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The termite microbiome and its role in disease resistance

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Microorganisms, which are ubiquitous, are known to span the entire range of symbiotic associations, from pathogenic to mutualistic interactions. As such, they likely act as important selection forces and ultimately, are responsible for key evolutionary innovations. Because termites exploit microbial rich environments and have had a long co-evolutionary, we hypothesize that some mutualistic microbes help in the control of termite infectious diseases. From the environmentally acquired microorganisms that colonize the insect's cuticle and outer surface of the eggs to the diverse and abundant hindgut microbial community, termite hosts appear to derive protection against pathogens from their mutualistic microbes. Over one hundred strains of actinomycetes have been isolated from *Zootermopsis angusticollis* nest material and egg washes. Among the isolates several strains produced highly diffusible compounds with high activity against *Metarhizium anisopliae*, a common termite pathogen. Additionally, through a combination of *in vitro*, *in vivo* and *ex vivo* experiments, we show that protozoa and/or their associated bacteria colonizing the hindgut of *Z. angusticollis*, are responsible for the synthesis of multiple active beta-1,3-glucanases, enzymes known for their fungistatic activity. These microbial-derived enzymes are also present in the termite's liquid feces which are commonly used in nest building and proctodeal feedings. By externalizing, depositing and sharing these mutualist-derived enzymes, termites can potentially expand individual-level antifungal defenses to encompass colony-wide protection. This research establishes a novel role for the mutualistic association between termites and some of their microbial consortia and provides new insights into factors that could have influenced the origin and/or maintenance of complex mutualisms, the evolution of termite sociality and the host's individual and social immunity.