

When should a trophically and vertically transmitted parasite manipulate its intermediate host?  
The case of *Toxoplasma gondii*

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## Abstract

Parasites with complex life cycles are expected to manipulate the behavior of their intermediate hosts (IHs) to increase their predation rate and facilitate the transmission to definitive hosts (DHs). This strategy, however, is a double-edge sword when the parasite can also be transmitted vertically in the IH. In this situation, the manipulation of the IH behavior, which increases the IH death rate, conflicts with this second route of transmission which requires healthy and reproducing IHs. The protozoa *Toxoplasma gondii*, a wide spread pathogen, combines both trophic and vertical transmission strategies. Is parasite manipulation of host behavior still adaptive in this situation? We model the evolution of the IH manipulation by *T. gondii* and study the conflict between these two routes of transmission under different epidemiological situations. We show that the evolutionary outcome of this conflict depends on the level of virulence and vary between early and later stages of an epidemic: manipulation is particularly advantageous for virulent strains and in epidemic situations. In addition, we show that different levels of manipulation may evolve depending on the sex of the IH: the intensity of manipulation is expected to be higher in males than in females. These results may help to understand the variability of strain characteristics encountered for *T. gondii* and may extend to other trophically transmitted parasites.