PLANT SYSTEMATICS: THE *SINE QUA NON* OF ECONOMIC BOTANY

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Summary

A fundamental objective of economic botany is linking a plant–derived product with the plant from which it came. Scientific binomials provide a universally accepted means of communicating the identity of plants. Common names for a species vary within and across cultures and are therefore insufficient designators. Moreover, one common name may apply to several species. Plant taxonomy or plant systematics is the discipline concerned with plant names and classification. Taxonomy has always been a fluid discipline and with the ever increasing quantities of molecular data that are available it is even more so.

Taxonomy is important not only in establishing a unique identifier for a plant taxon, but it also reflects phylogentic relationships among taxa. The International Code of Botanical Nomenclature provides the framework for plant taxonomy and knowledge of the code facilitates the understanding of plant names. The correct name for a plant product is a necessary but insufficient requirement. Voucher specimens deposited in herbaria serve as permanent records which allow the verification of plant names by taxonomic experts. They also permit changing names as taxonomic circumscriptions change.

1. Introduction

Economic Botany is the study of plants that are of direct importance to humans. However, the definition begs the question as to what constitutes a plant. During most of recorded history, the natural world was divided into animal, vegetable or mineral. The advent of the microscope in the 1600s led to the recognition of single-celled organisms. These newly discovered life forms were placed in either the animal phylum Protozoa or the plant division Thallophyta. In 1894, Ernst Haeckel suggested creating a third kingdom Protista that would include all single-cell organisms.

Herbert Copeland's elucidation of the prokaryotic cell structure of bacteria prompted him to place them in a distinct kingdom, now known as Monera. In 1969, R.H. Whittaker segregated the Fungi into their own kingdom. His five-kingdom system became a standard for biology texts in the 1970s and 1980s. Subsequently, Carl Woese divided the prokaryotes into two kingdoms – the Eubacteria and Archaebacteria. The six-kingdom system has become widely accepted. In 1990, Woese proposed that the Eubacteria, Archaebacteria, and Eukaryota represent three primary lines of descent and accordingly he promoted them to domains, renaming them Bacteria, Archaea, and Eucarya. What once were recognized as plants, are now distributed among at least four kingdoms.Plants are autotrophic eukaryotic organisms. Their circumscription sometimes includes autotrophic prokaryotic forms, especially cyanobacteria. Largely for historical reason, introductory botanical texts include the fungi. The study of human uses of fungi has its own moniker – ethnomycology. Simple plant forms, including microscopic and macroscopic algae are utilized by human cultures throughout the world, as are "bryophytes," a non-monophyletic group that includes hornworts, liverworts, and mosses. Nonetheless, the plants with the greatest human importance are the tracheaophytes or vascular plants. These can be divided into three groups, the lycophytes, the ferns, and the seed plants. Five groups of seed plants are extant: Gnetophytes, Conifers, Ginkgo, cycads, and the angiosperms. Of these the angiosperms are the most important for human survival. Conifers are significant as well, especially as sources of timber.

2. Overview of Plant Taxonomy

The most fundamental question regarding human plants is a taxonomic one. What is it? While folk names vary across and even within cultures, scientific nomenclature demands that a species has one and only one accepted binomial in any given system of classification. Plant systematics or plant taxonomy has two primary objectives. The first is a practical one – the identification of diversity. The second is a cognitive one – understanding relationships among organisms. Both objectives are important in the study of economically important plants. Unless a plant can be unambiguously identified, there is no certainty of repeatability, the fundamental underpinning of science. Identification requires a unique name – the scientific binomial.

The term taxonomy, first used by De Candolle in 1813, is derived from the Greek roots - taxo (arrangement) and nomy (related to laws). Taxonomy is the study of nomenclature, description, classification, identification, and relationships. All five aspects of the discipline are relevant to economic botany. Nomenclature is an

international employed system of naming plant taxa. Common names need not follow a single classification system and are therefore inadequate labels. In Brazil, *Plectranthus* species (Lamiaceae) are known as boldo. In Chile, boldo refers to *Peumus boldus* (Monimiaceae). Common names for *Pluchea carolinensis* (Asteraceae) include bushy fleabane, cough bush, cure-for-all, Indian tobacco, la choige, salvia de la playa, saab, salvia cimarrona, Santa Maria, sour bush, shrubby fleabane, sour bush, tabac diable, tabac zombie wild tobacco.

