Chemical Arms Race between Insects and Plants Contributable to Next-generation Pest Management

Naoko Yoshinaga (Kyoto University, Faculty of Agriculture)
yoshinaga.naoko.5v@kyoto-u.ac.jp

Through a several billion-year history, insects and plants have evolved adapting themselves to various environments and developing unique chemical defense/offense strategies. A successful utilization of such established strategies to biological pest control requires comprehensive knowledge on both the integrated ecological frameworks and the molecular mechanisms underlying the interactions.

Herbivorous insect pests can show the best detoxification performance in crop fields where in general the nutrient conditions are most suitable for them. In this context, we took note of the nutrient metabolism in common cutworm, *Spodoptera litura*, one of the most severe pest species in Japan. Fatty acid amino acid conjugates (FACs) and gardenoside are key compounds to understand the insect nutrient metabolism and its interaction with detoxification metabolism.

FACs were first identified as insect elicitor that evokes plant indirect defense reaction. In response to herbivory attack, corn seedlings release volatile compounds that attract parasitic wasps. In this tritrophic interaction, plants detect FACs in the insect saliva as a signal of insect attacks. We revealed the original function of FACs for insect itself as an enhancer of their nitrogen metabolism[1)]. Nitrogen metabolism are crucial for the herbivorous insects, not just because they feed only on nitrogen-poor plant tissues but because the rapid growth can shorten the vulnerable larval stage and also they acquire a better detoxification ability in later larval stages[2)].

Gardenoside is one of the iridoids in gardenia plants, and stored as a glucoside in leaf tissues. On herbivory, β-glucosidase releases the aglycone, which automatically forms dialdehyde and nonspecifically binds to any proteins in insect intestine. In response to this toxicity, *S. litura* larvae induced a large amount of β-alanine that binds to the dialdehyde and inactivate it. The concentration of induced β-alanine exceeds hundredfold of the other amino acid concentration and may cause a serious load to the whole amino acid metabolism. Nevertheless, the insect cannot survive when the gardenoside concentration in the leaf is high enough.

The case of gardenia iridoids is a clear example that insect nutrient metabolism directly links to detoxification metabolism. The amino acid metabolism is also related to the FACs metabolism. The study will give us a better idea for future biological pest control, as well as a deeper insights in historical arms race between insects and plants.

1) Yoshinaga, N., Aboshi, T., Abe, H., Nishida, R., Alborn, H.T., Tumlinson, J. H., Mori, N.: Proc. Natl. Acad. Sci. USA 105, 18058-18063 (2008).
2) Yoshinaga, N.: Biosci. Biotechnol. Biochem. 80, 1274-1282 (2016).
3) Yoshinaga, N. and Mori, N.: Chemical Ecology of Insects: Applications and Associations with Plants and Microbes, Tabata, J. edit, CRC Press, Chapter 2, (2018).