

Free-living Amoebae (FLA), Introduction

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General Information

The term “free-living amoebae” (FLA) delimits a rather heterogeneous group of organisms of the obligate parasitic amoeba (e.g., *Entamoeba histolytica*); however, it has no phylogenetic, systematic, and taxonomic relevance (Walochnik and Aspöck 2007). The free-living amoebae, occasionally called “limax amoebae,” live ubiquitous in many humid habitats as components of biocenoses. The trophozoites feed as aerobic, heterotrophic predators on algae, bacteria, cyanobacteria, and fungi, as well as smaller protozoa. They even serve as prey for other microorganisms, such as for amoebophagous fungi. FLA can be found especially in biofilms on various surfaces and substrates. As resistant life stage, a cyst is formed in some species, which largely protects from adverse environmental conditions and therefore provides an enormous tenacity.

Since the FLA feed on bacteria, they affect the microbial community and reinforce the return of nutrients in the soil. By their heterotrophic nutrition, they excrete materials (e.g., minerals), which were bound in the biomass, so that these are available within the environment (Siddiqui and Khan 2012). Biofilms serve the FLA as a basic food and protection, where they adhere as trophozoites on the surfaces. FLA are involved in the biofilm formation and succession as part of this ecological community due to the secretion of metabolic products (Khan and Panjwani 2000). In such a biocenosis, the FLA are in contact with many other microorganisms. Even after the phagocytosis of microorganisms by FLA, some of these microorganisms are not always digested. There are also microorganisms of human or hygienic relevance hereunder (Scheid 2014).

Such microorganisms are adapted to the intracellular conditions in the amoebae, find suitable growth conditions, if necessary, protection from negative environmental influences, and take advantage of the dispersal in the environment by their amoebic hosts.

Humans are often in contact with the FLA occurring in the environment, under which there are also facultative parasitically living pathogenic species, respective strains (Barker et al. 1992). In particular, when the intensive contact to the people occurs, as it is done through the use of contaminated contact lenses on the cornea, it can cause infections (Grün et al. 2014). The taxonomy of the FLA or other single-celled organisms is subject to a constant change as genetic studies bring new insights concerning phylogeny, which often conflicts with the “classic” phylogeny approach, based mainly on morphological characteristics (Khan 2009). The applied classification (Table 1) includes those FLA that play a role as human parasites and reflects the classification up to the genus level (Page and Siemensma 1991; Mehlhorn and Ruthmann 1992; Khan 2009).

A current FLA alternative FLA phylogeny and nomenclature is presented useful for comparison, which is deduced from information specified by Walochnik and Aspöck (2007) and Adl et al. (2012) (see Table 2). In the phylum Amoebozoa, the authors group in addition to other taxa the Lobosea and the Variosea together with the Mycetozoa. The Hartmannellidae are placed to the Lobosea and the Acanthamoebidae to the Variosea. The Excavata include among others the Heterolobosea with the Vahlkampfiidae, including the genus *Naegleria*. The taxa within the Amoebozoa are extremely hetero-

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Table 1 Taxonomy of specified FLA according to Page and Siemensma (1991), Mehlhorn and Ruthmann (1992), and Khan (2009)

Domain: Eukaryota	System: Protozoa (collective term) Phylum: Percolozoa Class: Heterolobosea Order: Schizopyrenida Family: Vahlkampfiidae Genus: <i>Naegleria</i> Phylum: Amoebozoa Class: Lobosea Subclass: Gymnamoebia Order: Amoebida (Euamoebida) Family: Hartmannellidae Genus: <i>Hartmannella</i> Family: Thecamoebidae Genus: <i>Sappinia</i> Order: Acanthopodida Family: Acanthamoebidae Genus: <i>Acanthamoeba</i> Genus: <i>Balamuthia</i>
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Table 2 Alternative taxonomy of FLA (exemplary tree) according to Walochnik and Aspöck (2007), Scheickl (2009), and Adl et al. (2012)

Domain: Eukaryota	Group: Unikonta Phylum: Amoebozoa Class: Lobosea (Euamoebida) Genus: <i>Hartmannella</i> , <i>Saccamoeba</i> Class: Variosea Genus: <i>Acanthamoeba</i> , <i>Balamuthia</i> Group: Bikonta Phylum: Excavata Class: Heterolobosea Genus: <i>Paravahlkampfia</i> Genus: <i>Naegleria</i>
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geneous, and their genetic divergence is partly considerably greater than between animals and fungi (Walochnik and Aspöck 2007; Scheickl 2009; Adl et al. 2012).

Tellingly, the FLA are classified in this context as “prime examples of problems in phylogeny, classification, and nomenclature” (Walochnik and Aspöck 2007). As these classifications based on morphological descriptions are not always congruent to the molecular biological findings, therefore often molecular phylogeny and morphological descriptions with their traditional classification exist side by side.

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