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THE GENUS : A NATURAL OR ARBITRARY ENTITY

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Abstract

Category is an abstract term that simply represents a rank or level in classification. The taxon represents real biological objects and is assigned to a category. In the Linnaean system, taxon names are assigned categorical levels, where the category is a measure of rank, like species, genus, family, order, class and so on. The genus is an essential, uninominal, monophyletic and natural category, which include species cluster of distinct boundary. In this paper, we will present a general review and application of various aspects of genus including basic concept, circumscription, remodelling and importance of monotypic genera.

Key words : Category, genus, monophyletic, circumscription, remodelling, monotypic.

Introduction

One should never quarrel about words and never get involved in questions of terminology. One should always keep away from discussing concepts (Popper, 1972). French botanist, Joseph Pitton de Tournefort (1656–1708) is considered "the founder of the modern concept of genera or father of generic concept''. Tournefort (1700) attempted to make informal groups of genera with some similar characters and tried to describe them. The concept of the genus is probably the oldest among all taxonomic categories and perhaps the oldest one recognized by mankind. The genus is useful to modern-day scientists as well, as the category on which many paleontological and biological macroevolutionary and systematic studies are based. The genera plantarum (1734) listed and briefly described the plant genera recognized by Linnaeus. This work has carried forward the work of Bauhin and Tournefort in giving prominence to the rank of genus. There are about 10 editions of genera plantarum (containing 1105 genera) with taxonomically important fifth edition (1754), which is still recognized by botanical code of nomenclature together with Species Plantarum (1753) containing 7700 species. Linnaeus produced sixth edition of genera plantarum in 1764, which is to be regarded as associated with the second edition of species plantarum just as the fifth edition was with the first edition of the latter. Many editions of genera plantarum came after the death of Linnaeus (Stace, 1989).

If binomial become a system of hyphenated uninomial (Cain, 1959; Michener, 1963, 1964), then botanical name of *Mangifera indica* will become *Mangifera-indica*. If hyphenated uninomials were incorporated into the current rank-based system, the genus category would simply be treated in the same way as other ranks, since it is not currently possible to determine from a species name what family, order, etc. it belongs to except in the case of type genus. The genus is not fundamentally different from any other supraspecific category, so it is appropriate that it be treated in the same way (Cantino, 1998). Although, much less has been written about genera than species and the genus is more difficult to define than the species. Very few taxonomic papers published during the last 35 years have included descriptions of one or more new genera. Only a few workers have attempted to provide a biologically based genus. Defining the genetic category is difficult and recognizing generic taxa in practice is even harder.

Definitions and basic concept of genus

The term comes from the Latin *genus* ("origin; type; group; race"), a noun form cognate with *gignere* ("to bear; to give birth to", Plural = Genera)). The concept of genus is as folk as science and it represents an inclusive category. The genus is an essential uninominal category which is used in applying the binomial nomenclatural system of Linnaeus. A group of plants which are closely related, definable, exhibits similar characteristics (flowers, fruit, stems, leaves, or roots) and genetic affinity constitute

genus. From Linnaeus' time to the present, the concept of the genus has remained relatively stable, but obviously there have been many changes in particular generic limits, especially in large genera. The larger genera have also been subdivided into subgenera and sections. Genera have been added and others subtracted, obviously resulting in an increase of total genera as new material has been obtained through additional field exploration. The genus is the next principal category in the taxonomic hierarchy above the species. The International Code of Botanical Nomenclature allows several intervening categories also, *viz*., series, section (section) and subgenus, but these are not fundamental to the hierarchy and are not always used in classification within a particular group. They can be very helpful, however, especially in providing an infrageneric structure within large genera. Their use is to be encouraged in certain situations.

Species represent biological realities, but it not true for the higher-level categories of the Linnaean hierarchy whose definition are arbitrary. "The species category signifies singularity, distinctness and difference, while the higher categories have the function of grouping and ordering by emphasizing affinities among groups of species." However, even if there are no non-arbitrary criteria, "a taxon correctly delimited and placed in a higher category is natural provided it is consistent with the theory of common descent" (Mayr and Ashlock, 1991). Genus represents monophyletic group of species and non-monophyletic genera must be avoided because they do not represent natural group. Despite the vagaries of systematists, there are, in a taxonomic sense, many dense clusters of biotic diversity (Minelli, 1993). It is a group or assemblages of related species, which resemble one another in certain correlated character. Correlated characters are those similar or common features which are used in delimitation of various taxa. The species of one genus differ from species of a related genus in one or more characters. The reason of close similarity between species of a genus is because of their common ancestry.

