POINT OF VIEW

# The end justifies the means

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*Exitus acta probat.*
Publius Ovidius Naso
in *Heroides* (ca. 5 BC)

Brummitt (2006) has identified the paraphyly-monophyly controversy as the most important issue under debate in taxonomy today. In essence the argument is about the merits of the evolutionary (Darwinian) versus phylogenetic (cladistic/Hennigian) approaches towards plant classification. Brummitt's response is in support of the letter by Nordal & Stedje (2005) who pointed out, together with 148 co-signatories, that the rejection of paraphyletic groups as taxa in classification construction by the phylogenetic school is not only a logical impossibility but is causing unnecessary chaos in plant taxonomy. As a field/herbarium taxonomist in the world's richest temperate flora, that of southern Africa, I can only but endorse this observation. To deny this fact, as some phylogeneticists tend to do (e.g., Dias & al., 2005), is to be out of touch with reality. With more than 20,000 plant species in South Africa alone, the practical value of classifications that are optimally stable, informative and predictive is of utmost importance to come to grips with such astounding diversity. Hence I would like to offer some observations in defense of paraphyletic groups from the perspective of an end-user of plant classifications. In this contribution I argue that practical considerations and the needs and expectations of society should provide the primary guidance in a debate that has hitherto focused mainly on academic issues. For the benefit of readers not familiar with the distinction between evolutionary and phylogenetic taxonomy (mainly espoused and debated in the zoological literature), concise information on the two approaches and its relevance to the current debate is provided. Since completion of the present contribution, the two approaches have also been discussed by Hörandl (2007).

**Evolutionary and phylogenetic classification. —** Classification by its very meaning implies an ordering for practical purposes. It also implies the grouping of objects into classes based on shared characters (similarity). From its inception as folk taxonomies, plant classification has been an applied and practical activity. The success that Linnaeus' artificial sexual system enjoyed was largely due to its simplicity and practical advantages in identification. To address the needs of science, industry and broader society, taxonomists over the years have striven to produce general-purpose (multi-purpose) classification systems, not only by purely phenetic means (including taxometrics), but since the inception of evolutionary theories increasingly by the use of the best available phylogenetic framework for incorporating attributes of plants from as many fields as possible. The aim is to construct evolutionary classifications allowing us to store and retrieve information where it is known and predict its presence or absence where it is not. In this way plant taxonomy has not only fulfilled its essential role as an integrative and unifying discipline in botany, but has also enhanced the information storage and predictive value of classification systems.

For practical plant identification and information storage and retrieval, the advantages of evolutionary classifications over phylogenetic ones (see below) are beyond question. Essentially evolutionary classification is based on the evolution of organisms, not just their phylogeny. Both the evolutionary classification and phylogenetic classification are genealogical, but the former is a genealogy of groups (classes) and the latter of clades. Mayr & Bock (2002) define evolutionary classification as 'a classification that duly considers both evolutionary processes, the ecological adaptiveness of evolutionary divergence (degree of difference) and the genealogy (phylogeny) of the taxa.' Mayr & Bock refer to the phylogenetic approach as cladification (instead of classification) and define it as 'an ordering system in which branches of a cladogram, or parts of such branches, are arranged with reference to the sequence of the branching points in the cladogram and based on the principle of holophyly'—holophyly which refers to the cladists' definition of monophyly, namely 'pertaining to a branch of the phyletic tree (and the species on this branch) derived from a stem species (with the first apomorphy diagnostic of this branch) and all of its descendants, no matter how different.' In *practice*, however, the two approaches have much in common, one of the main distinctions being recognition of paraphyletic taxa by evolutionary taxonomists (strictly speaking, paraphyly as a concept does not exist in an evolutionary classification). The methodological differences between the two

approaches, their philosophies, strengths and weaknesses, are particularly clearly explained by Mayr & Ashlock (1991), and Mayr & Bock (2002). As far as plants are concerned, the Angiosperm Phylogeny Group [APG] has, in addition to the rejection of paraphyletic groups, also adopted certain 'guiding principles', some of which are not supported by proponents of the evolutionary school. For example, the APG prefers not to maintain/create monogeneric/small families (often ten or fewer genera) to preserve the 'morphological integrity' of another, larger family. They consider it '… unrealistic to argue that certain families should not be combined because it will make them difficult to diagnose in this new circumscription.' (Chase & al., 2000).

**Responsibilities towards society and choice of classification. —** Why do we classify? Since classification is a consequence of man's need to deal with his environment, different needs may require different approaches. The responsibility of plant taxonomy towards society is well expressed by the vision statement of the International Association of Plant Taxonomists: 'Botanical systematics, in the broadest sense, understood and valued by society.' Hence for very specific needs an artificial classification is the one most widely used in society for a broad range of special purposes. Based on one or very few plant characters, the artificial approach does not necessarily require botanical training. Most gardeners tend to divide the higher plants into trees, shrubs and herbs, etc. The construction of general-purpose evolutionary systems, on the other hand, has for many years been the aim of professional plant taxonomists. As pointed out by Johnson (1970), the suitability of any particular classification can only be judged in relation to the purpose for which it is required—stated differently, the end justifies the means; a maxim already expressed by Roman poet Publius Ovidius Naso [Ovid] in ca. 5 BC.

