Locomotion is a crucial component of animal survival that has to be adaptable to be consistently successful. This adaptability is necessary for walking insects to overcome complex and changing terrains in a task-dependent manner. The six legs of insects are coordinated and controlled by local and over-arching networks that control each limb and limb joint, and this modular structure creates necessary flexibility in the system. Locomotor networks consist of pattern-generating interneurons, motor neurons, muscles, and sensory organs. Sensory organs monitor the motor output and provide dynamic modifying and reinforcing feedback onto other network components. Proprioceptive information on limb positions and movements allows the networks to adapt to perturbations.

Campaniform sensilla (CS), sensory organs found on the majority of limb segments, are analogous to the vertebrates Golgi tendon organ. CS encode highly dynamic strains that spread through the cuticle. Different strains arise during different behaviors. For example, when a leg switches between its stance and swing phase during walking, the leg is exposed to various strains that change over time. CS on different limbs can monitor these tonic forces and the rate of forces changes over time, and their feedback can modify or reinforce muscular output to ensure coordinated movements and stability.

In *Drosophila melanogaster*, a model organism with many novel genetic tools, leg CS research is limited. The tools that *D. melanogaster* provides can be utilized to answer questions on CS encoding, function, and network dynamics. Furthermore, although there are CS locations homologous to other insects, it is unclear how small-weight insects like *Drosophila* utilize CS during walking. This dissertation lays out multi-faceted experiments on leg CS in *D. melanogaster*.

A collection of methods gives insight into the morphology, biomechanics, and function of these sense organs.

Initially, I targeted the outer morphology of CS using electron microscopy. These experiments demonstrated interindividual and interleg variability in CS number and positions. I then used nano-computed tomography to connect the morphological data with modeling, which underlined the role of CS structures in the distribution of strain across the cuticle. In a parallel series of experiments, I focused on the neural components of CS and tested how they influence leg movements and coordination using optogenetic manipulations. This demonstrated the sufficiency and necessity of small CS subsets for these behaviors, highlighting their importance for both kinematic and temporal coordination.

The research herein portrays the complexity of leg CS morphology and elucidates their role in the lightweight insect *D. melanogaster*. In the age of connectomics, understanding morphology and behavior are critical aspects for complete investigations of neural networks. The findings in this dissertation provide a foundation for fully understanding the function of proprioceptive information in the motor networks of *D. melanogaster*.