Toll Receptors, a Potential Molecular Candidate in the Compensatory Plasticity of the Cricket

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My project this summer was focused on characterizing Toll receptors in the cricket with the goal of understanding if they are involved in the compensatory plasticity of the nervous system. Neural plasticity is how the nervous system changes or regenerates itself after injury, and adult organisms have a difficult time recovering from central nervous system injuries (Chen and Zheng, 2014; Kerr et al., 2011). Learning more about how the central nervous system regenerates in adult organisms would provide incredible treatment opportunities for patients with devastating injuries like spinal cord injuries (Chen and Zheng, 2014; Dietz, 2006; von Bernhardi et al., 2017).

The Mediterranean Field Cricket, *Gryllus bimaculatus* is a great model organism as it has a simple central nervous system and demonstrates compensatory plasticity after injury in the adult. The cricket is dependent on its hearing for mating and detecting predators, and when the axons from a cricket's ear are severed, disconnected dendrites cross the midline of the prothoracic ganglion (which they normally respect) and connect to dendritic partners from the intact ear (Figure 1). This compensates for the injured ear (Brodfuehrer and Hoy, 1988; Hoy et al., 1985; Schildberger et al., 1986). Thus, the Horch lab aims to understand the molecular characters that underlie the phenomenon of Compensatory Plasticity.

Figure 1. Compensatory Plasticity in the cricket. (Adapted from Horch et al, 2009)

The Horch lab has found that Toll receptors are possibly involved in compensatory plasticity since they are differentially regulated in crickets after injury. In other insects, Tolls function in the central nervous system similarly to neurotrophins, promoting neuronal survival (Anthoney et al., 2018; Li et al., 2020; McIlroy et al., 2013; Wang, 2020).

With the goal of characterizing Tolls in the cricket, we examined how different Tolls were evolutionarily related and where they were expressed in the cricket. First, we constructed phylogenetic trees with Toll proteins sequences from fruit flies, crickets, and other similar insects to understand evolutionary relations of the Tolls. Afterwards, we conducted whole-mount *in situ* hybridization (ISH) to visualize cricket tissue to see where Toll proteins are expressed in the cricket.

For the phylogenetic trees, we found that Tolls 1, 6, 7, and 8 expressed in the cricket with 6 and 8 expressed the most. In our ISH experiment, we looked at where Toll 7 was expressed and found that it was expressed in the neurogenic tip of the mushroom bodies in the cricket brain and the limb buds of cricket embryos. This result falls in line with studies in other insects that conclude that Toll 7 is responsible for neuronal survival in invertebrate embryos and brain development (Li et al., 2020). We did not find Toll 7 expressed in the prothoracic ganglion (PG) with ISH, despite the fact that it was present in our PG transcriptome. It is possible that we need to improve our desheathing the PG in our dissections so that the probe can visualize the proteins that might be located there and were not visualized. It is also possible that Toll 7 expression is quite weak and not visible in the ISH. Regardless, we hope to continue characterizing different Tolls in the cricket in my honors project next year.

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