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CORRESPONDENCE

Malassezia in the central nervous system and multiple sclerosis

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We read with interest the review about fungal infections of the central nervous system (CNS) by Góralska et al. [1]. Our interest stems from the many recently discovered links between fungi and idiopathic inflammatory diseases [2] including multiple sclerosis (MS) [3, 4]. Góralska et al. review is very thorough, and covers nearly all medically important fungi [1]. However, the most common fungal genus present in humans, *Malassezia*, is not mentioned. *Malassezia* infections of the CNS can result in severe illness [5]. Like all infections of the CNS, *Malassezia* infections which cause acute neurological symptoms are rare and often associated with immunosuppression [5]. *Malassezia* are difficult to detect: they are small, fastidious, resistant to lysis and their ribosomal genes mismatch commonly used consensus primers [2]. This suggests *Malassezia*-induced neurological symptoms may often be missed.

Malassezia are usually described as ubiquitous commensals of mammalian skin. Improved detection techniques based on deep sequencing have led to the detection of *Malassezia* in many human organs [2] including the CNS [6, 7]. We overlooked these key studies in our recent article summarizing the links between fungi and MS [4]. This omission is important because *Malassezia* is the only known fungal genus which has all the right properties to cause MS [4]: it has been reported present in the mouth, gut and CNS, and its association with spondyloarthritis and Crohn's disease suggests it first colonizes the gut of young adults [2], mirroring the age at onset of MS. The paucity of pediatric MS cases—despite ample childhood exposure to most infections including the Epstein–Barr virus and fungi—has long puzzled us [4]. We now realize that *Malassezia*'s absence from the gut of children could explain their low risk of MS.

Malassezia appear to be ubiquitous in the mouth, nose, gut and breast of healthy adults [2], suggesting this genus may colonize many internal organs. Though small studies report finding *Malassezia* in the CNS [6, 7], these data are too preliminary to estimate its prevalence. Reliable techniques to detect fungi in the CNS should be designed to cover *Malassezia* in addition to other medically important fungi. Future studies attempting to confirm that *Malassezia* colonizes the mouth, gut and CNS should use techniques which are less susceptible to contamination, such as fluorescent *in situ* hybridization (FISH) and immunohistochemistry (IHC). The adaptive immune response against *Malassezia* should be tested in MS case-control studies by measuring antibodies against *Malassezia* antigens, and by measuring memory B cell and CD4 + T cell recognition of *Malassezia* antigens. Finally, a clinical study should be run to test the efficacy of voriconazole in MS, similarly to itraconazole in Crohn's disease [8].

Compliance with ethical standards

Conflict of interest We declare no competing interests.

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