Microsporidia – a new addition to fungi

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Almost 150 years of microsporidian research has led to a basic understanding of many aspects of microsporidian biology, especially their unique and highly specialized mode of infection, where the parasite enters its host through a projectile tube that is expelled at high velocity.

The **microsporidia** (more correctly **Microsporidiomycota)** constitute a phylum of spore-forming obligate unicellular parasites once thought to be protozoa. Whilst recent molecular evidence has reclassified the Microsporidia as fungi [1], they are not considered 'primitive'. Beta-tubulin phylogeny suggests that **microsporidia** evolved from a fungus sometime after the divergence of chytrids. [2] Morphological and life cycle data are consistent with **microsporidia** having originated from within **fungi**, but these data do not conclusively link **microsporidia** with a particular kind of fungus. [2] They should not be confused with **the genus, *Microspora* - a green alga.**

Microsporidia have undergone extraordinarily divergent and reductive evolution, losing most of the morphological and molecular clues as to the exact nature of their fungal heritage. The extreme reduction and compaction of most microsporidian genomes resulted in the loss of many metabolic pathways, which makes these parasites highly dependant on their host. This intimate relationship between parasite and host is unique. It allows the microsporidia to be highly exploitative of the host cell environment and cause such diverse effects as the induction of hypertrophied cells to harbour prolific spore development, host sex ratio distortion and host cell organelle and microtubule reorganization. They have no mitochondria and possess, instead, *mitosomes*.

They evert a *polar filament* from the dormant spore to inject the sporoplasm into a target cell. There, the injected cell develops into a small plasmodium, which then differentiates into many infective spores that are highly resistant outside the host for up to several years for some species. Spore morphology is useful in distinguishing between different species.

Molecular biology and genomic studies on microsporidia have also drawn attention to many other unusual features, including a unique core carbon metabolism and genomes in the size range of bacteria. [2] These seemingly simple parasites were once thought to be the most primitive eukaryotes; however, we now know from molecular phylogeny that they are highly specialized fungi. The fungal nature of microsporidia indicates that microsporidia have undergone severe selective reduction permeating every level of their biology: From cell structures to metabolism, and from genomics to gene structure, microsporidia are reduced. [3]

There are over 150 genera [4] and more than 1200 species of which about 14 species, primarily of *Encephalitozoon*, infect human beings especially those with immunocompromised disorders. [5] Most infect insects, but they are also responsible for common diseases of crustaceans and fish. [6] Vertical transmission of microsporidia is frequently reported. In the case of insect hosts, vertical transmission often occurs as transovarial, where the microsporidian parasites pass from the ovaries of the female host into eggs and eventually multiply in the infected larvae. [6]

The route of infection is usually by the alimentary or respiratory tract. Recent studies have shown that microsporidia gain access to host cells by phagocytosis as well. However, after phagocytosis,

the special infection mechanism of the microsporidia is used to escape from the maturing phagosomes and to infect the cytoplasm of the cells. Gaining access to cells by endocytosis, and escaping destruction in the phago-/endo-/lysosome by egressing quickly from the phagocytic vacuole to multiply outside the lysosome is a novel mechanism of efficient parasitism. [7]

Recent studies have found fresh fruit juices, commercial fresh orange, lemon, sugar cane, strawberry, and mango juices are not always safe. [8] Results showed that 35.43% were contaminated with one or more of Cryptosporidia, Microsporidia, and Cyclospora, as well as Giardia spp. Strawberry was the most contaminated juice (54.28%), while orange was the slightest (22.86%). Cryptosporidia was the highest contaminant (61.29%), and Cyclospora was the least (14.52%). Microsporidia spp. was the most robust contaminant which retained its viability and infectivity in juices in which it was detected. [8] This has potential implications regarding *'Free Trade Agreements'*.

After infection they influence their hosts in various ways and all organs and tissues are invaded. Some species are lethal, and a few are used in biological control of insect pests.
It seems in some cases their parasitic association is silent until the host undergoes stress or a dramatic change such as metamorphosis as seen in the butterfly caterpillar (Figs 1-7) that has ingested spores upon feeding on contaminated leaves of a citrus tree.

Notes:

1. http://www.ncbi.nlm.nih.gov/pubmed/18976912
2. http://mbe.oxfordjournals.org/cgi/content/full/17/1/23
3. http://arjournals.annualreviews.org/doi/abs/10.1146/annurev.micro.56.012302.160854?cookieSet=1&journalCode=micro
4. http://en.wikipedia.org/wiki/List_of_Microsporidian_Genera
5. http://comenius.susqu.edu/bi/202/Fungi/MICROSPORIDIA/default.htm
6. http://en.wikipedia.org/wiki/Microsporidia
7. http://www.ncbi.nlm.nih.gov/pubmed/16004362
8. http://www.ncbi.nlm.nih.gov/pubmed/20503593