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VIEWPOINT

What every chemist should know about plant names

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Chemists screen plants for their constituents on a daily basis, and the data gathered is of importance to a wide range of fields such as medicine, evolutionary biology and ecology. However, the use of this data is sometimes impeded by incorrect citation of the species names. In this *Viewpoint*, I explain why chemists should be aware of the essentials of plant naming, and describe some easy quality checks that can be performed to avoid errors being perpetuated.

Why species names are important

Species names might seem to play only an insignificant role in the chemical literature, but they are of major importance, because using incorrect names can lead to confusion and errors later on. Each plant species produces a characteristic set of hundreds of ecologically important metabolites that can serve as a 'fingerprint' for the species,[1] and certain classes of chemicals seem to be typical of certain groups.[2] For example, betalains occur exclusively in the plant families belonging to the order Caryophyllales,[1] so if a species with betalains is incorrectly identified, one might conclude that these chemicals also occur outside the Caryophyllales – in other words, the evolutionary significance of this chemical character would be compromised. The incorrect use of species names can thus hamper the drawing of valid conclusions about the evolution of these species or the relationships between species – or it could make the research go completely unnoticed.

Incorrect species naming can also have an impact in an area with a commercial value of billions of dollars – non-protein drugs. Natural products have long been recognized as an important source of therapeutically effective medicines.[3] In order to find alternative biochemically active variants of certain molecules in Nature, one could randomly screen many plants, which is economically highly unfavourable. On the other hand, one could screen related species, since the chance is high that they contain similar but slightly different molecules.[2] Incorrect naming would therefore lead to incorrect selection of species for screening. An example of this is *Guatteria gaumeri* (also called '*yumel*') (see Fig. 2A), a medicinal plant used in Mexico to treat – amongst other conditions – hypercholesteraemia (high blood cholesterol) and cholelithiasis (gallstones).[4] However, a researcher interested in this medicinal plant and wanting to find data on other species from the same genus should not just screen species from *Guatteria*, because the taxon of interest has been renamed and placed in the separate genus *Mosannona*.[5] The species in question should now be named *Mosannona depressa*, *Guatteria gaumeri* being a so-called synonym (or 'former name') of this species. Unfortunately, due to the nature of the publication in which the renaming appeared,[5] the change has gone more-or-less unnoticed, resulting in the wrong name being replicated in the literature until last year.[6]

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How biologists view species

The term 'species' is deeply ambiguous, although to the non-biologist it may seem very clear. We all talk about species of tulip, oak or dandelion. But this is just the result of a superficial view – biologists have defined over 20 species concepts,[7] meaning that there are more than 20 methods to delineate the boundaries of a species. The simplest method is based on morphology (the *morphological species* concept) which states that any observable difference between two taxa can serve as a separating character (*e.g.* two oaks can be different because acorn- or leaf-size differs). Another widely used concept is the *biological species concept* which states that two taxa† are distinct species when they cannot interbreed and yield fertile offspring. A lot has been said about this concept, but the obvious problem is how to test whether this

† *Taxa* is the plural of *taxon*, meaning any named group of organisms.

is true in Nature – for instance, for large trees in a rainforest. Other concepts exist, some easy to use, some enormously impractical. To make it more complicated, the importance of these concepts also differs between major groups, being of true importance for plants and animals, while less so for micro-organisms (indeed, in this group the question is whether one can speak of species at all). The important point is, however, that using different concepts can lead to the recognition of two species by a researcher where another just sees one. Species can therefore best be characterized as *hypotheses* about the distribution of variation in Nature – hypotheses that can be subject to verification or refutation on the basis of new data.[8] Since recognizing a species is therefore not as straightforward as it may seem, knowing how to check a species' identity before publishing an article about it is of great importance.

How to read a species name and description

Biologists discover on average two species per hour (or 18,000 species per year). Of these, approximately 12% are plants,[9] averaging to some 6 new species per day. In biology, describing a species as 'new' means that it has become known to science for the first time. The reason for this might be that biologists only recently discovered the species in the field, but it is also possible that the specimens were lying in a museum or herbarium collection, but were not recognized as new.

Once a researcher has established that the specimens indeed form a new species, the plant has to be named and a description published officially. The naming of plants is regulated by the International Code of Botanical Nomenclature (ICBN) and the International Code of Nomenclature for Cultivated Plants (ICNCP).[10] A plant name is considered correct if several conditions are met. Firstly, the name should be published effectively, meaning that it should be distributed (*via* printed matter) to the general public, or at least to botanical institutions with accessible libraries. Secondly, the name should be valid and legitimate, meaning that the rules about how plant names are formed are followed, and that some basic information about the species is present (such as a complete description). The name must also be associated with a single specimen deposited in a herbarium – the so-called *holotype*. Any duplicate of the holotype (*i.e.* parts of the same collection taken at same time from the same plant) is called an *isotype*. Which specimen is designated as the holotype (and where you can find it) is mentioned in the publication describing the new species. An example of a species description for a new species is given in Fig. 1.