The genus has a special importance in classification. As per rules of binomial nomenclature, a species cannot be name without assigning it to a genus. Generic names are nominative singular noun; they are capitalized and italicized or underlined. Generic name do not have standardized endings. According to Rollins (1953) the function of the genus concept is to bring together species in a phylogenetic manner by placing the closely related species with emphasis on the naturalness of the group as shown by its homogeneity and distinctiveness.

The basic concept is that a genus is an assemblage of species that have more significant features in common among its members than with any other species. A corollary is that there is a greater discontinuity, or phenetic gap, between groups of species than between species (called "*hiatus*" taxonomy by Singer, 1986).

The group as far as possible should be a natural one. The monophyletic nature of the group should be deduced by cytogenetic, geographic information in relation to morphology. According to Evolutionary and phenetic approach, "A genus (generic taxon) is a monophyletic group composed of one or more species that are separated from other generic taxa by a decided gap" (Mayr and Ashlock, 1991).

According to Cladistic taxonomists "A mandatory category to which every species must belong and which contains one species or a monophyletic group of species" (Wiley and Lieberman, 2011).

According to Clayton (1983) the genus is a composite idea, which has developed gradually alongside classification in general and which must seek to reconcile several parallel lines of thought that are not always wholly coincident. The genus concept involves a compromise between biological reality and practical convenience. The species themselves tend to occur in clusters, a phenomenon, which opens the way to a natural supra-specific classification. These clusters are called genera. Its original aim was simply to place species into some logical relationship that would serve as a cataloguing device. However, with the increased role of phylogenetics in elucidating evolutionary relationships, the category genus has been seen to signify a "group of species more closely related to one another than any are to other species" (Funk, 1985).

According to pragmatic approach, the term the genus may be defined as a grouping of "one or more species that are (usually) believed to be closely related" (Quicke, 1993).

The generic concept could have been set up by the synthesizing of species or, conversely, the species concept may have been derived from differentiation from the generic level. The generic concept antedates the species concept and that the latter was developed by differentiation from the former (Li, 1974). There is no objective standard to define the genus and it is true that species clusters of varying distinctness exist in nature. Its formal definition remains substantially same, *i.e.* an abstract and arbitrary level of morphological difference (Sivarajan, 1991).

According to Lee and Skinner (2007), there is no "genus concept" (analogous to a species concept) and thus no way of empirically determining the limits of a particular genus, even in the context of a single agreed phylogeny.

A genus is a group of species held together by several to many character states and distinct from other such groups, between which natural or artificial hybridization is usually not possible (Stuessy, 2009).

Generic Circumscription

The traditionally used data for the recognition of genera have been morphology and anatomy. Genera have been, still are and will probably always be delimited partly by morphological discontinuity. The circumscription of genera has remained, by and large, a function of the morphological cohesiveness and discreteness of the species group (Sivarajan, 1991). Floral, as well as vegetative, anatomy can be useful in generic delimitation. Pollen grains and spores have also been used to good effect. Basic chromosome number and chromosome shape and size are the important features that have been utilized for at the generic level. Geography has also been used traditionally to help delimit genera but circumscription by reference to distribution is much more complex with genera than with species and infraspecific taxa (Stuessy, 2009). When generic limits are being drawn, it is absolutely necessary that the group of species should be studied throughout the distribution range of the group, because characters stable in one region may break down elsewhere. So it requires detailed knowledge of the range and pattern of variation. The concept of monophyly has been quite useful in determining naturalness and demarcation between genera. Inspite of the concept of naturalness and the monophyletic requirement, the circumscription of genera has largely remained a subjective affair (Sivarajan, 1991). Cladistic analyses based on morphological and molecular data may also be utilized for better circumscription of genus. Recently, on this basis a new genus (*Sanjappa cynometroides* of Mimosaceae) has been established to accommodate a species excluded *Calliandra cynometroides* (de Souza *et al*., 2016). Different approaches for generic delimitation are given below:

Tournefort's Approach : Tournefort (1700) believed that of the six parts of a plant (roots, stems, leaves, flowers, fruits, seeds), five should be considered for purposes of generic circumscription. He also stressed that usually features of the flowers and especially those of fruits would give the best criteria upon which to found genera. He did use some single features of bark, underground stems, or other characters for some generic distinctions.