Most important of all for relevance to society is the information storage and predictive value of a classification (Stuessy, 1993). The concept of predictivity greatly assists in plant identification. Admittedly, the powerful advantages of a classification system with good information storage and predictive value are best utilized and appreciated by end-users of plant names, especially practicing field and herbarium taxonomists. For predictive purposes in the real world the information content of mainly three categories of the Linnaean hierarchy are relevant, those of species, genus and family. To maximize the storage and predictive value of a general-purpose classification system requires monophyletic *or paraphyletic*, well-circumscribed, fairly homogeneous taxa (notably genera and families), even though these may be relatively small, because only then can the information storage and predictive value be fully exploited. Although the importance of information content and predictivity is acknowledged by phylogeneticists (e.g., Chase & al., 2000), their classifications contradict this expressed intention. Perhaps I am missing something, but I fail to see (or experience) how, for example, reducing the number of angiosperm families maximizes the information content of the system and makes the taxonomic scheme itself more predictive, as is being claimed by these authors.

The phylogenetic approach as practiced at present in essence aims to produce a special-purpose classification, one best constructed to reflect assumed genealogy (common descent). Whereas warnings against confusing a cladogram with a classification have merit, and the logical arguments behind phylogenetic classification are very questionable, such classifications are being produced and are the fashion of the day. To the phylogeneticist the primary goal of systematics is, understandably, phylogeny (e.g., Simpson, 2006). Or, as stated by Wheeler (2004): 'Because phylogenetic biologists are concerned with "tree thinking", their top priority is reconstructing trees.' *Yet, of all the attributes of plants of interest to society, phylogeny by itself must rank as one of the least significant.* What society is interested in is a stable classification that organizes and stores the properties of plants. Coincidentally, the phylogenetic classification has reasonable to good information storage capabilities and predictivity, because these properties are made possible by common descent (phylogeny), the same principle that forms the basis of the evolutionary approach. But whereas phylogenetic systems primarily reflect genealogy by focusing on the inferred nearest common ancestor and all of its descendents for defining taxa, evolutionary systems also take into account the expression of characters associated with evolutionary/adaptive specialization (modification), that is, degrees of difference.

**Modular plants and identification. —** The modern phylogenetic approach towards classification was established mainly by zoologists who extensively debated its principles and methods in the 1960s and '70s. Only since the 1980s have botanists started to actively adopt the same procedures. An often overlooked aspect is the fundamental difference between unitary animals and modular plants and the practical implications this distinction may have for ease of identification when a strict phylogenetic classification is adopted. As organisms of comparatively simple basic construction (roots, stems and leaves), the traditional classifications and day-to-day identification of plants rely heavily on macroscopically visible adaptive features of the reproductive module and other metamorphic structures. Association between structure and function is particularly pronounced in plants. In flowering plants, for example, the diagnostic differences between many traditional genera and families are strongly associated with different pollination and seed dispersal syndromes, the formal recognition of which (if supported by common descent)

in a classification is often responsible for rendering taxa paraphyletic. Yet these adaptive features ('canalized suites of functionally correlated traits' sensu Chase & al., 2000) are amongst the most useful properties for identification and the information requirements of society at large. Although the significance of divergence is acknowledged by many phylogeneticists, the insistence on monophyly in a cladistic sense as the primary demarcation criterion for families and especially genera often results in maximizing cryptic (often esoteric) phylogenetic information content, but also the loss of more pragmatic visual information reflecting adaptive radiation (divergence).

**Converting cladograms into classifications. —** The recognition of only monophyletic (holophyletic) taxa is at the centre of the rather mechanical methods employed by phylogeneticists to convert cladograms into classifications (also see Brummitt, 2002). The obsession with monophyletic taxa and vehement rejection of paraphyletic groups by cladistic thinking not only conveniently avoid the hassle of having to accommodate in a classification the very many adaptive plesiomorphic and apomorphic characters expressed by plants, but it also does not make it essential for compilers of such classifications to have an intimate knowledge of the plants themselves. Phylogenetic taxonomists rely heavily on field/herbarium botanists to supply them with authentically named plant material, whereas in return they provide so called 'improved' classifications that often hamper and frustrate the work of those who must face the challenges of coming to grips with plant diversity in the real world, notably in regions of high floristic diversity. To evolutionary taxonomists the perceived fanaticism with which the phylogenetic approach rejects formal recognition of paraphyletic groups, especially at generic and family level, is peculiar. It is tempting to recall the observation of philosopher George Santayana (1905): 'Fanaticism consists in redoubling your effort when you have forgotten your aim.' But then, the primary aim of phylogenetic systematics is to reflect phylogeny—admittedly also a valid one in terms of service to society—not to provide general-purpose classification systems. To justify their essentially academic pursuit, phylogeneticists are turning cladograms into classifications, the latter mistakenly seen by many uninformed end-users as modern, improved general-purpose classifications.

