Suggestions for a new species nomenclature

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The *PhyloCode* (Cantino & de Queiroz, 2003), which intends to replace the current international codes of nomenclature (bacterial, botanical, and zoological; or *ICNBa*, *ICBN*, *ICZN*), is a rank-free system in which traditional Linnaean categories such as genus, family, or order are abandoned. It is important to note that the current version of the *PhyloCode* is a rank-free code of nomenclature only, and not a set of rules for rank-free classification (although we are in favor of both rank-free nomenclature and classification to avoid any confusion concerning ranks). Only two types of taxa exist under the *PhyloCode*, species and clades, and the terms "species"and "clade" refer to "different kinds of biological entities, not ranks" (Note 3.1.1; most recent revision December 21, 2003). Because the *PhyloCode* governs only the naming of organisms, and not classification, species names should not convey information (or misinformation) about supra-specific classification. However, the current binominal species nomenclature, which is based on a combination of a generic name and a specific epithet, by its very nature conveys information about supra-specific classification. Therefore, it is not compatible with the independence of names and classification proposed in the *PhyloCode*. Furthermore, the use of binominal species names also is not compatible with the absence of a mandatory genus rank under the *PhyloCode* (Cantino & al., 1999). These issues are especially problematic because the current draft of the *PhyloCode* only governs clade names; it does not deal with species names. We are promised (p. 3) that "rules governing species names will be added in the future", but an official schedule is not provided.

We assert that the *PhyloCode* should not be implemented if no method for naming species is proposed (currently, this implementation is scheduled to occur with the publication of the symposium volume based on the First International Phylogenetic Nomenclature Meeting, which will be held in July, 2004, Paris). Otherwise, we may face the paradoxical situation where the *PhyloCode* would oblige systematists to continue using the current rank-based codes for species names.

There are two main classes of possible methods for naming species in the *PhyloCode*: those that maintain a binominal form, and those that are epithet-based. For the reasons mentioned above (i.e., distinction between names and classification, and the absence of a mandatory genus rank, and thus generic names), we reject the binomial-based methods that have been proposed for use with the *PhyloCode*. The potential for confusion is particularly striking in the case of the creation of new species names. Therefore, we argue that the solution is for species names to become epithet-based. A problem that must be solved in this context is how to guarantee the uniqueness of epithet-based species names, considering that many species share the same epithet.

We present an epithet-based form of species name that is fully compatible with the rank-free system of the Phylocode, in which the genus rank does not exist. Also, it guarantees uniqueness in all situations. However, we do not intend to argue that species names under the *PhyloCode must* follow the method we describe, although we find it convenient. Instead, we wish to stimulate a needed debate on the form of species names in a rank-free system.

The absence of rules for species names in the *PhyloCode*. — A discussion of species nomenclature is conspicuous in its absence from the current draft of the *PhyloCode*. Several issues could account for the delay in proposing a form for species names. For example, there is disagreement on whether or not species should be considered "biological entities" distinct from clades, and several authors have suggested that the status of species as a special biological "entity" be abandoned in Phylogenetic Nomenclature (e.g., Mishler, 1999; Pleijel, 1999). However, the form of "species" names is independent of one's opinion on the distinction of species and clades, and consensus must be reached on the rules for naming the least-inclusive taxa, regardless of whether they are "species", "least-inclusive clades", or "fundamental units".

A related debate concerns how "species" names should be defined (e.g., Lee, 2002). This question is of primary importance because it will determine if "species" names will be based on type specimens (as in the current codes) or by means of phylogenetic definitions (similar to clades in the *PhyloCode*). Moreover, it is related to broader issues, such as the applicability of phylogenetic methods at the intra-specific level, where

(according to the Hennigian framework) relationships are tokogenetic, not phylogenetic.

Finally, no method for naming species that agrees with the rank-free *PhyloCode* has been agreed upon, although several possibilities have been described (Cantino & al., 1999).

Our goal is not to discuss the conceptual issues surrounding the nature of "species", but rather to address the form that species names should follow in the *PhyloCode*. This must be dealt with regardless of whether species are qualitatively different than higher clades, or if phylogenetic definitions should be provided when establishing species names. Furthermore, a convincing form of species name is critical to impel taxonomists and users of taxon names to adopt the *PhyloCode*.