Biologists classify the living world according to a fixed scheme, with species being the central element. The most essential

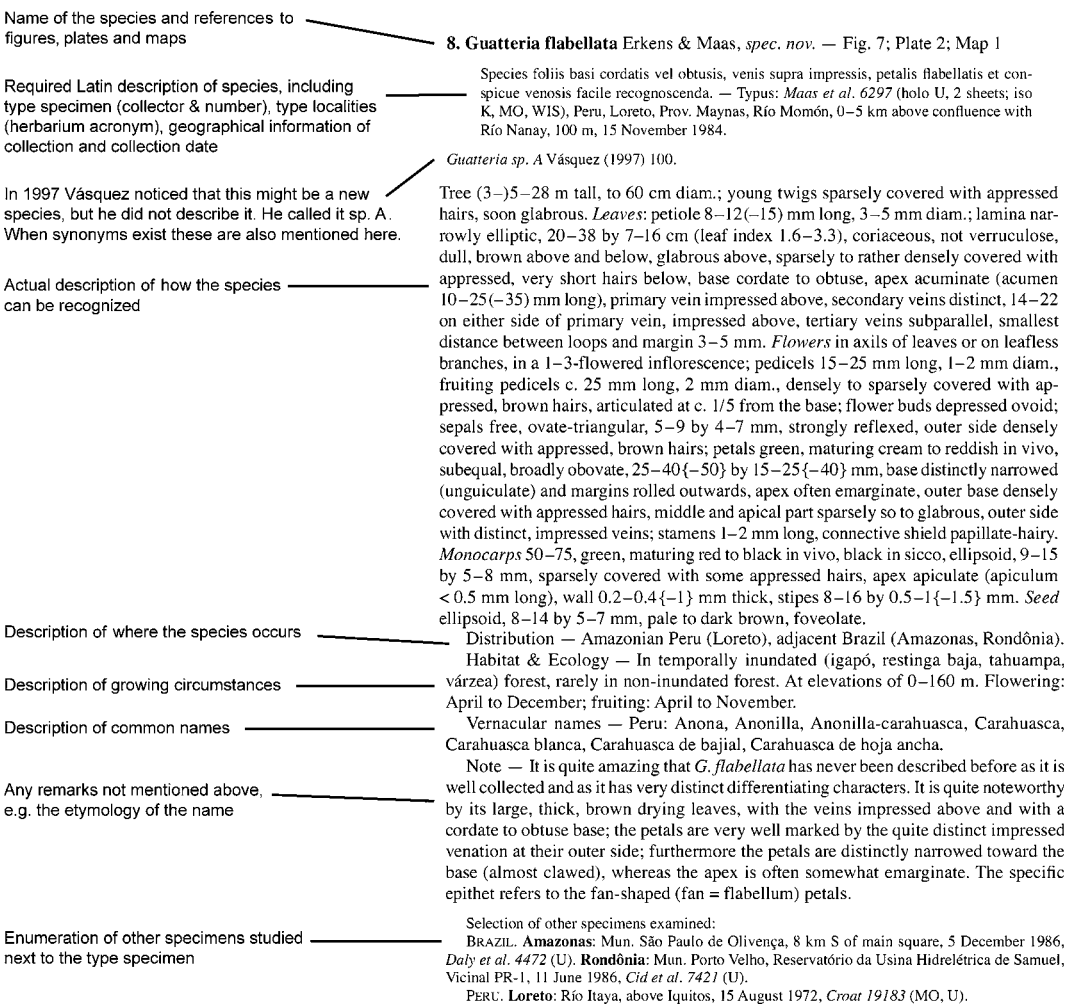

Fig. 1 Example of a species description for a new species with an explanation of the different parts (reprinted with permission from R. H. J. Erkens, L. Y. T. Westra and P. J. M. Maas, *Blumea*, 2008, **53**, 467–514).

