Self-medication is a specific therapeutic and adaptive behavioral change in response to disease or parasitism (Singer et al., 2009). Such as a feeding behavior whereby herbivores preferentially consume non-nutritive but medicinal substances, which is called "pharmacophagy" (Boppre, 1984). Self-medication is well known in herbivorous and omnivorous vertebrates (Fowler et al. 2007), but the knowledge of insects is still insufficient. In this review, I will introduce several examples of self-medication in herbivorous insects, a dominant group in insects' self-medication.

In 1997, Karban and English-Loeb observed that tiger moths Platyprepia virginalis (Lepidoptera: Arctiidae) changed host preference whether they were parasitized or not ①. They demonstrated that the choice of caterpillars increased their survival probabilities during adulthood ②③.

After that, Bernays and Singer’s group reported that caterpillars of another polyphagous tiger moth Grammia incorrupta could feed on over 80 species of plants from nearly 50 phylogenetically disparate families. These caterpillars preferentially ingest non-nutritive pyrrolizidine alkaloid (PA) compounds from certain highly acceptable host-plant species (Bernays et al. 2002). Thus, it was suggested that the intake of PA compounds by G. incorrupta larvae is an effective strategy against parasitoid fly Exorista mella (Diptera: Tachinidae), a major natural enemy of this species.

Subsequent experiments confirmed this supposition. Singer et al. (2009) found that PA compounds affected the survival of parasitized G. incorrupta moths positively but of non-parasitized ones negatively ④⑤. In addition, feeding preference changed after parasitism ⑥⑦⑧.

Smilanich et al. (2011) reported that the change of feeding preference of parasitized G. incorrupta took time. Parasitized caterpillars at later phase consumed much more PA compounds-containing diets than those at the earlier phase ⑨. Normally, eggs of parasitoid tachinid fly hatch between 48 and 60 h after oviposition, then this parasitoid larvae burrow through the cuticle and enter into the hemocoel of host caterpillars. It suggests that infection of parasitoid tachinid larvae triggered the feeding preference changing of host caterpillars.

Furthermore, Bernays and Singer (2005) examined altered feed preference on physiological angle and found that gustatory cells of G.incorrupta changed the responses to PA compounds after parasitism ⑩. It means parasitism of tachinid fly affected gustatory sense of host caterpillars and then caused feeding preference changing. In 2012, Milan et al. showed that the intake of ethanol by fruit fly larvae increased the survival against their endoparasitoids ⑪. Ethanol is more effective to survive the generalist parasitoid wasps
than the specialist ones. Parasitized larvae prefer ethanol containing food compare with non-parasitized larvae.

In conclusion, the phenomena of self-medication exist not only in vertebrate herbivores but also in insects. Self-medication of insects may happen when benefits of feeding toxic plants are higher than costs or risks. In another aspect, parasitoids also need to adapt themselves to self-medication of host insects for surviving. As Milan et al. (2012) mentioned, specialist parasitoids may be stronger to tolerate many kinds of self-medication compounds than generalist parasitoids, because for generalist parasitoids it is difficult to adapt various self-medication chemicals took by their host insects.

Key words Self-medication, herbivorous insects, parasitoid, pharmacophagy, plant toxins

References