Life history of an introduced parasitoid, *Torymus sinensis*, and dynamics of the host-parasitoid system

Masakazu Shiga
Entomology Research Team, National Institute of Fruit Tree Science, NARO, 2-1 Fujimoto, Tsukuba, Ibaraki 305-8605, Japan
kazshi@affrc.go.jp

Life history of *Torymus sinensis* around Tsukuba City

Adult wasps of *Torymus sinensis* emerge from withered galls of the chestnut gall wasp (CGW), *Dryocosmus kuriphilus*, in spring, synchronous with sprouting of buds of chestnut trees and also with the appearance of CGW galls. The parasitoid attacks the CGW larvae and aestivates as a full-grown larva. The parasitoid larvae defecate after late November and pupate from December to January, the coldest season of the year around Tsukuba. The parasitoid wasp overwinters in the early pupal stage. Pupal development occurs as a function of ambient temperature.

Defecation is considered to be a visible sign of the termination of diapause in *T. sinensis* larvae, and most of the diapausing larvae tested successfully defecated under a 10°C, 12L/12D photoperiod.

Mature larvae of *T. sinensis* obtained in various seasons were exposed to 10°C at a 12L/12D photoperiod, and the date of initiation of defecation was observed. The larvae collected from May 12 to June 18 and tested started defecation in 40-120 days, and the pattern of defecation timing sometimes seemed polymodal. After June 23, the trend of larval defecation drastically changed, i.e., almost all larvae continuously started defecation within 75 days. After late August to early September, larval defecation occurred within 60 days. After late October, the time required for 50% of individuals to defecate at 10°C was rapidly shortened as a function of the dates of transfer from outdoor to the laboratory conditions. Almost all larvae collected in this season successfully defecated, even under a 20°C, 16L/8D photoperiod.

In conclusion, the termination of summer diapause of *T. sinensis* larvae around Tsukuba proceeds gradually with several physiological steps in summer, is accelerated in autumn and is completed in late October.

Dynamics of host-parasitoid systems

Population trends of the chestnut gall wasp and its parasitoids in chestnut groves around Tsukuba after the release of T. sinensis

Moriya *et al*. (1989) reported that the percentage of gall-formed buds of chestnut trees at the release plot in Tsukuba decreased drastically in 1986, the fourth year after releasing of *T. sinensis*.

Since 1987, the abundance of CGW galls as the percentage of gall-formed buds of chestnut trees has been observed in various chestnut groves around Tsukuba. The percentage parasitism of *T. sinensis* and of various native parasitoids and the survival rate of CGW larvae were estimated.

Shiga (1999) documented the host parasitoid fluctuations around CGW in Tsukuba from 1988 to 1996. In the 1990s, the percentage parasitism of *T. sinensis* remained high, CGW survival was

much decreased and infestation of CGW was highly suppressed in most of the chestnut groves.

However, the abundance of CGW galls increased in many chestnut groves in Tsukuba around 2000, reaching high levels in some groves. Such an increase of CGW galls also occurred synchronously around 2007. It was obvious that the percentage parasitism of *T. sinensis* and also total parasitism by all parasitoid species decreased prior to the CGW increase and then increased, inducing a decline of the CGW population.

Parasitization of multivoltine facultative hyperparasitoids, especially of *Torymus geranii*, *Eupelmus urozonus* and *Ormyrus* spp., is much increased in summer and autumn. The apparent percentage parasitism of *T. sinensis* is often much decreased after summer.

It should be noted that peak densities of CGW remained at low levels even around 2000 and 2007 in well-maintained chestnut groves in which chestnut trees were pruned appropriately (e.g., those in NIFTS). This was true even in CGW-susceptible trees, including most of the Chinese chestnuts, *Castanea mollissima*. Pruning of chestnut trees may be important for IPM of CGW under effective introduction of *T. sinensis*.

Effects of T. sinensis *on the chestnut gall wasp affecting the European chestnut in Tsukuba*

Although the chestnut gall wasp populations in the experiment fields of both the Japanese chestnut, *C. crenata*, and the Chinese chestnut, *C. mollissima*, in NIFTS were highly suppressed after the release of *T. sinensis*, some cultivars or races of the European chestnut, *C. sativa*, (e.g., “Marron Avellino,” which was introduced from France, and “Carpinese,” which was introduced from Italy) are so far bearing many more CGW galls than are other trees. Buds of such European chestnut trees sprout much later than do those of other trees, and CGW galls appear about one month later in Tsukuba. After the observation in 1990, both the percentage parasitism of *T. sinensis* and the survival rate of CGW larvae highly correlated with the percentage of sprouted buds observed on May 6 ($r=0.915$, $P<0.01$ and $r=-0.836$, $P<0.01$, respectively; calculated after angular transformation). Furthermore, the 50% emergence date of adults of *T. sinensis* from the withered galls of each tree in the next spring was delayed in *C. sativa* trees, correlating significantly with the percentage of sprouted buds on May 6 of the previous spring (Male emergence: $r=-0.780$, $P<0.05$; Female emergence: $r=-0.771$, $P<0.05$). Those observations suggest that *T. sinensis* has thus far been less effective on some European chestnut trees in Tsukuba because of poor synchronization of the appearance of CGW galls, and that timing of adult emergence of *T. sinensis* may be variable.

References

Moriya, S., K. Inoue and M. Mabuchi (1989) The use of *Torymus sinensis* to control chestnut gall wasp, *Dryocosmus kuriphilus*, in Japan. *FFTC Tech. Bull.* 118: 1-12.

Shiga, M. (1999) Classical biological control of the chestnut gall wasp, *Dryocosmus kuriphilus*: Present status and interactions between an introduced parasitoid, *Torymus sinensis*, and native parasitoids. In *Biological Invasions of Ecosystem by Pest and Beneficial Organisms* (E. Yano, K. Matsuo, M. Shiyomi and D. A. Andow eds.). NIAES Series 3, National Institute of Agro-Environmental Sciences, Tsukuba, pp. 175-188.