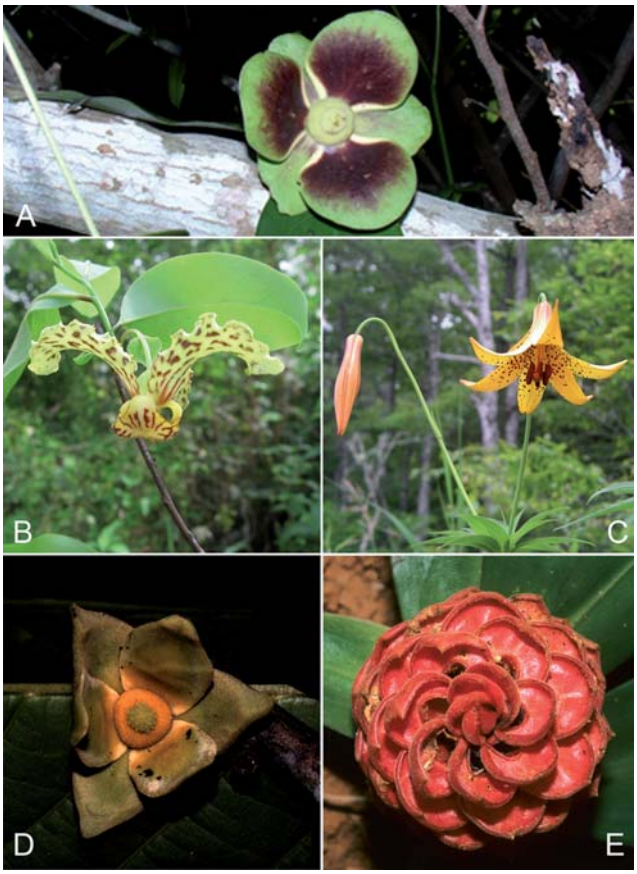

Fig. 2 Photographs of species mentioned in Table 1 and the main text: A: *Mosannona depressa* (Baill.) Chatrou (formerly known as *Guatteria gaumeri* Greenm.); B: *Monodora carolinae* Couvreur; C: *Lilium canadense* L.; D: *Guatteria megalophylla* Diels; E: *Costus ricus* Maas & H. Maas.

categories (so-called 'taxonomic ranks') are species, genus, family, order, class, phylum, kingdom and domain. Except for the highest ranks, one can see from the name of the taxon which rank it has. Class names always end in -iopsida (*e.g.* Bryopsida, the mosses), orders end in -ales (*e.g.* Magnoliales, the order of the Magnolia) and families end in -aceae (*e.g.* Rosaceae, the rose family). Genus names are latin or latinized nouns and written in italics with an initial capital (*e.g. Tulipa*, the tulip genus). To construct a species name, one combines the genus name with a specific epithet, which functions as an adjective, and is also latinized (but lower-case) – *e.g. Quercus alba* (the White Oak) or *Quercus robur* (the English Oak). Species names can etymologically be derived from several sources (Table 1).

In taxonomic (but not always in general scientific) publications the species name is followed by the name of the person(s) who first validly published the name, in upright type – *e.g. Guatteria rostrata* Erkens & Maas. This is often referred to as the *botanical authority*.[11] Depending on the name, this is written out in full or abbreviated (*e.g.* L. is an abbreviation for Linnaeus, as in *Acer campestre* L., the common Field Maple). Often two author names are cited, with the first being in parentheses (*e.g. Guatteria guianensis* (Aubl.) R. E. Fr.). This indicates that the first author validly published the name, but that the second author placed it at a different rank or in another genus. In this example, the species was first described by Aublet as belonging to the genus *Aberomoa*, but Robert Fries considered it to belong to the genus *Guatteria*, and so gave it its current name. The original name is called the *basionym*.

How to check a name

Although it might seem that plant names (and species names in general) are set in concrete, names can change. The most common reason for a change is misidentification: a name was applied to the wrong taxon (*i.e.* an oak was thought to be a maple). Another often-encountered reason for a name change is the description of a 'new' species that actually already existed under another name. The new name is thus incorrect, and should be abandoned in favour of the pre-existing name. Also, a name can be given that already exists, in which case a new name has to be given. Lastly, new data might reveal a previous species actually to be two species (or two to be one). In short, new or misinterpreted data, or new taxa, can lead to new/changed species names. It is important to realize that some of these changes are indicated in the name of the species, since they are reflected by the authors mentioned after the name, as explained above.

Chemists understandably do not keep up with these changes (and in all fairness many biologists also do not). The result is that some names are repeated in the literature despite having been synonyms of the correct name for a long time (like the *Guatteria gaumeri* example above). However, it is fairly easy to check the identity of a specimen if one knows the collector and the collection number, because a detailed list is made of the specimens collected in the field by each biologist. So, although species names may change, this number stays the same. Therefore, it is important to mention these numbers in primary phytochemical publications. In addition, one should deposit voucher specimens in a herbarium, as in this way the identity of the specimen can always be checked at a later date.

