

Validation and justification of the phylum name *Cryptomycota* phyl. nov.

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Abstract: The recently proposed new phylum name *Cryptomycota* phyl. nov. is validly published in order to facilitate its use in future discussions of the ecology, biology, and phylogenetic relationships of the constituent organisms. This name is preferred over the previously tentatively proposed “Rozellida” as new data suggest that the life-style and morphology of *Rozella* is not representative of the large radiation to which it and other *Cryptomycota* belong. Furthermore, taxa at higher ranks such as phylum are considered better not based on individual names of included genera, but rather on some special characteristics – in this case the cryptic nature of this group and that they were initially revealed by molecular methods rather than morphological discovery. If the group were later viewed as a member of a different kingdom, the name should be retained to indicate its fungal affinities, as is the practice for other fungal-like protist groups.

Key words:

chitin
chytrid
Fungi
phylogeny
Rozella
Rozellida

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INTRODUCTION

The designation “cryptomycota” was introduced by Jones *et al.* (2011) to accommodate a well-supported clade (using ribosomal DNA (rDNA) phylogenies) of organisms putatively branching deep within the fungal radiation. The rank of phylum is the most appropriate for this group as current results show that it has fungal characteristics but is distinct from other fungi in not having a chitin-rich cell wall in the major stages of its life-cycle so far identified, including putative trophic interactions. However, *Cryptomycota* was not validly published as a scientific name in that work as no Latin diagnosis was provided (McNeill *et al.* 2006: Art. 36). A Latin diagnosis is provided here in order to formally establish the name. In addition, comments are made on our decision to introduce this name rather than take up the earlier informal name “Rozellida”, and on the distinctive features of the phylum and its position.

TAXONOMY

Cryptomycota M. D. M. Jones & T. A. Richards, **phyl. nov.**

MycoBank MB563383

Etymology: *crypto-* – hidden; and *-mycota*, a phylum of fungi.

Fungi unicellulares, zoosporis unicellularis, uniflagellatibus, flagellis microtubularis, cystes sine tunica chitinosae vel cellulosa. Consortia epibiontica formata.

Fungi unicellular, zoospores single-celled with a single microtubular flagellum, and cysts without a chitin/cellulose cell wall. Forming epibiontic associations.

Representatives: GenBank accession nos AJ130857, AJ130849.1, AJ130850, FJ687265, FJ687267 and FJ687268, and *Rozella*.

Illustrations: Jones *et al.* (2011: figs 1d, 2a–e).

DISCUSSION

It has been demonstrated that *Rozella* occupies a deep branching position in phylogenetic analyses of kingdom *Fungi* (James *et al.* 2006a, b), although bootstrap support for this relationship is inconsistent and often weak in the most comprehensively sampled phylogenies (James *et al.* 2006a, b, Jones *et al.* 2011). The name “Rozellida” was coined by Lara *et al.* (2010) to accommodate *Rozella* and a number of environmental sequences that form a distinct clade, but we refer to this group henceforth as *Cryptomycota* for reasons indicated below. Jones *et al.* (2011) showed that *Cryptomycota* are more diverse than previously recognised and that the molecular diversity of this group may be as diverse as the rest of the known *Fungi* according to rDNA gene markers.

Members of *Cryptomycota* are found in freshwater, soil, sediment, and some marine habitats. Jones *et al.* (2011) used

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lineage-specific fluorescence *in situ* hybridization (FISH), cell wall stains, and immuno-fluorescence staining to show two distinct lineages within *Cryptomycota*, which comprised ovoid cells of ca. 5 µm diam, existing in at least three morphologies in freshwater environments: unflagellate zoospores, more variably-shaped cells without flagella attached to other eukaryotic microscopic organisms (e.g. diatom hosts), and non-flagellate cysts. None of these stages were shown to possess a chitin or cellulose wall, although other life-cycle phases with a chitin and/or cellulose cell wall may remain undetected. A chitin cell wall is sometimes cited as defining feature of kingdom *Fungi*, although we note that this is not a reliable diagnostic feature as distantly related protist groups also possess chitin on their cell surface (e.g. Kneipp *et al.* 1998).

The name “Rozellida” was applied to this phylum by Lara *et al.* (2010) but in an informal way between inverted commas and with no formal diagnosis. The ICZN (International Code of Zoological Nomenclature; International Commission on Zoological Nomenclature 1999) does not apply to names above the rank of family-group, but if it were in those ranks it would be viewed as unavailable as a conditional name (Art. 15.1). For names introduced under the ICZN which later are found to belong to *Fungi*, the ICN (International Code of Nomenclature for algae, fungi, and plants) now accepts them as available under Art. 45.4 (as revised at the Melbourne Congress in July 2011; McNeill *et al.* 2011). Thus, no Latin diagnosis was required, as it was for fungal names introduced between 1935 and 1 January 2012). However, we are inclined not to accept “Rozellida” because of the use of the inverted commas suggesting the usage was a tentative suggestion and in any case note that it is not mandatory to follow the principle of priority of publication for names above the rank of family (ICN) or family group (ICZN). Indeed, the ICZN does not cover ranks higher than family group.

