



Reply to Fordham and Welter-Schultes's comment on “Taxonomic review of living planktonic foraminifera” by Brummer and Kučera (2022)

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In our recent review of the taxonomy of extant planktonic foraminifera (Brummer and Kučera, 2022), we explicitly stated that we consider the work by Fordham (1986) to not satisfy the criteria of the International Code of Zoological Nomenclature (ICZN, 1999). For this reason, the 73 clade-groups and 57 infraspecific taxa erected in Fordham (1986) were not considered in our revision. We are grateful to Fordham and Welter-Schultes for allowing us to elaborate on our judgment of the Fordham (1986) monograph. The arguments presented by Fordham and Welter-Schultes in support of the validity of the taxonomic acts made in Fordham (1986) hinge on two claims: (a) that the usage of a phenon by Fordham (1986) represents “informal nomenclature” and (b) that the clade-groups of Fordham (1986) represent taxa above the rank of names of the family group.

- a. On p. 6, Fordham (1986) defines “phenon” to “represent morphologically defined infraspecific taxa”. A more extensive definition is then given on p. 12, where he states the following:

The category, phenon, is used herein for a system of names complementary to and, as a system, as equally inclusive as that based on the species category. Whereas the latter system is used to recognize lineages defined solely by their position in the phylogeny, the system of phenon is used to segment the morphologic variation, in the broadest sense, through time or space into practically useful units.

Indeed, Article 1.3 of the Code explicitly excludes names proposed for infrasubspecific entities or names proposed not for formal taxonomic use. However, Fordham’s “phenon” is explicitly labelled as infraspecific rather than infrasubspecific, and it is denominated as referring to “taxa”, with no part of the definition providing any indication for the category to be intended as informal. Fordham (1986) thus clearly treats “phenon” as an additional taxonomic category which exists at the same rank as subspecies. This is a departure from the Linnean nomenclature, consistent with Article 11.4 of the Code. Next, and this is the main point of the argument in Brummer and Kučera (2022), in the work of Fordham (1986) all new infraspecific taxa have been erected as both “phenon” and subspecies, being given the same names in either category. The situation is further complicated by the fact that in the nomenclature as applied by Fordham (1986), the same name for an infraspecific taxon may be associated with more than one species, as long as the name is considered to represent a “phenon”. For example, Fordham (1986) considers the phenon “*megastoma*” to occur in *Globigerina bulloides* (p. 118) as well as in *G. concinna* (p. 115). These points have been ignored in the comment by Fordham and Welter-Schultes. Yet, it is precisely in this way that the infraspecific nomenclature as applied by Fordham (1986) challenges a key cornerstone of zoological nomenclature: unambiguity of names. It cannot be in the interest of the stability of the zoological nomenclature to first invalidate a name for an infraspecific taxon

because it is associated with an invalid category (phenon), then accept the same name because it is associated with a valid category (subspecies), with each name in the work where it has been erected being in different places associated with a different taxonomic category of a higher rank.

- b. Fordham and Welter-Schultes claim that the 73 clade-groups as erected and used in Fordham (1986) are not in conflict with the Code because the Code does not regulate names above the family level. Yet on p. 6, Fordham (1986) compares some of his clade-groups to what he denotes “cladophyletic” classification. Here, he proposes that the conventional “cladophyletic” subfamily Candeininae corresponds to Fordham’s “cladistic” Candeinidecimae, thus admitting himself that some of his clade-groups correspond to taxa of the family group, which are regulated by the Code. Fordham (1986) describes the application of his “cladistic” taxonomy on p. 14 as being “implemented by dividing the branching sequence of a phylogeny into sections beginning at the top, or most recent, extremity. Specifically, two terminal (living or extinct) species which share an immediate common ancestor are assigned, along with this ancestor, to a taxon of the lowest suprageneric category.” In this definition, the lowest-ranking clade-group would always correspond to a family-level taxon. Fordham (1986) offers no means to determine the level of distance from the terminal taxa at which his classification departs from the five conventional family-group taxa. We therefore felt compelled to not consider any of the clade-group names of Fordham (1986), as did several taxonomic authorities before us.

We concede that what we meant by “not follow the principles of binomial nomenclature” with reference to Fordham (1986) could have perhaps been better formulated as “not follow the Linnean classification system”, given the use of the categories “phenon” and “clade-group”. However, this changes nothing in our judgment on the validity of the concerned taxon names. If a scientific work decides to use categories outside the Linnean system (i.e. using the phenon and clade-group), it can only be appropriate to agree with previous opinions that the names contained therein are unavailable, as argued by Loeblich and Tappan (1987). This is not to say that we disagree with the merit of innovation in the classification of living organisms and fossils. However, we believe such innovations are only helpful if they promote the key hallmarks of zoological nomenclature: unambiguity and stability of names given to taxa.

Competing interests. The contact author has declared that neither of the authors has any competing interests.

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