Plant Systematics a Phylogenetic Approach

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Abstract

This paper attempts to study **phylogenetic approach** of Plant Systematics **reflects changes in the circumscription of several families** in order to represent monophyletic groups, following the classification of the Angiosperm Phylogeny. Plant systematics is a science that includes and encompasses traditional taxonomy; however, its primary goal is to reconstruct the evolutionary history of plant life. It divides plants into taxonomic groups, using morphological, anatomical, embryological, chromosomal and chemical data. However, the science differs from straight taxonomy in that it expects the plants to evolve, and documents that evolution. Determining phylogeny of a particular group - is the primary goal of systematics. Phylogenetic studies are revealing that major ecological niches are more conserved through evolutionary history than expected, implying that adaptations to major climate changes have not readily been accomplished in all lineages.

Phylogenetic niche conservatism has important consequences for the assembly of both local communities and the regional species pools from which these are drawn. If corridors for movement are available, newly emerging environments will tend to be filled by species that filter in from areas in which the relevant adaptations have already evolved, as opposed to being filled by *in situ* evolution of these adaptations. Examples include intercontinental disjunctions of tropical plants, the spread of plant lineages around the Northern Hemisphere after the evolution of cold tolerance, and the radiation of northern alpine plants into the Andes. These observations highlight the role of phylogenetic knowledge and historical biogeography in explanations of global biodiversity patterns. They also have implications for the future of biodiversity. The rise of phylogenetic biology has revolutionized the study of molecular and developmental evolution, but has still had rather limited impact in ecology. Interest in phylogeny is growing within community ecology, but it has received almost no attention among ecosystem ecologists. It is possible that knowledge of phylogeny is less relevant in these areas, but it seems more likely that the most productive intersections have not yet crystallized. Recent work on community phylogenetics, and emerging ideas on the integration of historical biogeography in studies of biodiversity, may be yielding a key principle governing the historical assembly of communities, which could in turn provide the basis for a new synthesis of phylogeny and ecology. Put simply, it may often be easier for lineages to move than it is for them to evolve..

*Key words: Phylogenetic niche, ecology, diversity, organisms, Systematics, plants*

Introduction

The study of kinds and diversity of organisms and the evolutionary relationships among them is called systematics or taxonomy. The study systematics gives the order and relationships among thp organism. This order and relationship arise from evolutionary processes. These studies also give description of the new species. It organizes the animals into groups (taxa). This grouping is based on degree of evolutionary relatedness. Some biologists differentiate between systematics and taxonomy. They believe

(a)**Taxonomy:** The original description of species is called taxonomy.Taxonomy or systematic is based on two aspects

(a)**Morphology:** The modern classification system has been given by Carolus Linnaeus. This system of classification is still used today. Carious Linnaeus believed that different species can be grouped into same categories on the basis of similarities between them. The group of animal with similar characteristics forms a taxon. Carolus Linnaeus recognized five taxa. Modern taxonomists use eight taxa including earlier five taxa. The taxa are arranged hierarchically. These taxa are: Kingdom, Phylum, C'lass, Order, Family, Genus, and Species.

(b)**Evolution:** Carolus Linnaeus did not accept evolution. But still many of his groupings show evolutionary relationships. Morphological similarities between two animals have a genetic basis. It gives rise common evolutionary history. Thus the animals are grouped according to similar characteristics. The members of the same taxonomic group are more closely related to each other than to members of different taxa.
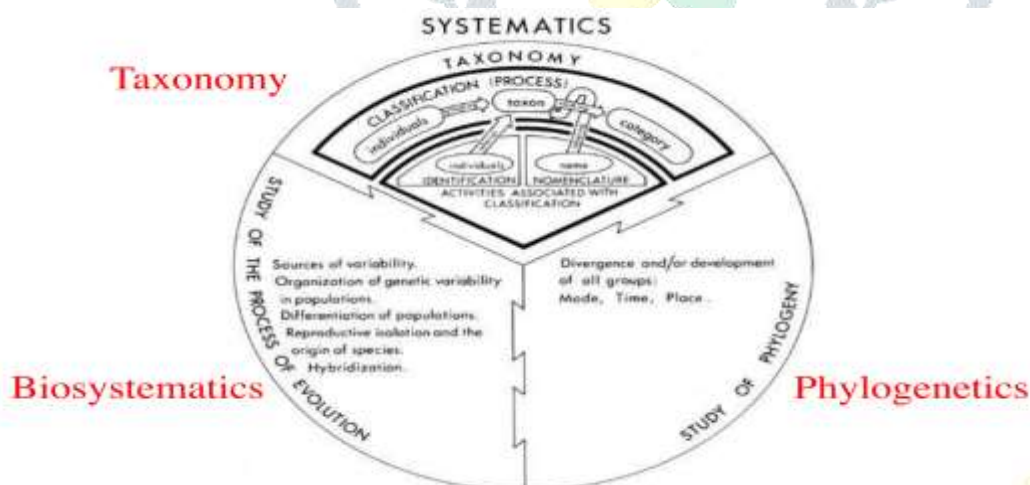
Objective:

This paper intends to explore and analyze how **plant systematics** bridges the specific subject areas of evolution, encompassing evolutionary, **phylogenetic**, genomic and biogeographical **organization. Also** comparisons of **plant** species or gene sequences in a **phylogenetic** context

Classification Systems For Plant Systematics

Approaches to classifying plants include cladistics, phenetics, and phyletics.

