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Evolution and maintenance of mutualism between tubeworms and sulfur-oxidizing bacteria

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Tubeworms and sulfur-oxidizing bacteria mutualism, an essential part of the chemosynthetic ecosystem in the deep-sea, has several puzzling features. After acquiring sulfur-oxidizing bacteria from the environment, tubeworms becomes fully dependent on their symbiont bacteria for nutrient intake. Once ingested by the tubeworm larva, no additional symbionts join from the environment, and no symbionts are released until the host tapeworm dies. Despite this very narrow window for symbionts, some tubeworm species can live for >200 years. Such a restricted release of symbionts could lead to a shortage of symbiont bacteria in the environment without which tubeworms could not survive. In our study, we examine the conditions under which this mutualism can persist, and whether the host mortality evolves toward a low value, using a mathematical model for the tubeworm-symbiont bacteria system. Our model reveals that mutualism can persist only when host mortality is within an intermediate range. Moreover, with weak competition among symbionts and their slow growth within a host, host mortality evolves toward a low value, without driving either host or symbiont to extinction. We also found the parameter conditions that lead to the unlimited evolutionary escalation of host mortality toward extinction of both tubeworms and symbionts populations (evolutionary suicide).

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