It can be argued that name changes make the process of retrieving information more difficult, and to many non-taxonomists, it might seem that having different names for the same organism makes matters unnecessarily complicated. Therefore, many scientists do not like to change names between publications, especially in ongoing studies. Although understandable, correct name usage is important, as explained above. In ongoing

Table 1 Examples of species names and their etymology; see Fig. 2 for a photograph of each species

Species name	Etymology of specific epithet	Meaning
Monodora carolinae	Commemorative	*carolinae*: named after the author's wife, Carolina
Lilium canadense	Geographical	*canadense*: from Canada
Guatteria megalophylla	Descriptive	*megalophylla*: *megalos* (large) + *phyllon* (leaf), referring to the large leaves
Costus ricus	Nonsense	*ricus*: no meaning – the plant was identified as belonging to the genus *Costus*, and, because it was collected in Costa Rica, the author decided to play a botanical joke by giving it this specific epithet!

studies it might therefore be useful to refer to the old and new name together (*e.g.* plant X previously known as Y), to at least assure retrievability of the information. In the case of literature searches for phytochemical constituents, one could easily overlook publications in which constituents have been published using obsolete plant names.

How to find the correct name

If you have a collection of a plant, and want to know its correct name, several specimen-based checks of the identification are possible:

- Show or send the specimen to a taxonomist or botanically knowledgeable person with the skills to identify the plants under study.
- Visit collections of plants in museums and herbaria, and compare your specimen to the specimens in the collection that have been named by specialists in the group.
- Look up information on the plants in floras and fieldguides that describe the flora of the region you are working in.
- Look up information on the plants in publications that describe the species in a certain group (these are called *revisions* or *monographs*, and usually cover all the species in a genus).
- Refer to online databases. The most important database is Tropicos (http://www.tropicos.org/), with over one million scientific names and 3.5 million specimen records collected and compiled by the Missouri Botanical Garden. Here one also finds links to other useful online resources.

If you just want to check if the name you're using is still valid, you can use several other sources of information:

- *Mabberley's Plant-book* (D. J. Mabberley, Cambridge University Press, 3rd edn, 2008): this book is an essential reference text for anyone studying or writing about plants. It provides information on every family and genus of seed-bearing plants (including gymnosperms), plus ferns and clubmosses, and contains taxonomic details and uses along with vernacular names.
- *International Plant Names Index* (http://www.ipni.org/index.html): a database of the names and associated basic bibliographical details of seed plants, ferns and fern allies. This database facilitates the lookup of literature about species names, but just because a name-listing is present does not mean that it is valid.
- *Index Nominum Genericorum* (http://botany.si.edu/ing/): a compilation of generic names published for all organisms covered by the ICBN. The electronic version is a draft edition, and is constantly being revised as new information becomes available. At the time of writing, this database is fairly current up to and including 1990.
- *World Checklist of Selected Plant Families* (http://apps.kew.org/wcsp/home.do): a database with information on the accepted scientific names and synonyms of (so far) 151 selected plant families. Next to the scientific names of a particular plant, the database also provides details of its global distribution.

Finally, some more general information that can help in understanding taxonomic practice is available:

- *Describing Species* (J. E. Winston, Columbia University Press, 1st edn, 1999): this book deals with all aspects related to species descriptions, and is an easy introduction to the world of taxonomy.
- *Index Herbariorum* (http://sciweb.nybg.org/science2/IndexHerbariorum.asp): an online index that lists all herbaria of the world. Each entry includes the herbarium's acronym, physical location, web address, contents (*e.g.*, number and type of specimens) and history, together with names, contact information and areas of expertise of associated staff.

Conclusion

In my opinion, when chemists are writing and publishing primary phytochemical research, they should put serious effort into the correct naming of their plants. This may not always be an easy task, but it will improve the quality and usefulness of the work. In particular, care should be taken to use the currently accepted names, ideally with mention of any synonyms (*e.g.* taxon Y formerly known as X), along with citation of the botanical authorities.

In phytochemical review articles, one should preferably devote a paragraph or so to describing how determinations of plants were checked, which databases were used, or who was consulted (as was done in a review of isoflavonoids from the Leguminosae (Fabaceae)[12]). The above-described sources of information are a good starting point for this. However, it might not always be feasible to cite synonyms and botanical authorities in the text (especially in reviews of complicated taxonomic groups). In such situations, one should use accepted names throughout the main text, but consider listing their synonyms and the botanical authorities in the electronic supplementary information. This ensures that the main text is not unnecessarily complicated, while making the information retrievable. Most of this information will be gathered during the writing of a review anyway, so it might as well be shared to benefit us all!

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