On uniqueness, homonymy, synonymy. — In the current codes, uniqueness applies to all so-called "legitimate" (*ICBN*, *ICNBa*) or "available" (*ICZN*) names. All of the current codes prohibit homonymy (both primary and secondary), and this framework guarantees that a particular combination of a genus name and species epithet is unique. In the context of the current codes, the uniqueness of names is a nomenclatural issue that should not be confused with the notion of "correct" (*ICBN*, *ICNBa*) or "valid" (*ICZN*) names. A valid (or correct) name is the name selected among all the available (or legitimate) names that refer to the same taxon. The selection of valid (or correct) names is regulated by a set of nomenclatural rules, such as priority, but it also depends on taxonomic knowledge. All available (or legitimate) names that are not valid (or correct) are synonyms.

Uniqueness also is one of the most basic principles of the *PhyloCode*, but its usage there conflates the nomenclatural and taxonomic issues. In the current draft of the *PhyloCode*, the term "uniqueness" at times refers to the nomenclatural uniqueness of names, which is guaranteed by the rejection of homonyms. However, it also is used in the context of the validity (sensu *ICZN*) or correctness (sensu *ICBN*) of names (p. 16): "Uniqueness. To promote clarity, each taxon should have only one accepted name, and each accepted name should refer to only one taxon". Likewise, Article 14 (synonymy) of the current draft of the *PhyloCode* states (p. 36): "If there are two or more synonyms for a taxon, the accepted name for that taxon is the earliest acceptable one that applies to it, except in cases of conservation". In other words, under the *PhyloCode* synonymous names that are not "accepted" remain "acceptable". Selecting an "accepted" name among several "acceptable" names in the *PhyloCode* depends on priority and a particular phylogenetic context; exactly as selecting a "valid" (or correct) species name among several "available" (or legitimate) names in the *ICZN* (or *ICBN*) depends on priority and a particular taxonomic context.

We are interested in how the uniqueness of "acceptable" species names can be ensured in a rank-free system such as the *PhyloCode*, regardless of further decisions on their actual status (e.g., whether or not they should be "accepted"). This is a difficult problem because the abandonment of the genus rank means that uniqueness can no longer be guaranteed through the binominal combination of a genus name and species epithet. The uniqueness of clade names in the *PhyloCode* is guaranteed by requiring them to be uninominal and rejecting homonyms. Such an approach would not work for species, however, because many epithets such as *nigra*, *alba*, or *vulgaris* are shared by different species. If species names consisted only of single words, most would not be unique. A potential solution to this problem can be found in a species nomenclature first proposed in a non-phylogenetic context by Url Lanham in 1965, but that surprisingly has not been considered since.

On Lanham's method for species names. — In a brief but visionary article titled "Uninominal nomenclature", Lanham (1965) proposed a species nomenclature in which species names would be both unique and stable. Lanham's goal concerning species names was clear: "A binominal combines three functions: it designates by means of a unique name, it provides a filing system, and it indicates evolutionary relationships. Of these three functions, the only one logically demanded by nomenclature in the abstract is the first. It is possible to uncouple the last two functions from the designatory function with an essentially uninominal device already in use as a bibliographic tool: to have the name of the organism consist of the specific name ("latinoid" in form), followed by the author's name and the date and page of publication". (Lanham, 1965: 144) Thus, under Lanham's method the Linnaean binominal species name *Montereina nobilis* would be converted into the epithet-based name *nobilis* MacFarland, 1905: 38. Because it is epithet-based, and does not refer to any taxon name of genus rank, Lanham's method is fully compatible with the rank-free system proposed in the *PhyloCode*.

Ironically, Lanham's goal was not to propose a nomenclature compatible with a rank-free system or even with a phylogenetic context. According to Lanham, his "uninominal nomenclature" would not require abandoning the genus or any other rank. He simply wanted to construct a system in which species names could be both stable and unique. To achieve this, Lanham suggested that the first part of the name, which is a source of instability, be removed from the species name itself. However, he also suggested that the specific epithet be attached to other information (author's name, the date of publication, and the page number) in order to meet the criterion of uniqueness.