- **Cladistics:** Cladistics relies on the evolutionary history behind a plant to classify it into a taxonomic group. Cladograms, or "family trees", are used to represent the evolutionary pattern of descent. The map will note a common ancestor in the past, and outline which species have developed from the common one over time. A synapomorphy is a trait that is shared by two or more taxa and was present in their most recent common ancestor but not in earlier generations. If a cladogram uses an absolute time scale, it is called a phylogram.

- **Phenetics:** Phenetics does not use evolutionary data but rather an overall similarity to characterize plants. Physical characteristics or traits are relied upon, although the similar physicality can reflect evolutionary background as well. Taxonomy, as brought forth by Linnaeus, is an phenetics.

- **Phyletics:** Phyletics is difficult to compare directly with the other two approaches, but it may be considered as the most natural approach, as it assumes new species arise Phyletics is closely linked to cladistics, though, as it does clarify ancestors and descendants.
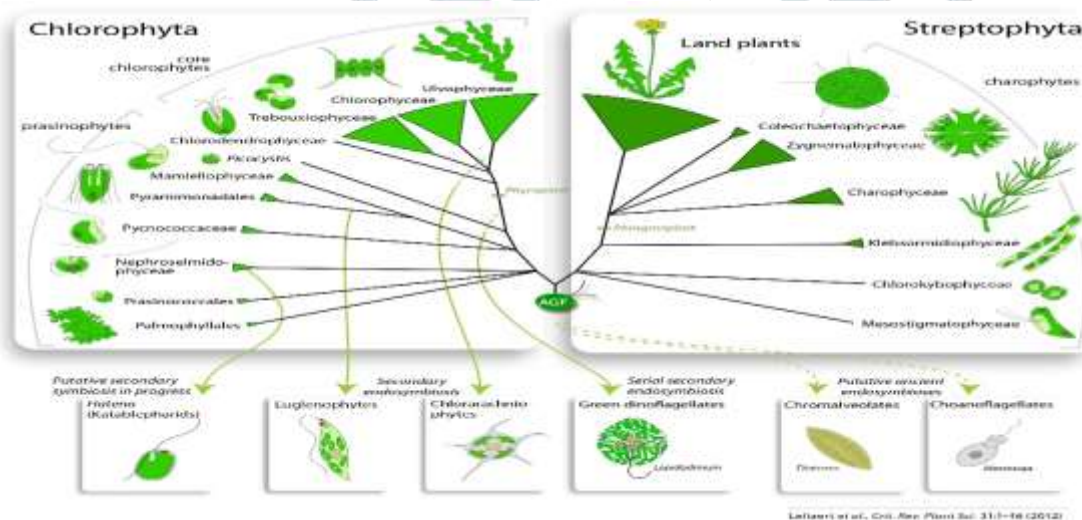
Phylogenetic Niche Conservatism (PNC)

What Harvey and Pagel (17) termed PNC refers to the expectation that, all else being equal, related species will tend to occupy the same sorts of environments (18). PNC is not meant to imply that ecological barriers

are insurmountable, or even that niche shifts are rare. Niche evolution obviously occurs, and may even be the norm under certain circumstances (e.g., ref. 19). However, PNC, to the extent that it exists, does imply that speciation can occur regularly without major niche shifts (e.g., ref. 20). Furthermore, under the assumption that opportunities to undergo major shifts have regularly presented themselves, PNC implies that these opportunities have not been seized so readily that high-level eco-phylogenetic correlations are completely overridden by ongoing low-level niche shifting. Although, strictly speaking, it is not necessary to link PNC with the view that there are constraints on niche evolution, I believe that it is the relative difficulty of making major ecological shifts that explains the patterns I have highlighted above, and which, as discussed below, render PNC especially consequential in explaining the distribution of biodiversity.

