Discussion

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Diagnosis: Differing interpretations of the ICZN

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Description forms the foundation for systematic biology. It provides the basis for taxonomic recognition, from which phylogeny, classification, and higher levels of evolutionary interpretation are ultimately constructed. For the purposes of taxonomic recognition, biologists have long distinguished between a general, broadly inclusive description, and one that is limited to characteristics that show how a taxon differs from others similar to it. This distinction is embodied in Linnaeus' concepts of the *descriptio* and the *differentia specifica* (Linnaeus 1758; see also Svenson 1945). The essential characters of a taxon are embodied in the modern concept of the diagnosis. Although the diagnosis has long been a component of systematic accounts in which new taxa are proposed or existing taxa revised, interpretation of the content and concept of a diagnosis varies widely among recent authors. Herein we argue that a diagnosis must be differential and that it must include, at least implicitly, comparison to similar taxa.

In the early years of paleontological discovery, new taxa were commonly so distinct from all others known that diagnostic characteristics were self-evident. The 19th and early 20th centuries witnessed a rapid proliferation of fossil taxa, often based on differing criteria (owing to non preservation of comparable parts; see Simpson 1929; Martin 1999) or on minor differences ("splitting") later recognized as populational variation (e.g., Simpson 1945). To provide a common basis of understanding, Article 13.1.1 of the International Code of Zoological Nomenclature (ICZN or "the Code") requires new names published after 1930 to include (ICZN 1999: 17): "[…] a description or definition that states in words characters that are purported to differentiate the taxon […]" Recommendation 13A (p. 17) further specifies that "[…] an author should make clear his or her purpose to differentiate the taxon by including with it a diagnosis, that is to say, a summary of the characters that differentiate the new nominal taxon from related or similar taxa".

The central purposes of the Code are to establish rules, standardize, and provide guidance for taxonomic practice, thereby promoting stability in zoological nomenclature. Unfortunately, Article 13 has been too broadly interpreted or ignored altogether. As a result, it is not always clear whether this mandatory criterion for name availability has been met, how the author arrived at his or her diagnosis, or whether or not the diagnosis actually serves its purpose. To illustrate, we have drawn a few examples from a volume each of *Palaeontology* and *Journal of Vertebrate Paleontology*, both of which include a diagnosis section among their instructions to the authors, though implementation appears to differ between the two (see below)[1]. For *Palaeontology* see Palaeontological Association (1996: 1069–1075, and Palaeontological Association's website http://palass.org/index.html; and for *Journal of Vertebrate Paleontology* see *Style Guide to the Journal of Vertebrate Paleontology* (2003, unnumbered four pages following 206). Both periodicals are internationally recognized, popular media for dissemination of research dealing with systematic paleontology.

Systematic accounts that we reviewed in *Journal of Vertebrate Paleontology* invariably include a diagnosis when treating taxonomic revision or new taxa. In some cases, these diagnoses are differential: that is, they make explicit comparisons identifying unique characters or character combinations that distinguish the new (or revised) taxon from all others with which it might be confused (see "differential diagnosis" in Winston 1999: 190).

An excellent example is that of Wang et al. (2004: 447), who provide a diagnosis of their new species of carnivorous mammal *Aelurodon montanensis* that compares it with five other species assigned to the same genus.

It reads as follows:

"*Diagnosis*.—Differs from *Aelurodon asthenostylus* in its larger size, a more reduced M1 relative to P4, a narrower m1 talonid, a more reduced m1–m2 metaconid, and a shorter m2 relative to m1; and from the *Aelurodon ferox–A. taxoides* clade in its relatively small non-carnassial premolars and less reduced M1 internal cingulum. *A. montanensis* shares with the *A. mcgrewi–A. stirtoni* clade such derived features as a widened p3 posterior cingulum, initial development of a posteriorly expanded M1 internal cingulum, and a relatively large P4. Within the *A. mcgrewi–A. stirtoni* clade, *A. montanensis* is easily distinguishable from *A. stirtoni* in its larger size, presence of both m1 and m2

[1] Differential diagnoses are to be found also in other biological (including paleontological) journals, e.g., (cited in alphabetic order): *Abhandlungen der Senkenbergischen Naturforschenden Gesellschaft*; *Acta Palaeontologica Polonica; American Museum Novitates*; *Berliner geowissenschaftliche Abhandlungen*; *Bulletin de l'Institut Royal des Sciences naturelles de Belgique*; *Bulletin of the Carnegie Museum of Natural History*; *Canadian Journal of Earth Sciences*; *Chinese Science Bulletin*; *Comptes Rendus de l'Académie des Sciences, Paris*; *Geodiversitas*; *Geological Sciences of the University of California*; *Journal of Paleontology*; *National Science Museum Monographs, Tokyo*; *Nature*; *Palaeontographica*; *Palaeovertebrata*, *Montpellier*; *Records of the Queen Victoria Museum*; *Revista Brasileira de Paleontologia*; *Russian Journal of Theriology*; *Senckenbergiana lethaea*; and many others from all around the world.

metaconids, and less reduced M1 talon; and *A. montanensis* differs from *A. mcgrewi* in its larger P4 protocone, longer m1, larger m1 metaconid, larger m2 and smaller p1–4."

