

## Metchnikovellids as basal microsporidia: Research history and perspectives

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The first metchnikovellid microsporidium was described in 1897 by Caullery and Mesnil as *Metchnikovella spionis*, a hyperparasite of the intestinal eugregarine *Polyrhabdina brasili* from the polychaete *Spio martinensis*. In the later studies of these scientists (Caullery, Mesnil, 1914, 1919), the description of this type species was improved and detailed; more species were discovered and the genera *Metchnikovella*, *Amphiamblys* and *Amphiacantha* were erected. Thus, the history of the metchnikovellid study has begun. Metchnikovellid microsporidia are hyperparasites of intestinal gregarines parasitising marine worms, mainly polychaetes. Based on the morphology of spores believed to be a primitive form of those in higher microsporidia, two types of sporogony and suggested lack of the merogonial proliferation in the life cycle, the metchnikovellids were regarded as a monotypic taxon affiliated with microsporidia (Vivier, 1965; Vivier and Schrével, 1973; Sprague, 1977; Sprague et al., 1992). Recently, the SSU rDNA phylogeny and phylogenomic analyses have confirmed this conclusion and demonstrated the basal position of metchnikovellids in the microsporidian tree (Simdyanov et al., 2009; Nassonova et al., 2015, 2016; Mikhailov et al., 2016). To the present time, about 30 species of metchnikovellids have been described. The genera are distinguished by the morphological characters of the cysts and the number of spores per cyst. Many species are known only from old descriptions and illustrations. Only eight species have been investigated using electron microscopy (Vivier and Schrével, 1973; Hildebrand, 1974; Desportes and Théodoridès, 1979; Ormières et al., 1981; Larsson, 2000; Larsson and Køie, 2006; Sokolova et al., 2013, 2014). The majority of metchnikovellids were found in different bays of the English Channel and the Mediterranean Sea shoreline of France (Caullery, Mesnil, 1914, 1919; Schereshevsky, 1924; Mackinnon, Ray 1931; Hildebrand, Vivier, 1971; Vivier, 1965, 1975; Vivier and Schrével, 1973; Hildebrand, 1974; Ormières et al., 1981). There were several findings of metchnikovellid microsporidia in the North Atlantic, the Hebrides, the North Sea, and the Baltic Sea (Caullery, Mesnil, 1914, 1919; Reichenow, 1932; Desportes, Théodoridès, 1978; Larsson, 2000; Larsson, Køie, 2006). They were also found near California, the Pacific Ocean (Stubblefield, 1955). A few hyperparasites were discovered in the Kola Bay, the Barents Sea (Awerinzew, 1908; Dogiel, 1922). During the last 30 years, several species have been recorded in the Kandalaksha Bay, the White Sea (Sokolova et al., 2013, 2014; Rotari et al., 2015; Paskerova et al., 2016). Such a mosaic distribution is thought to be accounted by technical difficulties in searching and studying these organisms due to their microscopic size, hyperparasitic mode of life and presumable sporadic occurrence in the environment. The natural diversity of metchnikovellids seems to be unrevealed. Long-term monitoring studies of the natural habitats, modern light and electron microscopy, molecular ecological approaches, phylogenetic and phylogenomic analyses are necessary for further revealing the diversity of metchnikovellids and better understanding their evolution and relationships with other microsporidia.

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