An example of the potentially significant role that PNC plays in structuring the distribution of biodiversity relates to discussions of the latitudinal species diversity gradient (reviewed by Mittlebach et al., ref. 21). One long-standing hypothesis has been that this pattern is underlain by a simple historical cause, namely a longer time for diversification in the tropics in many lineages than outside of the tropics. If many extant lineages originated and began their diversification under tropical climatic conditions, and if movements of these lineages out into temperate climates occurred only more recently, this alone would go a long way toward explaining the gradient (e.g., refs. 22⇓⇓–25). Rangel et al. (26) put this verbal argument to the test in a simulation focused on bird biodiversity in South America, showing that realistic patterns can be obtained under a variety of circumstances.

A key ingredient of this argument, which led John Wiens and I to call it the "tropical niche conservatism" hypothesis (24), is that not all tropical lineages confronted with the retraction of tropical climates during the Tertiary managed to adapt to colder climates. Instead, many of these lineages simply tracked tropical habitats, and therefore became increasingly geographically restricted. If every tropical lineage had been able to readily adjust to cold temperatures and extreme seasonality, then the latitudinal diversity gradient would be far less steep than the one we observe today. This is the important sense in which PNC has explanatory power beyond the time-for-speciation factor.

How does a plant systematicist study a plant taxon?

Plant scientists can select a taxon to be analyzed, and call it the study group or ingroup. The individual unit taxa are often called Operational Taxonomic Units, or OTUs.

How do they go about creating the "tree of life"? Is it better to use morphology (physical appearance and traits) or genotyping (DNA analysis)? There are benefits and disadvantages to each. The use of morphology may need to take into account that unrelated species in similar ecosystems may grow to

resemble one another in order to adapt to their environment (and vice versa; as related species living in different ecosystems may grow to appear differently). Phylogenetic relationships among the major lineages of green plants. The values in parenthesis represent the approximate number of species. Adapted from Pryer et al (2002) Deciding among green plants for whole genome studies.
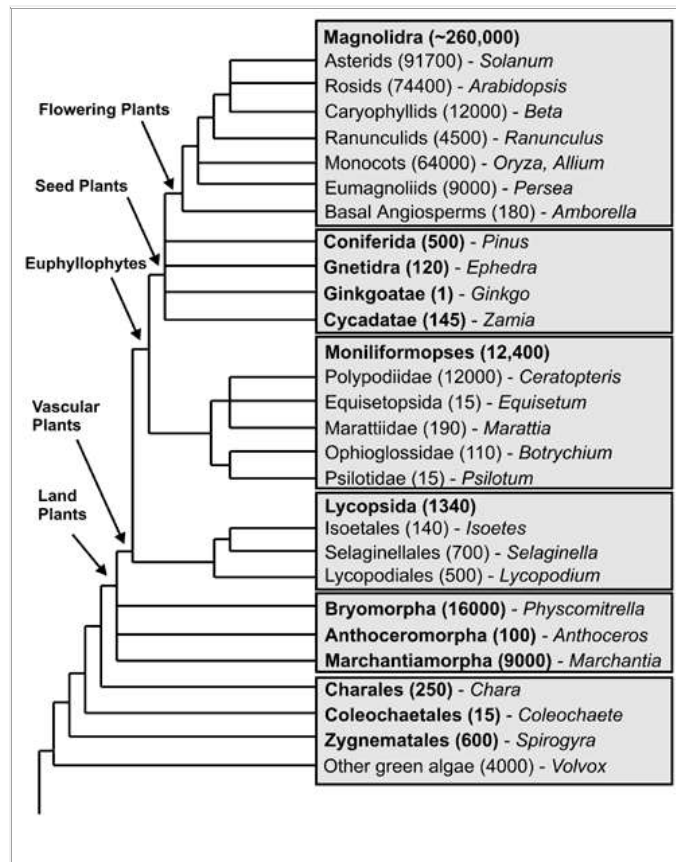
It is more likely that an accurate identification can be done with molecular data, and these days, performing DNA analyses is not as cost prohibitive as it was in the past. However, morphology should be considered.

There are several plant parts which are particularly useful for identifying and segmenting plant taxa. For example, pollen (either via the pollen record or pollen fossils) are excellent for identification. Pollen preserves well over time and is often diagnostic to specific plant groups. Leaves and flowers are often used as well.

Systematic Studies; plant species

Early botanists such as Theophrastus, Pedanius Dioscorides, and Pliny the Elder may very well have unwittingly started the science of plant systematics, as each of them classified many plant species in their books. It was , however, who was the main influence on the science, with the publication of *The Origin*

Of Species. He may have been the first to use phylogeny, and called the rapid development of all the higher plants within recent geological time

Studying Plant Systematics

The International Association for Plant Taxonomy, located in Bratislava, Slovakia, seeks "to promote botanical systematics and its significance to the understanding and value of biodiversity." They publish a bimonthly journal devoted to systemic plant biology.