In the majority of cases, however, the diagnosis is non-differential. Characters purporting to distinguish the new or revised taxa appear in a variety of places, including "remarks" (Young 2004) and headings other than Systematic Paleontology, such as Comparisons (González-Rodríguez et al. 2004), Discussion (with summary in a table; Filleul and Dutheil 2004), and Phylogenetic Analysis and Appendix (where character states must be teased out from a numerical matrix and decoded from a character list; Bolotsky and Godefroit 2004). Notably, there is sometimes limited correspondence between diagnosis and comparisons with other taxa. Finally, some treatments of new or revised taxa include a diagnosis but no explanation anywhere in the text as to which (if any) characters are unique or what combination of characters distinguishes such taxa from those similar to them (e.g., Elliott et al. 2004; Hua and Jouve 2004).

Most of the contributions that we reviewed in *Palaeontology* include diagnoses, though they are also rarely differential (one of a few exceptions being that of Bonis et al. 1997). The diagnosis of Benton and Allen (1997: 932) listed one unique apomorphy and indicated that the combination of remaining features is unique, but did not provide details. In some cases, differences between taxa can be extracted by comparing diagnoses in the same section (e.g., Loydell et al. 1997). As with *Journal of Vertebrate Paleontology*, most non-differential diagnoses in *Palaeontology* include taxonomic comparisons elsewhere in the text (e.g., Ruta 1997; Fortey 1997), often with inexact or little correspondence to characters listed in the diagnosis (e.g., Barker et al. 1997). Some contributions include diagnoses but no comparisons to clarify characters listed therein (Armstrong 1997; Gasparini 1997). Remarkably, some accounts dealing with new taxa include no diagnoses whatever, though taxonomic comparisons are included elsewhere (Cocks and Modzalevskaya 1997; Jeffery 1997).

As a rule, use of the differential diagnosis appears to be less common among invertebrate than vertebrate paleontologists, though it is sometimes employed in the former discipline. For example, in the *Treatise on Invertebrate Paleontology* (Whittington et al. 1997; first volume dedicated to Trilobita), differential diagnoses are given for at least 24 genera or subgenera among the order Redlichiida. This, however, amounts to only 10 percent of the genera (and subgenera) belonging to this order. The diagnoses of the remaining redlichiidan taxa are not differential.

We regard it as self-evident that comparison is the essence of systematic accounts; in its absence, no distinction can be made between taxa. Systematic biology, like other branches of science, must meet the criterion of repeatability; that is, the precise basis for taxonomic recognition must be provided, so that subsequent workers can evaluate its merits and test it as new data emerge. For this reason, diagnoses that enumerate taxonomic characteristics without indicating their uniqueness (singly or in combination) are, in themselves, insufficient. Likewise, comparisons of character combinations must make explicit reference to the respective conditions in other, similar taxa, in order to meet the criterion of repeatability. This condition is made explicit in Article 13.1.1 of the Code, cited above, wherein the qualifying infinitive, "to differentiate" is defined as (ICZN 1999: 103): "to distinguish something (e.g., a taxon) from others […]".

Given the obvious need to include specific comparisons in establishing or revising taxa, how and where should such comparisons be made? In our view, existing literature is excessively variable on this point. Comparative data are difficult to extract and interpret when dispersed within running text (as in a description) or when contained in a combination of a comprehensive data matrix and character list. Likewise, use of a non-differential diagnosis in combination with comparisons elsewhere can lead to confusion because such combinations rarely correspond exactly and commonly have only limited correspondence. In any case, such "diagnoses" are arguably oxymoronic in that they do not serve the basic purpose of distinguishing between like taxa, and they are superfluous when the proper comparisons appear elsewhere in the same work. Use of a differential diagnosis helps the author to determine whether the erected taxon indeed differs sufficiently from related taxa to merit a separation. Uniting the "Diagnosis" and "Comparisons" (or "Remarks") in a single section "Diagnosis", written in a telegraphic style, helps to avoid redundancy in the paper.

The Code is specific on this matter: Recommendation 13A, cited above, indicates that a summary of characters differentiating the new or newly revised taxon should appear in a diagnosis, to be included with the taxonomic account. In the most widely used, authoritative guide to interpretation of the Code and to the principles of systematic zoology in general, Mayr and Ashlock (1991: 391) comment: "Respectable taxonomists go well beyond this minimal requirement [i.e., Article 13.1.1 and Recommendation 13A] by comparing the newly proposed taxon with its closest relative(s) and describing the diagnostic characters carefully. Even though such a *differential diagnosis* is not a mandatory provision of the Code, it will be supplied by every conscientious worker." [Italics in the original.]

In our view, there is an obvious need to standardize the practice of taxonomic recognition and distinction between like taxa. We endorse the foregoing comment by Mayr and Ashlock (1991), and urge the paleontological community to adopt the practice of including a differential diagnosis when naming or revising a taxon.

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