

# Elucidation of multimodal use in insects and its application to pest control

Hiromi Mukai (Forestry and Forest Products Research Institute, Kansai Research Center)

mhisa8088@affrc.go.jp

Insects use a variety of modalities to perceive surroundings and adapt to complex and fluctuating environments. Use of sensory stimuli of insects and the behaviors controlled by these systems are exploited for the management and conservation of pest and/or beneficial insects.

In this study, I investigated the use of multimodal stimuli, which has not been extensively studied in invertebrates, using basic and applied approaches: 1) elucidation of the functions of multimodal use in insects, including vibratory and chemical senses; and 2) development of technologies to control behavior and growth of pest insects, and to attract natural enemies by applying these systems.

## 1) Elucidation of vibration and multimodal functions in insect communication

We discovered synchronous hatching occurred in sub-social burrower bugs when the mother periodically vibrates an egg mass. Synchronous hatching was artificially reproduced by using a hand motor to vibrate an egg mass, thereby mimicking the pattern of maternal vibration. In asynchronized hatching egg masses, the timing of molting became asynchronous and nymph were eaten by other nymphs immediately after molting. This suggests that vibration-induced synchronous hatching may function to mitigate the risk of sibling cannibalism. Such parent-embryo vibratory communication was observed in almost all closely related species of sub-social burrower bugs<sup>1</sup>.

Using neuro-anatomical and physiological techniques, we identified the presence of a vibratory receptor, called chordotonal organs, in the legs of Heteropteran insects. We also demonstrated that vibration functions as an important communication tool. In particular, the unique courtship behavior of a jewel bug showed that complex communication is made by the combination of multimodal senses, including vibratory, chemical, visual, and tactile senses, as well as the sequential use of these modalities<sup>2</sup>.

## 2) Development of pest control technology using vibration and multimodal functions

Fungus gnats that feed on shiitake mushrooms rapidly increase in numbers in mushroom cultivation houses. Thus, their larvae cause serious damage as loss and contamination of mushrooms. We demonstrated that these larvae strongly respond to specific vibratory stimuli. We also characterized vibrations that inhibit the behavior and growth of these larvae and have developed a new pest control technology that utilizes these vibrations. Furthermore, we identified parasite wasps which feed on larvae of fungus gnats. We are currently attempting to develop a new natural enemy attraction technology using chemical and visual stimuli to introduce and utilize as natural enemies of fungus gnats in mushroom cultivation houses<sup>3</sup>.

- 1) Mukai H., Noamakuchi S. (2022) Springer Nature, Singapore, 147–175.
- 2) Mukai H., Takanashi T., Yamawo A. (2021) Ecology, 103: e3632.
- 3) Mukai H., Kitajima H. (2019) Biol. Cont., 134: 15–22.