The most frequently used moniker is salvia. However, salvia or its variants also refer to *Austroeupatorium inulifolium*, *Chromolaena odorata*, *Hyptis suaveolens*, *Neurolaena lobata*, *Salvia divinorum*, *Salvia officinalis* (culinary sage), *Vernonanthura patens* and many others (see Appendix 1 for author citations and family names of all binomials cited in the text). Description is the recording of a complete set of character states of plants. Classification is the hierarchical ordering of plants into appropriate taxa. The two latter fields are the exclusive domain of taxonomists but knowledge of these subdisciplines are important to all plant researchers. Identification is the assigning of a plant to the correct taxon of an appropriate rank. This may be exceedingly difficult for a researcher who has access to only a small portion of a plant sample. Relationships refer to evolutionary relationships rather than phenetic similarities. Nomenclature, identification and phylogenetic relationships are the areas most relevant to economic botany.

Taxonomy is a fluid discipline. In 1957, Lincoln Constance wrote that "plant taxonomy has not outlived its usefulness: It is just getting under way on an attractively infinite task." John Heywood compared it to the stone of Sisyphus. The fluidity frustrates non-taxonomists who often complain about ever-changing taxonomic names. Taxa, however, are best thought of as hypotheses. New data and analyzes yield new circumscriptions, which often require new names.Taxonomy has been characterized by many approaches, culminating (for now) with phlylogenetics methodology, which began to dominate in the 1980s. Despite rapid changes in the past two decades, modern nomenclature dates to Carl von Linné or Carolus Linnaeus (1707-1778) who established the scientific binomial system of nomenclature. The publication date of Species Plantarum (May 1, 1753) is the starting point for modern taxonomy. Linnaeus's most enduring contribution was his consistent use of the binomial system, in which each species was referred to by two names, the genus name and the specific epithet.

Linnaeus developed a system of *nomina trivialia*, to supplement the phrase-names used in contemporary systems of classification. He named the tomato *Solanum caule inerme herbaceo, foliis pinnatis incisis, racemis simplicibus.* Linnaeus introduced the trivial names as an indexing device. In the margin of Species Plantarum, he gave tomato the trivial name of *lycopersicum*. The trivial name or specific epithet when combined with the generic named formed the binomial – *Solanum lycopersicum*. By the time of his death in 1778, binary nomenclature was firmly established. Linnaeus was not the first to employ binomials. Gaspar Bauhin had employed two-parted names more than a century and half earlier.

After Linnaeus, taxonomy continued to progress, adopting Darwin's evolutionary concepts after the 1859 publication of On the Origin of Species. Evolutionary theory

ended the fixed species concept of earlier periods and introduced the idea of evolutionary histories or phylogenies. H.G.A. Engler (1844-1930) and K. Prantl (1849-1893) wrote the multivolume Die Naturlichen Pflanzenfamilien from 1887-1915, others continued it until 1953. It served as an update of Species Plantarum. Engler and Prantl arranged plants in an evolutionary sequence beginning with putative primitive taxa and ending with more derived ones. Until the 1980s, most floras were arranged by the Engler and Prantl system. Cronquist's system, defined in his 1981 An Integrated System of Classification of Flowering Plants was employed during the 1980s and 1990s.

During the 1990s, studies of flowering plant phylogeny significantly increased. Molecular data, especially the plastid gene rbcL provided new data information to construct phylogenies. The Angiosperm Phylogeny Group (APG) published a seminal paper in 1998 ---An ordinal classification for the families of flowering plants.

The new phylogeny revealed relationships that often differed with contemporary classifications (e.g. Cronquist, Thorne, Takhtajan). The initial APG system comprised 462 families arranged in 40 putatively monophyletic (any taxon that includes its common ancestor and all its descendents, but no others) orders and a few monophyletic higher groups.The APG system was revised 5 years after its initial publication (APG II 2003). It provided a revised and updated classification of flowering plants. New orders were adopted and several major families were recircumscribed. For example, Salicaceae was expanded to include a large part of Flacourtiaceae. Euphorbiaceae was restricted to uniovulate taxa.