Linnaeus' approach : Generic concept of Linnaeus' is clearly same as those of Tournefort (1700) and Plumier (1703). Linnaeus' advice in establishing genera was to recognize species first and then to synthesize these into genera, thus essentially sidestepping the question of generic definition in a general sense. In practice, he tended to emphasize characters of the fruit for generic delimitation. His approach to generic circumscription was outlined in detail in the *Philosophia botanica* (1751), and it consisted of searching for three characters (after Svenson, 1945): (1) the natural character giving the complete description of all its features and upon which the classification system should be based; (2) the factitious character being a selection of features suitable for discrimination among genera in an artificial system of classification or even in a key; and (3) the character *essentialis* that were the features allowing for easiest description.

Walters approach : Species of a genus should be delimited from other genera by clear cut gaps or breaks. The concept of genus and natural grouping is difficult and problematic in large, natural and definable families (Walters, 1961) where genera are difficult to delimit (*e.g.* Compositae, Cruciferae, Umbelliferae, Acanthaceae, Gramineae etc). These families are very natural, homogenous and clearly delimited. Here, character discontinuities may be difficult to find. For example in the Compositae we have to be satisfied with pappus character for generic delimitation. Genera of indefinable families are easily definable due to clear morphological discontinuities. Magnoliaceae, Ranunculaceae, Cornaceae, Rubiaceae, Berberidaceae, Liliaceae, Saxifragaceae etc. are some indefinable families.

Nomenclatural Instability in Genus

The species category name constitutes a special problem in the Linnaean nomenclature, where described species always must be allocated to a previously described or new genus. This introduces nomenclatural instability since the generic part of the name has to change (under the present conventions), when the species is transferred from one genus to another (Sundberg and Pleijel, 1994). If generic limits are changed then it necessary to make changes in the binomial at species level. This makes nomenclatural instability in binomial. Sometimes changes are also made in specific epithet due to homonymy under the new generic assignment. But this is not true for other higher ranks like splitting a family into two families does not require changing genus names.

Discoveries about generic limits are often not translated into classifications because doing so would entail many alterations in species names. This is particularly problematical when dealing with large genera. The splitting of a genus into two or more genera (whether based on phylogenetic or phenetic considerations) sometimes requires dozens or even hundreds of new combinations. The prospect of both the work involved and the resulting nomenclatural instability is enough to discourage many systematists from making the requisite changes (Cantino, 1998).

Description of New Genus

Genera should be easily recognizable groups, in such a way that once a number of species of a group are known, most other species will at once be recognized as members of the same genus, although the species themselves may be unknown" (Boivin, 1950). The procedures used to describe a new species and new genus are same i.e. it include background research, composing a name, writing a description, selection of type specimen, publication in accordance with the ICN (International Code of Nomenclature for algae, fungi and plants). Every generic name is associated with a type species chosen. Early taxonomist used the term "genotype" for 'type species'. Now the term "genotype" has been replaced it with "type species of the genus," "type species," or "generitype" (Jeffrey, 1989). If an element is described as new to both genus and species, only species in the new genus will become the generic type. If a new genus is proposed for which a number of species have been described, then one must choose a type. There is no such taxonomic character (generic character) which indicates the placement of a particular species in a certain genus. Besides, there is no character that is always useful at the generic level rather than at the species or some other level, although in a particular group of organisms there may be characters that are important in defining genera or species. During writing a description of species, it is decided whether species in question require a new genus or it can be placed in an existing genus.