Three different levels of uniqueness. — The stable and unique association between a species epithet, an author's name, and a publication date guarantees the uniqueness of species names in all cases where an author named only one species with a particular epithet in a given year. For example, *Montereina nobilis* simply needs to be converted into *nobilis* MacFarland, 1905 because Frank MacFarland only named one sea-slug species with the epithet *nobilis* in 1905.

In addition, page numbers can be mentioned when an author has named more than one species with the same epithet in a single year. For example, in 1905, Rudolph Bergh created two distinct binomials with the same species epithet for two different species of sea slugs, *Aporodoris rubra* and *Halgerda rubra*. We can preserve the uniqueness of these names by distinguishing *rubra* Bergh, 1905: 94 from *rubra* Bergh, 1905: 126.

In a few exceptional cases, the page number will not distinguish unique species (Cantino, pers. comm.). For example, in several cases Linné gave the same epithet to distinct species named on the same page: in the 1753 edition of the *Species Plantarum*, one can find *Nepeta multifida* and *Lavandula multifida* on page 572. A simple solution is to add "a", "b", etc. to the page number: "a" for the first species, "b" for the second one, and so on. We recognize that this problem is a drawback, but it will be relatively rare in practice. The addition of "a" or "b" to the page number only will apply to a tiny fraction of the hundreds of thousands of species names currently in use.

Furthermore, in the interest of clarity, we recommend that page numbers and letters always be used when necessary, but never when unnecessary (e.g., *nobilis* MacFarland, 1905 would never be referred to as *nobilis* MacFarland, 1905: 38).

Finally, it is important to address two other pragmatic issues related to the use of an epithet-based form of species name. First, when several authors have named a species, all the authors' names must be attached to the species epithet. The second question concerns the termination of the epithet. In certain cases, when the genders of the species epithet and the generic name do not agree, the current codes require the termination of the epithet to be changed. We recommend that the original spelling of the epithet be used in such cases. In instances where an epithet has been changed because of an obviously incorrect original spelling (such as a typographical error), we suggest the use of the corrected epithet.

Other methods for naming species in a rank-free paradigm. — Other methods have been proposed for naming species in the context of rank-free nomenclature. Schander & Thollesson (1995) briefly mentioned an epithet-based method that differed slightly from Lanham's, and proposed to use the association between the species epithet, the author's name, and the date of publication for all species names. However, they did not discuss the implications of implementing this method, especially in cases where uniqueness might require additional identifiers. More recently, thirteen possible methods for naming species in a rank-free paradigm (designated "methods A to M") were compared by Cantino & al. (1999) for various criteria, including stability, continuity with the Linnaean nomenclature, degree of ambiguity, ease of pronunciation, and potential to convey information (or misinformation) about relationships. However, they did not consider Lanham's (1965) or Schander and Thollesson's (1995) systems.

The thirteen methods considered by Cantino & al. are divided into two main classes. In the first class (methods A to J), names are binomial-based. For methods A to H, Linnaean binomials are permanently stabilized: for example, the binomial *Anisodoris nobilis* would become *Anisodoris-nobilis*, and the first part of the name could never change. In methods I and J, the first part of the name could change under certain conditions (e.g., if *Anisodoris* is a clade name established under the *PhyloCode* to which "*nobilis*" does not belong).

We do not think these methods are satisfactory because they contradict one of the most fundamental principles of the *PhyloCode*, the rejection of all suprageneric ranks in nomenclature. The incompatibility between the binominal Linnaean species nomenclature and the rank-free nomenclature of the *PhyloCode* is particularly striking for the creation of new species names: it would still require the use of generic names, making the genus rank as mandatory as it is in the current codes. In addition, these binomial-based methods present the major disadvantage of potentially conveying misinformation about phylogeny (see below).