Other former members of the family were placed in Phyllanthaceae or Picrodendraceae. Scrophulariaceae was recircumscribed to include Buddlejaceae and Myoporaceae. Other members of the family were assigned to Calceolariaceae, Orobanchaceae and Plantaginaceae.

3. Botanical Names

Botanical classification, like that of other organisms is hierarchical. Apart from domain, kingdom is the most inclusive category, followed by division, class, order, family, genus, and species. The suffixes of names at the familial rank and above indicate their ranks (Table 1). Intermediate categories are sometimes recognized, and are indicated by the prefix sub. Subfamilies may be further divided into tribes; subgenera into sections. Infraspecific divisions include subspecies, variety, and forma.

Rank	**Ending**
Division	-phyta
Class	-opsida
Order	-ales
Family	-aceae
Subfamily	-oideae
Genus	-

Table1. Suffixes for plant taxa by rank.

3.1 Nomenclature

The rules of nomenclature are outlined in a series of codes. Plant nomenclature is governed by the International Code of Botanical Nomenclature (ICBN). The ICBN is based largely on rules established at the International Botanical Congress in Cambridge (1930). Codes are amended every six years at the IBC and commonly referred to by the name of the host city. The latest is the Vienna Code, which is available at: http://www.ibot.sav.sk/karolx/kod/0000Viennatitle.htm.

The ICBN has several principles. Among those relevant to economic botany are:Principle IV - Each taxonomic group with a particular circumscription, position, and rank can bear only one correct name, the earliest that is in accordance with the Rules, except in specified cases. In other words, there is only one accepted name for a taxon in any system of classification. This is where scientific taxonomy differs most significantly from folk taxonomy.

The number of folk names applied to a single taxon has no limit.Principle V - Scientific names of taxonomic groups are treated as Latin regardless of their derivation. All names must be in Latin form, written in the alphabet and subject to the rules of Latin. Supraspecific names are capitalized (e.g. Verbenaceae, *Citharexylum*)

3.2 Supraspecific Names

Supraspecific names are uninomials. They are capitalized and written in italics or underlined. The suffixes of suprageneric names these names indicate their rank (Table 1). Plant families end in the suffix “aceae.” There are significant exceptions to this orthography and to Principle IV for eight plant families.

These families can be designated by their current name, which ends in “aceae” or by a conserved name. For example, the palm family correctly may be called Arecaceae or Palmae (Table 2). Finding information about these families often requires searches with both names.

Standard Name	Accepted Conserved Name
Arecaceae	Palmae
Apiaceae	Umbelliferae
Asteraceae	Compositae
Brassicaceae	Cruciferae
Clusiaceae	Guttiferae
Fabaceae	Leguminosae
Lamiaceae	Labiatae
Poaceae	Graminae

Table 2. Families that may be referred to by either of two names.

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Biography Sketch

Dr. Bennett is Director of the Center for Ethnobiology and Natural Products and a professor in the Department of Biological Sciences at Florida International University in Miami, Florida. He earned a B.A. in Biology and Geology from Bucknell University, and M.S. in Biology from Florida Atlantic University, and a Ph.D. in Botany from the University of North Carolina at Chapel Hill. He was the 2004-2005 president of the Society for Economic Botany and currently is an associate editor of the journal Economic Botany. He also is a member of the American Botanical Council's Advisory Board and the National Institutes of Health's National Center for Complementary and Alternative Medicine Special Emphasis Panel. His main research focus is Neotropical ethnobotany and ethnopharmacology. Dr. Bennett and his graduate students work in Bolivia, Brazil, Cameroon, Cuba, Costa Rica, Ecuador, Guyana, Japan, Mexico, Panama, Peru, and the U.S. Dr. Bennett's book Ethnobotany of the Shuar of Amazonian Ecuador won the 2006 Klinger Award from the Society for Economic Botany. His research has been published in Ambio, BioScience, Brittonia, Economic Botany, Selbyana, Journal of Tropical Ecology, and Journal of Ethnopharmacology.