Evolution of fungi at boundaries of life

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The ice-free Antarctic areas in Victoria Land are characterized by high dryness, high UV radiation, very low temperatures reaching about –50˚C during the Austral Winter, strong and sudden thermal fluctuations leading to very unstable environmental conditions. Precipitations, represented only by snow, are less than 100 mm water equivalent per year, which mostly sublime and only a small amount melts and remains available inside the rocks; furthermore the strong evaporation causes soluble salts accumulation on the surface. The rock surfaces appear mostly sterile and only rare epilithic lichens occur in protected niches; microbial cryptoendolithic communities, living under the rock crust at the absolute biological limits for life, represent the predominant life form. Among them the most widespread is the lichen-dominated community where black meristematic fungi have been currently isolated. They belong to an enigmatic group of extremotolerant microorganisms with polyphyletic origins, generally isolated from substrates hard to be colonized like sandstone, marble and saltpans. Recently two new Antarctic endemic genera, isolated from rock samples, (*Friedmanniomyces* Onofri and *Cryomyces* Selbmann *et al.*) with four species (*F. endolithicus* Onofri, *F. simplex* Selbmann *et al.*, *C. antarcticus* Selbmann *et al.* and *C. minteri* Selbmann *et al.*) were established. Some other unidentified strains are still waiting to be described and one at least seems to be associated also with epilithic lichens. Phylogenetic analyses have been carried out by comparing both SSU and ITS rDNA sequences. In the SSU tree the genus *Cryomyces*, represented by 9 strains, seems to be a maverick without any obvious direct ancestor. It is restricted to Southern Victoria Land and its very limited distribution could be related with a very slow growth rate, dispersal mechanisms strictly associated with the weathering processes of the rocks, and a yeast-like organization. The genus *Friedmanniomyces*, represented by 10 different strains, is spread both in Northern and in Southern Victoria Land.

These two Antarctic endemic genera as well as all the other Antarctic black fungi studied are each other distantly phylogenetically related and their morphological similarities could be due to a convergent evolution as adaptation to extreme environmental conditions. Although there is no recent relationship with any other fungus known at the moment, their nearest neighbours are other extremotolerant or/and rock fungi.

We suggest that, among a higher fungal biodiversity living in the Antarctic rocks when

the continent was located at higher latitudes, Antarctic black fungi may have been positively selected during cooling of the Antarctic and endemic species may subsequently have emerged as a result of geographic isolation from the global gene pool over a timescale of evolutionary significance.

Speculations on the origin and the evolution of life on Mars, if ever existed, are possible since life could have evolved under similar environmental conditions during the early history of the Red Planet and, at present, the McMurdo Dry Valleys, located in Southern Victoria Land, are considered the closest terrestrial analogue of Mars. Black Antarctic extremotolerant fungi have been proposed, and accepted, as models to test their ability to survive in space conditions in the framework of EXPOSE ESA mission.