The genera should not be distinguished on the basis of single character. A sum total of several characters should be taken into consideration. These characters are correlated either functionally or genetically. These characters should be present in all the members of the groups. Although, it is not necessary for the members of a genus to share all the characters. One or more diagnostic characters may be absent in one or more species of a genus. These diagnostic characters may be present in a modified form. If the degrees of modified characters are small, it will be better to revise the diagnosis of genus. In such cases it is not desirable to create a new genus **(**Mayr and Ashlock, 1991). A new genus should be created- 1) When most of the taxonomic characters found in a new species do not correspond well with those in other species of any known genus. 2) When most of the taxonomic characters found in a new species cannot be made to fit into any described genus. 3) If the modified diagnostic characters are present in moderate or fairly good amount beyond the revision of diagnosis of genus (Winston, 1999).

Remodelling of Genera

To change the diagnostic characteristic of a taxon is called remodelling. A number of suggestions for the remodelling of genera, especially in the recognition of generic segregates are (1) qualitative morphological characters should be given special significance; (2) the recognition of segregate genera based on minor or single characters should be allowed only in particular instances to preserve usage; (3) the biological unity of a genus is more important than the "gap" between it and its close relatives; (4) changes made in generic limits should be done only after a full study of variation within the complete range of the group; (5) decisions on whether to establish segregate genera should be based on the relationship of the segregate to its core genus and not on relationships of the core group to other established segregates; (6) segregate genera should be sharply delimited (any intermediate species should be included in the larger genus); (7) the strength of the argument to recognize segregate genera varies proportionally to the number of differentiating characters; and (8) the decision to recognize a generic segregate is strengthened if the group has a distinctive geographical range (Stuessy, 2009). There should be a decided gap between the species of two genera. If the two genera are not readily separable, then they can be merged into one and distinguished as subgenera or sections.

Naturalness and Size of Genus

Bentham did not consider genera to be natural entities, but rather arbitrary. According to him genera should be broadly delimited. Genera that give their substantive names to every species they represent should remain large" (Bentham, 1858). Lamarck thought that distinct genera were not natural and that the distinctness of large, isolated genera would probably disappear as further collecting led to the discovery of undescribed species. Nature was not yet fully known. As more organisms were discovered the continuum would become more evident and the apparent discontinuities that delimited such groupings would disappear (Lamarck,

1785, 1788). According to Lamarck grouping above the species level are arbitrary affairs (*i.e.* arbitrary as to exclusion and not to inclusion) and made by people. Lamarck felt that genera should be neither too long nor too short and these should be readily distinguishable. He thought that features used to distinguish genera could be artificial and did not have to be chosen from among the primary characters used to construct the natural orders (Stevens, 1994). The Naturalness and size of genus is given under following headings.

1. Genus -a monophyletic group

Natural taxa consist of all the descendants of a single common ancestor, *i.e.* they are 'strict monophyletic' or holophyletic taxa and correspond to clades. In other words, a natural taxon is a group of organisms (two or more species) that exists in nature as a result of evolution and constitutes a clade or monophyletic group. Many traditionally circumscribed genera are paraphyletic or polyphyletic groups, defined by characters not shared by monophyletic groups. They are defined by plesiomorphies and often by characters indicating what they are not, rather than what they are (Eldredge and Cracraft, 1980). The concept of genus as a composite concept - *i.e.* including both monophyletic and paraphyletic entities is accepted by Clayton (1983) and cladists disagree with it and are of the opinion that genera should be strictly monophyletic (*i.e.* they include all and only the known descendants of a given species (Stevens, 1985). Monophyletic groups are not necessarily the best predictors of overall similarity, but they are likely to predict the distribution of derived characters best, since the existence of such groups depends on derived characters. This does not mean that the generic name is not predictive, in fact a system of classification which reflects evolutionary history as accurately as possible should have predictive value. The cladistic view would regard genera as no more nor less natural than species or even higher taxa, so long as they are treated as holophyletic groups (based on synapomorphies) in the reconstructed phylogeny.