We decided that it would be better not to definitely establish a name based on *Rozella* for several reasons:

(1) The fungal termination to be used for names in the rank of phylum is “-mycota” under the ICN (McNeill *et al.* 2006; Art 16.4), and that termination has also been used for phyla traditionally studied by mycologists but which are no longer considered *Fungi* but placed in other kingdoms. Examples include *Hyphochytriomycota* R.H. Whittaker (Whittaker 1969: 154) now placed in *Straminipila* M.W. Dick 2001, *Myxomycota* Bold (Bold 1957: 152) for slime moulds in the *Protozoa*, and *Oomycota* Arx (Arx 1967: 16) for fungal analogues in the *Straminipila*. This practice has been employed in standard reference works (e.g. Kirk *et al.* 2001) and also the most recent textbooks (e.g. Moore *et al.* 2011).

(2) *Cryptomycota* represent a very diverse radiation, potentially equivalent to or larger than the rest of the known fungi. Of the three lineages within the radiation for which morphological data exist, *Rozella* appears to be exceptional in that it is primarily an intracellular parasite; indeed the possession of intracellular sporangia is included in the generic description of *Rozella* species (Held 1981). To extend the implication of this life-cycle characteristic across the rest of the radiation – where there is no evidence of this life-

cycle characteristic – would be misleading. Lara *et al.* (2010) were also hesitant commending the use of the proposed name “between quotation marks until morphological and/or ultrastructural synapomorphies are defined to diagnose and validate this entire group”. Jones *et al.* (2011) demonstrate that this key characteristic of *Rozella* does not seem to extend across the whole group and therefore the name “Rozellida” is not representative of the group as a whole.

(3) It is important to recognize that our current knowledge of the life stages of the newly discovered *Cryptomycota* and of *Rozella* is very incomplete. As Jones *et al.* (2011) suggest, chitin may be present in the walls of some currently unknown *Cryptomycota* life-cycle stage(s) and/or present in uncharacterized lineages within *Cryptomycota*, and even in currently unknown stages in *Rozella*. It would be premature, therefore, to separate *Cryptomycota* from the kingdom *Fungi* on the single character that they do not possess chitin walls (which, as mentioned above is not diagnostic for *Fungi*).

(4) *Cryptomycota* have some strong resemblances to *Chytridiomycota* (‘chytrids’) in both structure (e.g. flagellar apparatus) and ecology, if not in cell wall chemistry. There is no agreed defining non-molecular characteristic for identifying the boundaries of kingdom *Fungi*. Therefore, as several other key characteristics are shared by *Cryptomycota* and some *Fungi*, the former are most sensibly and parsimoniously considered as belonging to the latter as they form the closest branches on phylogenetic trees (James *et al.* 2006a, b, Lara *et al.* 2010, Jones *et al.* 2011). This stance is entirely consistent with the historical position regarding *Rozella*: for the last 40 years leading mycologists have classified this genus within *Fungi* (e.g. Held, 1981; Kirk *et al.* 2008).

(5) *Cryptomycota* (including *Rozella*) consistently branch with *Fungi* in all phylogenies so far constructed. However, their position as the primary branch within fungi is much weaker (e.g. James *et al.* 2006; Jones *et al.* 2011). Indeed, they could actually occupy a higher branching position within *Fungi*. If this is the case, their lack of some traditionally diagnostic fungal features such as a chitin cell wall may be the result of secondary losses, which would not preclude them from being considered *Fungi*. In this case, excluding *Cryptomycota* from the *Fungi* could potentially make the rest of fungi paraphyletic – a highly undesirable and not logically sustainable situation. In the absence of a strong morphological argument to exclude this group from the fungal kingdom – we must therefore look to the only available data, which is phylogenetic, and argues that *Cryptomycota* are most reasonably considered to be within *Fungi*.

(6) Consequently, we agree with Lara *et al.* (2010) that there are sound reasons for considering *Rozella* (and now we suggest other *Cryptomycota*) as *Fungi*. Whether or not *Cryptomycota* other than *Rozella* prove to be phagocytotic (which in itself would not be a sufficiently strongly deterministic trait for inclusion in – or exclusion from – *Fungi*, as some plant lineages and oomycetes have also lost phagotrophy), their chytrid-like unflagellate zoospore stage and particularly their phylogenetic position argue most parsimoniously for a fungal affiliation.

(7) The names used for taxa at the highest ranks, such as phylum, are better not based on names of included genera, but rather on some special characteristic, as is the case with, for example, the phyla *Ascomycota* and *Basidiomycota*. In this way the names immediately convey some feature of the taxon. In this case, we highlight the cryptic nature of *Cryptomycota* in that they were hidden from science until revealed by molecular methods rather than morphological discovery.

In conclusion, we consider the formal validation of the name *Cryptomycota* to be justified, and commend it for use for this group of organisms as it emphasises the fungal affinity and attributes of the organisms so far known within this group. Even if in some future classification these organisms were placed outside the Fungi, we consider the name should be retained to reflect their nature as fungal analogues.

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