One of the major weaknesses of earlier evolutionary classifications was the lack of a rigid methodology to reconstruct phylogeny. The development of cladistics and other methods utilizing molecular data for inferring phylogenetic relationships have caused a revolution in plant systematics. For the first time classifications can be constructed based on sound phylogenetic hypotheses combined with appropriate recognition and interpretation of character evolution. Moreover, the power of these methods also lies in their transparency and reproducibility. It is ironic that at a time when phylogenetic understanding is at an all time best, the usefulness as perceived by end-users of the classifications produced by phylogeneticists has deteriorated, sometimes to the point of becoming absurd. On the other hand, one must acknowledge that the phylogenetic information has vastly improved the traditional evolutionary systems, especially at the higher levels (notably ordinal) of the taxonomic hierarchy. At these higher levels monophyletic groups are often desirable in view of a paucity of coherent morphological attributes. Was it not for the phylogeneticists' refusal to recognize paraphyletic taxa at mainly generic and family level, we now for the first time would have come close to the ideal general-purpose classification, the unattainable ideal perceptively referred to by Johnson (1970) in his classical paper entitled: 'Rainbow's end: the quest for an optimal taxonomy.' What is perceived as a lost opportunity to better serve society is one of the main reasons for the call for the acceptance of paraphyletic taxa.

**Serving the needs of society. —** At present the phylogenetic approach is flourishing to the detriment of the evolutionary approach. These successes are largely driven by rapid technological advances in molecular techniques and the confidence of revolutionaries imparted to phylogeneticists by the *Zeitgeist* of our time (similar to the upsurge of taxometrics in the 1960s and '70s, as highlighted by Johnson, 1970), all promoted by excellent salesmanship and the availability of research funding. Ideally the driving force should have been the needs of biology and society. Modern textbooks of plant taxonomy are unbalanced by defiantly promoting the phylogenetic approach, with little or no mention of the alternative evolutionary approach, thus giving students an indoctrinatory one-sided view of plant taxonomy as a science.

But is it fair to blame 'tree thinking' phylogeneticists for not promoting the philosophies and methods of the evolutionary school? Where are the evolutionary taxonomists? Where are the text books on plant taxonomy and the scientific papers that unashamedly promote an evolutionary approach—an approach that not only employs modern methods of phylogenetic inference but also utilizes the powerful judgemental reasoning of the human mind to produce superior general-purpose classifications to serve the real needs of society? Criticizing phylogenetic classifications would seem a rather wasteful and sterile pursuit without offering competing evolutionary alternatives. Instead, evolutionary taxonomists have a golden opportunity to cash in on the improved phylogenies that now become available and translate them into evolutionary classifications with powerful information-storage, predictive and identification advantages, and to promote these among end-users of plant names.

Undoubtedly, part of the current evolutionary taxonomic impasse is an apparent 'identity crisis' suffered

by many non-phylogenetic taxonomists. Surprisingly, many field and herbarium taxonomists frustrated (and dare one say, intimidated) by phylogenetic classifications are uncertain what to call their own preferred approach towards classification. 'Linnaean', 'classical', 'conventional' and 'traditional' are too easily read as 'out-of-date'; many also think a 'phylogenetic/cladistic' classification is synonymous with an 'evolutionary' one. Admittedly many traditional evolutionary classifications are indeed 'out-of-date', but this should not be seen as applying to the philosophical foundations of the evolutionary approach itself. Nordal & Stedje (2005) caption their letter 'Paraphyletic taxa should be accepted', which may sound to some as if permission from somewhere is needed to do just that. Fortunately acceptance of paraphyletic taxa is not prevented by any decree, natural law or code. In fact, it is *promoted* and *required* by the pragmatic and logical reasoning of the evolutionary approach. Nor is the approach towards plant classification being regulated, save for the historical constraints imposed by the traditional Linnaean hierarchy and nomenclature. Furthermore, the choice of classification system has always been and still is the prerogative of the end-user. This fact is not always appreciated, especially by the non-botanical community of end-users.

It is my hope that eventually proponents of the evolutionary and phylogenetic schools would join hands and work together towards best serving the needs of society. There is already considerable agreement in classification approach between the two schools and acceptance of paraphyletic groups where necessary would bring them much closer together. Such a step would be a major advance towards resolving an unfortunate controversy. Until then evolutionary taxonomists have a responsibility to practice what they preach, namely to produce general-purpose classifications based on the best phylogenetic evidence, but with full recognition of both paraphyletic and monophyletic taxa (especially genera and families) based on all available sources of taxonomic evidence. If this does not happen, plant taxonomy has failed society. Plant taxonomy, despite all its impressive achievements towards phylogenetic reconstruction, will then risk being denoted as yet another ivory tower science—a pursuit disconnected from the practical concerns and needs of everyday life; esoteric, over-specialized, its classifications of little practical use to the majority of end-users.

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