The second class of methods (methods K to M) is epithet-based, and uniqueness is ensured in two different ways. In method K, uniqueness is guaranteed by the addition of a number >1 after the epithet. For example, *Montereina nobilis* would simply become *nobilis*. However, if the name *nobilis* had already been established under the *PhyloCode* for another species, then the converted name for *Montereina nobilis* is *nobilis2*. Although the number is part of the name, it can be dropped after the first use in a scientific communication. The old genus name optionally can be added as a so-called "taxonomic address", but is not part of the name. In method L, *Montereina nobilis* would become *nobilis236387*. The registration number "236387" is part of the name, and it must be cited at least once in a communication, although it can be dropped after the first use. Each species name established under the *PhyloCode* would receive a unique registration number. The old genus name can be added as a taxonomic address, but is

not part of the name. Method M is equivalent to method L, except that the registration number is not part of the name: citing the registration number is only recommended. The old genus name can be used as a taxonomic address as well, but also is not part of the name. Method Method M is problematic because a species epithet alone cannot guarantee uniqueness in all contexts without the inclusion of additional information. We assert that a species name must be able to guarantee uniqueness independent of its context. In practice, the inclusion of a registration number would make method M equivalent to method L, whereas the inclusion of a "taxonomic address" would make it equivalent to a binomial-based method.

We find the ways uniqueness is guaranteed in methods K, L and M difficult to remember and aesthetically unpleasing. One may argue that the name of an author and a date of publication might be as difficult to remember as a registration number, but we disagree. "Bergh, 1905" or even "Bergh, 1905:94" minimizes the effort required for reading and memorizing names because Bergh is the name of an author and a date is not a random series of numbers. Furthermore, this information is already familiar to the most frequent users of species names, taxonomists and systematists. More importantly, methods K, L and M will disrupt the compatibility that must exist between the current Linnaean literature and the new literature that will emerge when a new form of species name is introduced.

On the importance of compatibility between current and future taxonomic literature. — We assert that compatibility between the existing Linnaean literature and the new literature (which will emerge when a new form of species name is introduced) is essential. It facilitates the easy tracing of species names from one literature to the other. It also guarantees that existing taxonomic identifications of specimens in museum collections will remain easily intelligible to users of both the current and the new nomenclatures. According to Cantino & al. (1999), a new species nomenclature is in "continuity" with the current Linnaean nomenclature if full binomials are preserved when converted to the new system.

Although we agree that continuity between current and future nomenclature is important, we do not think it should concern binomials. Because binomials are unstable, they cannot be used for tracing species names through the abundant taxonomic literature. In fact, this process requires additional information that is not contained in, and cannot be guessed from, a binomial itself. This crucial information is the association of the species epithet, the author's name, the publication date of the name, and the number of species named with the epithet in question in that year by the author.

Consider a biologist who is interested in the sea slug *Anisodoris nobilis* and wishes to find the contributions in which this species was studied. An immediate problem is the fact that *Anisodoris nobilis* might not be the only binomial used for this species in the literature. In this particular case, several other names may be relevant, including *Peltodoris nobilis*, *Montereina nobilis* and *Archidoris nobilis*. But were these names used for the same species as *Anisodoris nobilis*? Some additional information partly answers this question. *Anisodoris nobilis*, *Montereina nobilis* and *Peltodoris nobilis* necessarily designate the same species because they are "nomenclatural synonyms" ("nomenclatural synonyms" of the *ICBN* are the "objective synonyms" in the *ICZN* and *ICNBa*). We know that they are nomenclatural synonyms because they all refer to the sea slug *nobilis* first described from the northeastern Pacific coasts by MacFarland in 1905, and MacFarland named only one species *nobilis* in 1905. *Archidoris nobilis* refers to the sea slug *nobilis* first described from the North-Atlantic Ocean by Odhner in 1907 (and Odhner named only one species *nobilis* in 1907). The fact that these names will always designate no more than two individual species is strictly a nomenclatural matter, independent from any taxonomic context. However, the question of their potential "taxonomic synonymy" depends on the taxonomic context and therefore goes beyond nomenclature ("taxonomic synonymy" of the *ICBN* is the "subjective synonymy" in the *ICZN* and *ICNBa*). This also is the case for synonymy in the *PhyloCode* as well.