In the USA, the University of Chicago Botanic Garden has a They seek to put together accurate information about plant species so as to describe them for research or restoration. They keep preserved plants in-house, and date when they are collected, in case that is the last time the species is ever collected!. Niche Conservatism and Local Community Assembly

That there should exist a general relationship between phylogenetic relatedness and ecological interactions that are crucial to community assembly, has been evident from Darwin (27) onward. As G. Evelyn Hutchinson put it in 1965 (28): "It is evident that at any level in the structure of the biological community there is a set of complicated relations between species, which probably tend to become less important as the species become less closely allied. These relations are of the kind which ensure niche separation." With the rapid expansion of phylogenetic knowledge (e.g., see ref. 29), it has now become possible to study this rigorously.

A series of recent analyses imply that PNC influences community composition both by the filtering of the regional species pool based on abiotic niche parameters and through competition and other biotic interactions. The signals of these processes may be reflected in the distribution of species across the phylogeny of the regional species pool (quantified using a variety of phylogenetic diversity measures; refs. 9, 30, and 31; www.phylodiversity.net/phylocom). As Webb et al. (32) and Cavender-Bares and Wilczek (33) reasoned, where abiotic habitat filtering is the dominant force shaping coexistence, PNC should result in phylogenetic clustering in the phylogeny of the regional species pool. On the other hand, where biotic competitive exclusion is the dominant ecological force, PNC should result in a more even (overdispersed) distribution of species on the regional tree than expected by chance.

These relations may hold in the abstract, and have oriented the interpretation of a number of studies (e.g., refs. 34⇓–36), but there are a variety of complications or necessary extensions. For example, as Webb et al. (32) and Cavender-Bares and Wilczek (33) appreciated, an overdispersed phylogenetic pattern can also result from abiotic filtering from an underlying phylogeny showing convergent niche evolution. This observation simply highlights the need to couple such studies with independent phylogenetic tests of the

extent of PNC in the clades under consideration (cf. refs. 36 and 37). Likewise, "ecological facilitation," rather than competition, might underlie an overdispersed phylogenetic pattern (38), again emphasizing that there is not a simply one-to-one relationships between a phylogenetic pattern and an underlying cause.

It is also clear that possible causal processes will vary in intensity, and even in kind, as a function of scale (39). For example, Webb et al. (40) hypothesized that seedling phylodiversity patterns within small rain forest plots reflect the sharing of fungal pathogens among close relatives, whereas at a larger scale in the same forest they found evidence of habitat filtering. Cavender-Bares et al. (34, 37), in studies centered on oaks (Quercus) in Northern Florida, showed evidence for phylogenetic evenness at smaller spatial and taxonomic scales (interpreted as the outcome of competition), but phylogenetic clustering at larger scales (interpreted as habitat filtering of phylogenetically conserved ecological traits). Clearly, sorting out among such possibilities requires the development of appropriate null models, and simulations to evaluate the power to distinguish alternative explanations (e.g., refs. 41 and 42).

For present purposes it is especially important to note that entirely different causal factors become relevant as such studies scale up to much broader regions, or focus on clades that have moved around the globe. For example, Forest et al. (43) reported lower phylogenetic diversity (despite higher species diversity) in the western Cape flora of South Africa, in part as a function of multiple rapid radiations (44). In contrast, the eastern Cape showed higher phylodiversity, in part because it interdigitates with another biodiversity hotspot. The key point is that at such larger scales historical factors such as speciation, extinction, and biogeographic boundaries become highly relevant.

Conclusion

Explanations for major patterns in the distribution of biodiversity have traditionally tended to focus on environmental correlations and local determinism. With the rapid rise of phylogenetic knowledge, a growing appreciation of the extent and possible roles of phylogenetic niche conservatism, and the development of better analytical tools, especially to infer historical biogeography and rates of diversification (e.g., ref. 78 and see ref. 79), the stage is clearly set to reintegrate historical factors into such explanations.

These are in no way meant to replace environmental explanations, but rather to complement them and connect them to the speciation, extinction, and migration processes that ultimately underlie such patterns. Finally, it is worth reflecting on the future of biodiversity in light of the basic principle highlighted here. In the deep evolutionary past, corridors for the movement of biotas within and among continents were opened or shut based primarily on the relative position of landmasses, geologic particulars (e.g., the

location and orientation of rivers and mountain ranges), and climate changes. Moving into the future, anthropogenic habitat fragmentation adds a complicating new variable to the equation, as does the current rapidity of climate change and the wholesale movement of species by humans. Depending on the vagility of the organisms involved, the habitat discontinuities imposed by humans may limit the impact of the migration of preadapted species in community assembly, which we believe has played such an important role in the past. The consequences for community composition, structure, and function are unclear. One possibility is that anthropogenically isolated habitats will remain, at least for a time, "empty" of species from surrounding areas that might be well adapted to them. On the other hand, barriers to migration might create circumstances that favor niche shifts in the resident species

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