Abstract of Doctoral Dissertation

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Spatial perception through active sensing by cricket antennal mechanosensory system
（コオロギ触角機械感覚系のアクティブセンシングによる空間知覚）

Animals perceive their surroundings by using various modalities of sensory inputs to guide their locomotion by acquiring and integrating information of surrounding objects such as shape and location using multiple sensory organs. Crickets obtain sensory cues of spatial context mainly via antennal and visual systems, but it remains unclear whether the crickets modulate behaviors mediated by other sensory organs based on the spatial information. Crickets exhibit escape behavior in response to a short air-puff, which is detected by the abdominal mechanosensory organs called cerci and is perceived as a "predator approach" signal. In this thesis, in order to clarify if the crickets have an ability of spatial perception enough for a general use, I examined the effects contextual spatial information on the wind-elicited escape behavior, by using an open-loop treadmill system.

In chapter 1, I examined whether the spatial perception of the cricket antennal mechanosensory system affects the wind-elicited escape behavior. I placed objects of different shapes at different locations with which the cricket actively made contact using its antenna, and then examined the changes in various locomotion parameters of the wind-elicited escape behavior. The crickets changed their movement trajectory in response to nearby objects to avoid collision with these obstacles during the cercal-mediated behavior. For instance, when a wall was placed at the center in front of the crickets so that it was detected by both antennae, the forward movement triggered by the airflow from behind was suppressed and the escape trajectory curved bilaterally. In contrast, the one-sided frontal wall to be accessed by only one antenna significantly biased the movement toward the side opposite the wall. It was concluded that crickets modulated their escape behavior depending on spatial information of surrounding objects by using antennal inputs.

In chapter 2, to clarify how multisensory inputs are integrated to modulate the orientation behavior, I investigated the effects of both antennal and visual inputs on the wind-elicited escape behavior. A wall was placed in front of the cricket on one side so that only ipsilateral antenna could contact the wall. Then, the

responses to airflow from behind were examined in four conditions: both antennae were intact or removed and in complete darkness or light, respectively. Crickets relied on the mechanosensory input from the antennae to localize frontal objects and modulated their escape behavior based on the spatial information obtained by the antennal mechanosensory system. On the other hand, the visual input had little impact on modulation of the walking direction induced by antennal inputs but reduced the walking distance and tuning movement and delayed the reaction time. These results suggest that crickets integrate information mediated by multiple sensory organs of different modalities to effectively avoid obstacles along the trajectory routes.

In chapter 3, I set two research aims. The first was to explore how bilateral comparison of right and left antennal inputs was involved in the localization of the forward objects. For this, I placed the wall in front of the cricket either at the center or one sided and compared the escape responses to the air puff from behind between when both antennae were intact and when one antenna was ablated, respectively. When the antenna contralateral to the wall placed on one side was ablated, the movement biased to the wall-free side was remained but smaller than that in intact crickets. This suggests that the mechanosensory inputs from one antenna would be sufficient to localize the forward obstacle, but the bilateral comparison was more effective. The second was to clarify whether crickets can measure the object size relative to their own body. I placed the wall with opening gap of different width that both antennae could detect, and examined the modulation of their escape response to the air puff from behind. Depending on the escape gap width, the crickets changed their behavior to either the straight-forward escaping or the movements biased to either side. This result showed that the crickets were likely able to perceive the size of the expected route sufficient to accommodate the own body size to avoid collision during escape behavior.

In conclusion, this study demonstrated that crickets were able to use the spatial information by active sensing with their antennal system to modify their behavior mediated by other sensory organs.