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Are the memory and ataxia body control parasites in Rick and Morty real?

Louisa Wright-Watts
Natural Sciences (Life and Physical Sciences), School of Biological Sciences, University of Leicester
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Abstract
This paper will be looking at if it is possible for a parasite to infect humans and tamper with the hosts brain causing false visions and planting fake memories. I will also be looking at fungi that affects human behaviour causing schizophrenia like symptoms. I will also be analyzing other types of fungus which may not affect humans but take full control over the hosts body even leading them to death such as the fungus *Ophiocordyceps unilateralis*.

Keywords: *TV programme; Biology; Fungus; Parasites; Rick and Morty*

Introduction
An episode in season two of *Rick and Morty*, a series based upon the intergalactic adventures of a crazy scientist and his grandson, shows us where Rick's household is infiltrated by alien parasites who disguise themselves by planting fake memories and events. The parasites take on the form of the family members and friends to hide their true appearance. Once they have multiplied enough times their goal is to take over the planet and enslave the race [1,2].

Parasites
What is a parasite? It is an organism that inhabits a host organism and gets food and energy by obtaining it from the host. There are three types of parasites that can cause disease in humans: protozoa, helminths and ectoparasites. Protozoa are microscopic organisms which can multiply in humans and cause infection, transmission is normally via food or water or can live in blood and be transmitted to someone else by a vector such as a mosquito bite. Helminths are larger multicellular organism which can't multiply in humans but will cause damage e.g. flatworms such as cestodes which are tapeworms and nematodes which will live in the blood and other tissues. Ectoparasites are parasites such as organisms including tics, lice and fleas which break into the skin and remain for up to months also acting as vectors for transmitting different pathogens and often causing death [3].

Ophiocordyceps unilateralis
The fungus *Ophiocordyceps unilateralis* (which is a protozoa, part of the subkingdom of Protista) is found in tropical forests, and is also known as "zombie-ant fungus", at first seems harmless as a spore however when it meets an ant its true motive is revealed. Their main goal is to self-propagate and disperse. It works by breaking through the exoskeleton of the ant and then when its inside it will consume the hosts body's tissues making it extremely weak but still functional. When the fungus has then matured it will release chemicals into the brain making the ant completely under its influence. As the infection increases the ant is encouraged to leave its nest to look for a humid climate that is favourable to the fungus's growth. The ant will then climb a plant and lock its jaw onto the underneath of a leaf as the parasite continues to eat its brain (Fig. 1). A few days after this takes place fungal reproductive structures will be expelled from the ant's corpse and spores will fall onto other ants beneath it restarting the cycle. Research from Pennsylvania State University looked at fungal colonization from the abdomen to the head finding zero traces of fungal cells in the brain and that the fungi had made scaffolding around the ant's muscle bundles [4]. This could mean that the fungus is able to mind control the ants via bioactive residues that disrupt the ant's nervous system controlling the hosts directly at the muscles.

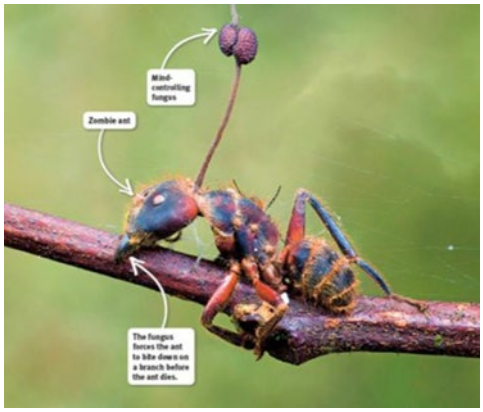

Figure 1 – Image showing an ant infected with the *O. unilateralis* fungus in later stages of infection when the parasite will bite down on a leaf resulting in the hosts death [5].

Ophiocordyceps sinesis

Another species related to *Ophiocordyceps unilateralis* is *O. sinesis,* a complex fungus with multiple biological functions that infects the larvae of ghost moths. It first infects the caterpillars in the summer when they are underground feeding of roots. It then starts to slowly grow through their bodies in the winter gradually consuming them. After the snow melts in the spring the fugus pushes their nearly dead host up above the surface and shortly afterwards expelling a dark-brown spore-filled stalk through their head [6] (Figure 2). In Chinese and Tibetan cultures, they collect the stalk and use in for cancer treatments and immune booster medication. It has also been shown that the *Ophiocordyceps* species that occupies Japanese cicadas has even replaced symbiotic bacteria so the cicadas can produce nutrients from the sap they drink from trees [3].

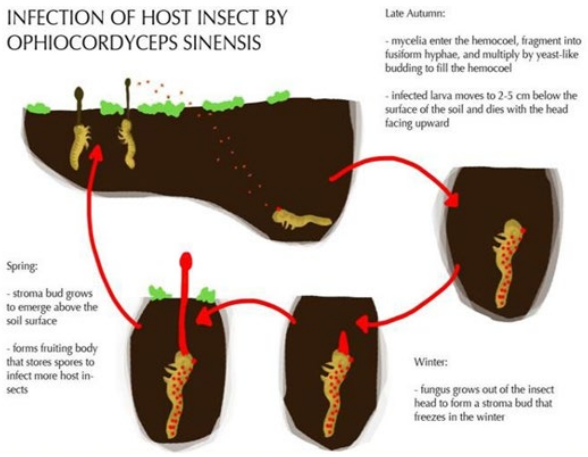

Figure 2 – Life cycle of *O. sinensis* from autumn infection, winter bud stage and finally summer-fruiting body stage [7].

Parasites causing schizophrenia like symptoms in humans

Toxoplasmosis is an infection caused by the parasite *Toxoplasma gondii* which can alter behaviour and neurotransmitter function in humans even producing psychotic symptoms like someone with schizophrenia [8]. It's possible to contract this parasite from eating undercooked meat or from contact with cat faeces. *T. gondii* is an intracellular parasite with a life cycle that can only be completed in felines. However, it can also affect intermediate hosts like humans. In other mammals it is a cause for abortions and stillbirths (congenital toxoplasmosis) due to it as it can cross the placenta and infect the foetus harming muscle and brain tissue causing cerebral palsy, mental retardation and other complications which sometimes aren't present at birth [9]. Other symptoms post infection include incoordination and headshaking, these have been reported in pigs, sheep, and monkeys.

A review of acquired toxoplasmosis showed 24 cases out for 114 in adults were associated with frequent psychiatric disturbances with reports that a 22-year-old female had delusions that she had no arms or legs and extreme paranoia. Another 34-year-old female also experienced auditory hallucinations and disorganized speech. At first both patients were diagnosed with schizophrenia but as their neurologic symptoms increased over time the correct diagnosis was Toxoplasma encephalitis [10], an infection that affects the central nervous system of immunocompromised patients or organ transplant patients if the latent *T. gondii* is reactivated [10].

Conclusion

Mind bending parasites are real, not to the point where they can disguise themselves as the host copying their appearance but instead infecting the host. For *O. unilateralis* they will control their muscles leading them to their death whilst not altering their mind. However, their goal is not to convert all the ants into "zombies" as the ecosystem needs to be balanced so only a few ants are infected at any different time. But in the case of Toxoplasmosis cause by *T. gondii* there is significant evidence of schizophrenic behaviour and delusions which is very similar to what Rick and his family members experienced. Fortunately, so far humans have not experienced parasites which are able to take control over our bodies leading us to death but that is not to rule it out in the future.

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