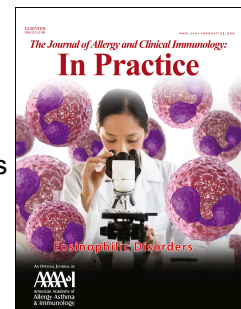


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The importance of binomial nomenclature for the identification of pollen aeroallergens

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ABSTRACT

The diagnosis and treatment of atopic disorders associated with specific aerobiological triggers require basic botanical training. However, the identification of specific pollen can often be confounded by broad naming conventions that range from categorized colloquial, to scientific names based on either higher taxonomic levels, or in some cases binomial nomenclature. Physicians specializing in allergy often lack a comprehensive understanding with respect to plant taxonomy and botanical nomenclature that are critical skills required for clinical practice and research programs evaluating pollen and airborne fungal spores. In addition, binomial and current family designation and synonyms, including author citation are often misused, causing a misinterpretation of existing plants species or pollen types. It is critical that the correct botanical name is linked to a validated specimen, and scientific naming conventions are used where possible by the clinician and researcher. In relation to pollen identification, we propose that clinicians and researchers should provide the currently accepted binomial nomenclature, offer relevant synonyms, and use the Angiosperm Phylogeny Group names.

Key words: pollen, allergy, clinical immunology, plant taxonomy, botanical nomenclature

Allergic diseases are prevalent in industrialized nations, and allergic rhinitis is the most frequent non-communicable disease^{1,2}. Airborne pollen, especially from wind pollinated (anemophilous) plant species are among the most important etiological agents of allergic rhinitis^{3,4}. Allergic sensitization to pollen has a worldwide distribution but is dependent on the regional contributions of endemic plant species. The pollen derived from these species are released into the atmosphere at various seasonal intervals throughout the year and personal exposure can result in unique aeroallergen sensitization profiles within a community.

Identification and quantification of airborne pollen by light microscopy continues to serve an important role to understand the spatial and temporal distribution of pollen allergen sources in a patient's environment⁵. However, the interpretation of the collected pollen types can often be confounded by broad naming conventions that continue to be used and range from categorized (weed), colloquial (ragweed) to scientific names based on either higher taxonomic levels (*Asteraceae*), or in some cases binomial nomenclature (*Ambrosia artemisiifolia*). The recent utilization of precision medicine in allergy and clinical immunology^{6,7} has seen an increased need to use scientific naming conventions for a variety of downstream processes that include allergen characterization, as well as the development of skin prick test extracts, component diagnostic techniques, and allergen-specific immunotherapy⁸.

The diagnosis and treatment of atopic disorders associated with specific aerobiological triggers e.g. allergic rhinoconjunctivitis, require basic botanical training. Physicians specializing in allergy frequently lack these skills, especially with respect to plant taxonomy and botanical nomenclature that are critical skills required for clinical practice and research programs evaluating pollen and airborne fungal spores⁹. In addition, binomial and current family designation, synonyms, including author citation are often misused, causing a

misinterpretation of existing plants species or pollen types¹⁰. It is critical that the correct botanical name is linked to a validated specimen and scientific naming conventions are used where possible by the clinician and researcher.

In most cases, questions regarding orthography, synonymy, and current family designations of most plant binomials can be solved using widely available published pollen atlases and online databases¹¹. Other electronic resources such as online keys software for smartphones and desktop computers, as well as automated classification approaches based on imaging technologies and more recently convolutional neural networks have also recently been developed to aid in the identification, classification, and quantification of plants and pollen captured in an image^{12,13,14}. In certain circumstances, consultation with a palynologist or plant taxonomist may be required. In relation to pollen identification, we propose that clinicians and researchers provide the currently accepted binomial where possible, provide relevant synonyms, and use the Angiosperm Phylogeny Group names¹⁵. This guidance also applies to scenarios where common plant names may vary according to different regions of the world due to folk and/or indigenous names provided to the same species¹⁶. It is equally as important that the binomial nomenclature along with the common name be presented to the general public. An example of some common pollen types and their scientific names are presented in Table 1.

Among the potential benefits of using binomial nomenclature is that the standardization of each allergen could help to avoid confusion among clinicians and researchers while performing literature searches, and the efficiency of care at different outpatient centers or geographical locations might also be improved due to patients knowing exactly the scientific name of the allergen they are sensitive to. However, we recognize that the additional training on binomial nomenclature might represent a challenge by itself since physicians might not be convinced or motivated enough to pursue additional training. Therefore, in real life a

multidisciplinary approach would be needed in which physicians should work closely with plant taxonomists to address the local components and geographical factors of aeroallergens to customize immunotherapy for individual patients and provide the needed training in binomial nomenclature.

The use of traditional palynological techniques for the identification of pollen have certain limitations to determine genus, species, or subspecies, as is the case of *Poaceae*¹⁷, *Cupressaceae*¹⁸, and *Moraceae/Urticaceae*¹⁹. However, the development of molecular biology techniques such as polymerase chain reaction and next generation sequencing have recently provided the use of binomial nomenclature for the identification of various species through the amplification of specific gene regions. Molecular phylogenetic analyses are now common place and these studies have provided unparalleled insights into relationships at all levels of plant phylogeny²⁰. At lower taxonomic levels, phylogenetic analyses have revealed the closest relatives of many crops and ‘model organisms’ for studies of molecular genetics, concomitantly pointing at possible relatives for use in comparative studies and plant breeding²¹. Furthermore, phylogenetic information has contributed to new perspectives on the evolution of polyploid genomes²². Other approaches such as immunoassays that use species-specific monoclonal antibodies, chemical-based methods, and even recently developed automated classification approaches are alternative methods that could also be used to assign binomial nomenclature to environmentally sourced pollen²³. Consequently, physicians will be forced to become knowledgeable about these methodological advances as well as the binomial nomenclature in their clinical practices and research programs.

In the era of big data, where research technologies and data collection methods are constantly evolving, it is essential that standardized keywords are used so that the search and association between them is optimal²⁴. This concept also applies to the identification of pollen collected in air samples. We propose that the currently accepted binomial, relevant

synonyms, and the Angiosperm Phylogeny Group names should be used where possible. The use of binomial naming conventions will have additional downstream implications for pollen monitoring networks and allow the comparison and analysis of pollen data for climate and health studies. Further, utilizing these naming conventions can also be applied to precision medicine²⁵ and provide improved *in vivo* and *in vitro* testing methods as well as immunotherapy reagents. This approach in combination with validated specimens will also be critical for the development of deep learning technologies and other automated methods to identify pollen.

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255 **Table 1.** Examples of common names of specific pollen species and their correct binomial
 256 nomenclature.

Common names	Binomial Nomenclature	Advantages of using binomial nomenclature instead of common names
Maple or Acer	<i>Acer pseudoplatanus</i>	- Avoids confusion of the same allergen among clinicians/researchers when performing literature searches.
Queen palm or cocos palm	<i>Syagrus romanzoffiana</i>	
Pussy willow or goat willow	<i>Salix caprea</i>	
Wormwood, sweet annie, or annual mugwort	<i>Artemisia annua</i>	-Contributes to the standardization of skin batteries used in prick tests.
Mountain cedar, Ashe juniper, or blue berry juniper	<i>Juniperus ashei</i>	
Osage orange, hedge apple, or bois d'arc	<i>Maclura pomifera</i>	-Improves the efficiency of treating outpatients at different centers/geographical locations since patients know exactly the allergen by its scientific name
American sycamore or American plane tree	<i>Platanus occidentales</i>	
Quaking aspen, trembling poplar, or white poplar	<i>Populus tremuloides</i>	

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