As shown by this example, the unbreakable association of the species epithet, the author's name, and the date of the original publication, is the information required for tracing names within the abundant Linnaean literature. Although they do not consider this information to be part of the name, the current codes explicitly note that it may be desirable in many cases to cite the author(s) of a species name (Article 46, *ICBN*) or the author(s) and the date of publication (general recommendations, *ICZN*). Furthermore, when a new combination is proposed, the *ICBN* (Article 33.3) requires the citation of a "full reference", including the author, the place of valid publication, the date of publication, and a page or plate reference. The critical importance in the current codes of the association between the species epithet, the author's name, and the date of original publication is the reason why Lanham suggested that uniqueness of names be based on this association. This also is why we suggest that any new form of species name in a rank-free system retain this information to ensure that it will be compatible with the existing taxonomic literature.

On stability and its drawbacks. — Nomenclature ideally should provide stable species names. However, this goal must be balanced by the need

to prevent the misrepresentation of supra-specific relationships. We think that the easiest way to deal with the fact that there will always be some debate in regard to which larger supra-specific taxon a species belongs is to construct a system in which species names do not convey *any* information (accurate or inaccurate) about supra-specific relationships. Lanham's method meets this criterion because it explicitly removes any reference of supra-specific relationships from species names.

Cantino & al. (1999: 796) also aimed to provide methods that would "differ from the Linnaean binominal nomenclature in that species names do not attempt to convey information about supra-specific relationships". Despite these clear intentions, Cantino & al. formulated methods (A to H) that could lead to confusing situations, such as the case where *Potentilla-bifurca* would be more closely related to *Alchemilla-alpina* than *Potentilla-norvegica* (case presented by Cantino & al., 1999). We suspect that this is mainly due to the fact that methods A to H convert whole binomials into permanently stable names in an attempt to ensure continuity (sensu Cantino & al.) with the Linnaean binomials. The fact that these binomial-based methods may convey misinformation about supra-specific relationships, and that compatibility with the Linnaean literature can be guaranteed through other means, are major drawbacks and additional reasons why they should be rejected.

Presentation of phylogenetic relationships: official species names versus common species names. — We strongly agree with Lanham that species names need only provide a unique and stable designation: information about phylogenetic relationships is more efficiently transmitted by other means, such as phylogenetic trees. However, we acknowledge that the relationships between species are important data for all biologists, and therefore might be worth mentioning when we communicate about species.

In this context, the fact that Lanham's epithet-based names do not provide any information about supra-specific relationships can be addressed easily by allowing the addition of a supra-specific name in front of the species epithet when convenient. This addition is strictly optional, and avoids the drawbacks of the mandatory genus rank in our current nomenclature. The resulting name would be equivalent to a common name, and would by no means replace the official, unique, stable epithet-based species name. The addition we propose here is close to the use of "taxonomic addresses" proposed by Cantino & al. (1999) in their epithet-based methods. Their main goal was to avoid confusion and to provide "continuity" with Linnaean binomials, which is why they suggested the use of the genus name that was formerly part of a binomial as a taxonomic address in front of the epithet. However, we wish: (1) to draw a stronger distinction between official names (epithet-based, unique, and stable), and names including a taxonomic address that are considered common names; and (2) to point out that the optional addition of a taxonomic address also provides an opportunity for handling cases where we know that the "old generic" relationships have no phylogenetic support.

The use of binominal common names addresses a potential concern many users may have about an epithet-based species nomenclature. For example, many people (including biologists, foresters, teachers, and hobbyists) know the name *Quercus alba* for the white oak, a North American oak species. Under the system we propose, the official name of this species would become *alba* Linné, 1753: 996. However, the name *Quercus alba* could continue to be used in a manner similar to "white oak". Furthermore, users would know that the term *Quercus* might not reflect current knowledge concerning the supra-specific phylogenetic relationships of this species. We suggest that the stable and unambiguous epithet-based names be cited at least once at the beginning of any scientific contribution. A common name, including a traditional Linnaean name, could be used throughout the rest of the paper if desired.

