizes, clear documentation of the collection's provenance and other information, and collections that are directly related to the planning of botanical projects. Chinese botanical gardens should 1) build specialized gardens and encourage research linked to those gardens, 2) enhance and create facilities for research that depends on molecular biology, and 3) build digital botanical gardens in order to boost capacity and scientific research.

CONCLUSION

Botanical gardens are amazing institutions that act as dynamic catalysts for public involvement, scientific inquiry, and conservation activities. These diverse plant sanctuaries are essential for tackling the urgent problems that our world confronts, notably in the area of plant biodiversity.

The botanical gardens serve as a fruitful environment for a variety of scientific fields by conducting research that crosses conventional boundaries. These gardens enable the research of the complex connections between plants and their surroundings, from taxonomic studies to inquiries into plant ecology, physiology, and interactions with the environment. Botanical gardens provide crucial insights into how plant species adapt and flourish as humans struggle with the difficulties of a changing climate and shifting ecosystems. As botanical gardens create living collections that hold rare and endangered plant species and act as genetic storage facilities for the preservation of biodiversity, conservation takes the stage. Ex situ conservation efforts are used to protect the genetic variety of species that are in danger of becoming extinct and are governed by international agreements. These gardens provide hope for the survival of our planet's flora by acting as fortresses against the flow of extinction. Additionally, botanical gardens are not only seen in academic settings. They broaden their audience by acting as ambassadors for education and environmental awareness. Visitors may actively participate in scientific research and contribute to biodiversity monitoring and our knowledge of the natural world via citizen science programs. Public engagement and education initiatives provide a greater understanding of the environment, encouraging behavioural changes and a feeling of shared responsibility for our world. The collaborative nature of botanical gardens is an example of how science, conservation, and education can work together to create a more sustainable and peaceful future for all species on Earth. Our appreciation, protection, and celebration of the great variety of plant life that supports our world are motivated by their lasting legacy.

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