According to Wiley and Lieberman (2011) "a natural taxon" as "a taxon that exists in nature independent of man's ability to perceive it and requires discovery". These taxa are neither artificial nor manmade and have real existence in nature. "Nature may make species, but man has made the genera" (Bisby and Ainsworth, 1943). In Linnaean taxonomy, both genus and species are natural by assumption and the limits of these entities are represented by discontinuities. Anderson (1940) in a study found that genus is more natural than species *i.e.* genus often reflects more actual discontinuity in organic nature. Genera are the accumulations of groups of reproductive units (the species) rather than the direct result of their formation. Monographic workers regarded genera as more natural than species. Genera are certainly less natural than species in terms of representing an actual discontinuity in the living world. In older groups, such as Magnoliaceae, both genera and species are well delimited from each other, whereas in recently evolved taxa, such as Compositae and Gramineae, both limits are often subtle and delimited only with difficulty *i.e.* they may be clearly delimited in some families, especially in older ones in which extinction has brought about definite phenetic gaps (Magnoliaceae), but less so in others (Compositae). Because extinction is an important factor in creating phenetic gaps between taxa, it seems reasonable that genera should be more distinct than species. But even if they are clearly delimited because of absence of intermediates, they are not as natural in the sense of being reproductive units of nature.

2. Monotypic Genera

4853 (38.6%) of the 12571 genera of Angiosperms that Willis (1922) recognized were monotypic with 12.9% containing only two species and only a very few had large numbers of species. Similarly, 236 of the 18,000 species of angiosperms are monotypic in the Indian flora (Rana and Ranade, 2009). There is no size requirement for a genus. It may include a single species known as monotypic eg. *Leitneria.* It may also include more than one species known as polytypic eg. *Solanum*:-*S. tuberosum*, *S. melongena*, *S. nigra* etc. or some time more than 2000 species e.g. *Senecio* (Jones and Luchsinger, 1987). Monotypic genera may be recognized more or less consistently in different families of flowering plants. Monotypic taxa are clearly natural entities and must be recognized as such taxonomically (Stace, 1989). The most serious challenge levelled at the concept of monotypic genera has come from the cladists. Platnick (1976) states that if we accept that evolution is a historical genealogical process by which ancestral, genetically unified population are (generally dichotomously) divided dichotomously into sister groups, then "monotypic genera seem impossible as they must always exclude at least one other species that is a descendant of the most recent ancestor (*i.e.* they must always be paraphyletic)." Thus, according to him a genus cannot be both monotypic and monophyletic theoretically. Besides, monotypic supraspecific taxa (e.g. families, orders, etc.) are also paraphyletic (Platnick, 1976) but, Wiley (1977) states that all higher taxa, if they are monophyletic, must have been monotypic at their time of origin. According to Stuessy

(2009) this is an insignificant problem because genera should be recognized based on all features of phylogeny and not just cladistic (branching pattern) data. He further stated that the most predictive and useful delimitation of genera will be by phyletic rather than cladistic. According to cladists genera should defined holophyletically and paraphyletic genera should be rejected.

Epilogue

In classification, the organisms that closely resemble one another are placed in a group, the groups which have similarities are combined together into larger group and these into still larger one. The various grouping levels or ranks in classification are known as categories. Each category has a name and is allotted to certain taxa. The taxon represents real biological objects and is assigned to a category. The genus is the next principal category in the taxonomic hierarchy above the species. There is no such taxonomic character (generic character) which indicates the placement of a particular species in a certain genus. The genera should not be distinguished on the basis of signal character. A sum total of several characters should be taken into consideration. These characters are correlated either functionally or genetically. These characters should be present in all the members of the groups.

Some traditional botanists consider genus as arbitrary group and circumscribed it broadly whereas some other thought that it should neither be too long nor too short. But according to APG (Angiosperm Phylogeny Group) group should be broadly circumscribed. According to some worker the genus is a composite concept *i.e.* both monophyletic and paraphyletic and cladistist consider it is as monophyletic group and hence natural taxon. Besides some are of the opinion that distinct genera were not natural because distinctiveness would probably disappear after the discovery of undescribed species *i.e.* discontinuities that have delimited groups would become disappear. It is true that species clusters of varying distinctness exist in nature. These clusters so called genus form natural and monophyletic group of wide occurrence.

"A knowledge of relative importance of characters can only be acquired by long study; and without a due appreciation of their value no natural group can be defined." – J. D. Hooker (1855)

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