Although the addition of an old genus name as taxonomic address in front of a species epithet may please people who are familiar with current names, we strongly favor the use of meaningful taxonomic addresses. Currently taxonomists *must* assign a species to a genus, regardless of whether the "generic" phylogenetic relationships of the species can be determined. For example, our only positive phylogenetic knowledge concerning the sea slug *nobilis* MacFarland 1905 is that it belongs to the clade Discodorididae (Dayrat & Gosliner, submitted). This species is one of several unresolved branches at the base of the clade, and it cannot be placed confidently in any sub-clade of Discodorididae. Three genus names have been used in the past for *nobilis*, *Montereina*, *Anisodoris*, and *Peltodoris*, but none in a phylogenetic context. The first name is monotypic, and therefore is uninformative regarding supra-specific relationships. The other two correspond to polyphyletic groups (Dayrat & Gosliner, submitted). In this case, the most rigorous common name for *nobilis* MacFarland 1905 is *Discodorididae nobilis* because it accurately conveys what is and is not known about the relationships of the species. Although the name *Discodorididae nobilis* does not meet Cantino & al.'s criterion of continuity with the Linnaean binomials, the fact that it provides accurate information about phylogenetic relationships is appealing to anyone who considers phylogeny important (Dayrat & Gosliner, submitted).

Recognition of taxonomic work. — Finally, Lanham's form of species name solves the problem of

how to recognize the work of taxonomists, which is particularly problematic now that taxonomy is facing a crisis (e.g., Godfray, 2002). Van der Velde (2001) suggested that the most accurate evaluation of taxonomic work is to take into account the number of times a species name coined by a taxonomist is cited in the scientific literature. For example, Van der Velde noted that *Drosophila melanogaster* was cited 14,451 times in 2001. The author of this species, Johann Wilhem Meigen [1763–1845], the founder of modern dipterology, rarely gets credit for having described and named *melanogaster* in 1830.

Although Meigen is not responsible for the genetic work done on *Drosophila melanogaster*, this species had to be discovered before any further inquiry could be undertaken, and describing and naming species certainly are critical steps in the discovery of biological diversity. Requiring that Meigen's (1830) contribution on European insects be cited would emphasize his personal role in the discovery of insect diversity. More broadly, it would emphasize the central role of taxonomy in the life sciences. Such recognition would be possible with Lanham's nomenclature: the stable, unique, scientific name "*melanogaster* Meigen, 1830" would need to be cited at the beginning of each scientific contribution, although the name *Drosophila melanogaster* could still be used among biologists, as well as with larger audiences, as a common name. Note that a page number is not required because Meigen gave the species epithet *melanogaster* to only one species in the year 1830.

Conclusion. — The rank-free nomenclature that will be implemented with the publication of the symposium volume resulting from the First International Phylogenetic Nomenclature Meeting will have major implications for the entire community of biologists and beyond. In particular, the current Linnaean binomial-based form of species nomenclature must be replaced because it is logically incompatible with the rank-free system of the *PhyloCode*. We argue that the method for species names first proposed by Lanham (1965)—once it is slightly modified to guarantee uniqueness in all cases—fits ideally within the new rank-free paradigm for several reasons.

First, it is fully compatible with a rank-free system because it does not include *any* mention of supra-specific taxon names. Also, it provides direct access to the key information of the Linnaean system, namely the unbreakable association of the species epithet, the author's name, and the date of publication. This respects the historical foundation of taxonomy and ensures compatibility between the literature using Linnaean names and future works using a new nomenclature. A break between these two literatures would be disastrous for all biologists because it would greatly jeopardize the necessary ability to go back and forth from one literature to the other. Finally, it would give biologists the opportunity to more rigorously denote the supra-specific relationships of species through common names.

We do not pretend that Lanham's proposal is *the* solution or that it *must* be adopted, although we find it convenient. The important thing is that it be considered, and accepted or rejected, based on its usefulness. If any new nomenclature is to be successful, the criteria upon which it is based must be widely debated. We think that the entire community of life scientists should be involved in this process; a small group of scientists should not decide for the entire community. Alpha-taxonomists, who will create the majority of new species names, as well as users of species names such as ecologists or conservation biologists, must all express their ideas and needs. The time for this discussion is now, while the *PhyloCode* is still under construction. Adopting a new species nomenclature that is less than optimal for taxonomists and users could prove to be disastrous.

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