Characterizing the Role of Toll Proteins on the Development of the Cricket Nervous System

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The common fruit fly (*Drosophila melanogaster*) is a widely used model organism in biological research, valued for its contributions to our understanding of genetics, behavior, and development. As a holometabolous insect, *Drosophila* undergoes complete metamorphosis, transitioning through distinct larval, pupal, and adult stages—none of which resemble each other morphologically. In contrast, the Mediterranean cricket (*Gryllus bimaculatus*) is a hemimetabolous insect. It undergoes incomplete metamorphosis, lacking a pupal stage. Juvenile crickets resemble miniature adults and mature through a series of successive molts.

From an evolutionary perspective, hemimetabolous insects are more basal, appearing earlier on the phylogenetic tree than holometabolous insects. *G. bimaculatus* has recently gained attention as an emerging model organism. Because crickets and fruit flies share a common ancestor, comparative studies of their genetics, behavior, and development are especially valuable.

One particularly compelling feature of the cricket model is its remarkable adult structural plasticity within the nervous system. For example, crickets can remodel their neural architecture in response to the unilateral loss of an ear. This phenomenon, known as structural plasticity, refers to the brain's ability to change in response to experience. Structural plasticity has also been observed in *Drosophila*, where it involves Toll receptors—a family of proteins present in the nervous system but best known for their roles in innate immunity. Exploring the role of Toll signaling in crickets may help uncover fundamental principles of adult neural plasticity and clarify whether its function in holometabolous insects like *Drosophila* is conserved in hemimetabolous species.

The goal of my research this summer was to characterize the role of Toll receptors in the *Drosophila* nervous system as a foundation for future studies in *G. bimaculatus*. To this end, I conducted a literature review synthesizing current research on Toll signaling in *Drosophila* and its developmental significance. Below is a summary of my findings:

In *Drosophila*, the Toll signaling pathway involves Toll receptors and their ligand Spaetzle (Spz). Toll receptors possess extracellular leucine-rich repeat (LRR) domains for ligand binding and intracellular domains that mediate downstream signaling. This pathway is crucial not only for immune responses but also for neural development. Specifically, Toll receptors play neurotrophic roles and are involved in motor axon targeting during embryogenesis.

The *Drosophila* genome encodes nine Toll receptors, and loss of these receptors can lead to significant defects in motor axon guidance. Notably, Toll-6 and Toll-7 have been implicated in axon targeting, neuronal survival, and locomotion, acting independently of their immune functions. The cricket genome encodes eleven Toll receptors, suggesting potential parallels in Toll signaling between the two species.

While further research is needed to elucidate the exact functions of Toll-6 and Toll-7 in *G. bimaculatus*, my literature review lays the groundwork for future investigations into the conservation and divergence of Toll signaling pathways in insect neurodevelopment.

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