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Utilization of *Lysiphlebia japonica* (Hymen.: Braconidae)

Junfeng GAO

(General Station of Agriculture of Tonghua County, Jilin)

The soybean aphid, *Aphis glycines* is one of the main pests of soybean. Extensive application of chemicals results in rapid increase of resistance of *A. glycines* against pesticides and serious damage to the soybean incurred by the high aphid population. Of the natural enemies, *Lysiphlebia japonica* was found to be a dominant species during investigation. This species is distributed broadly in all the soybean-planting areas. During 5 years of wasp release experiments during 1979-1983, the parasitism rates were over 56 % with the highest up to 76 % in the soybean fields, and the soybean leaf-rolling rates were under 1 % when the soybean aphids had a medium density.

1. Morphological characteristics of *Lysiphlebia japonica*

Adult: body length of females 1.5-2 mm, color various, antenna 12-14 segmented. Egg: usually 0.08-0.1 mm in length, 0.06 mm in width, lemonlike or fusiform, chorion mono-membranous. Larva: lacteous and muscidiform, 4-instars; 1st instars distinctly with a pair of mandibles, cauda significantly slender, body surface with piliferous spines; 2nd instars with short cauda, spines sparse and short; 3rd instars without cauda; 4th instars obese. Pupa: cocoon round and exarate pupa yellowish.

2. Biology of *Lysiphlebia japonica*

Lysiphlebia japonica is an endoparasite of the soybean aphid. It stays in the host aphid before the adult emerges. The number of generations per year is about 28-30 under 19-23±5°C and 60-85 % R.H. The development durations are 1-1.5 d, 6-9 d, 4-6 d and 5-8 d for egg, larva, pupa and adult, respectively. Single generation lasts 12-15 d. The parasitoids overwinter as late larvae in the aphids (note from translator: not soybean aphid, but no species name given) on motherwort herb *Leonurus heterophyllus* Sweet on the sun-facing hillside or near river.

The adult wasps emerge from a round hole in the back of mummy abdomen. Most eclosions occurred before 10 am. Newly emerged wasps could mate and lay eggs. Most eggs were laid in 2-3 d after eclosion and in the morning. The wasps laid 115-401 eggs in total for 5-6 d. The adult wasps were photophilous and their activities were influenced by light, temperature and humidity. They could walk, mate and search hosts at 12°C in the fields, fly, mate and oviposit at 17°C. The adults were very active when the temperature went up to 23°C, while they could continue to lay eggs in the hosts. The eggs were laid in the abdomen of aphids. Single oviposition last only 1-2 s. They could continue to lay eggs a moment after laying eggs in several aphids. The wasps preferred to parasitize 2nd and 3rd instars larvae of soybean aphids. They also parasitized the alatae when the host aphids were not abundant, however. The wasps stayed motionless on the back of plant leaves in the fields at 28°C when it was clear. They preferred to move from 7 to 11 am and after 3 pm, and moved during the whole day if it was cloudy. Light rain did not influence their oviposition. The adult wasps fed on nectar and honeydew. Honey solution (1 honey: 3 water) could provide the wasps with extra nutrition and extend their life for 3-7 d and increase 35-93 eggs. *Lysiphlebia japonica* emerged in early April with a sex ratio of 2:3 (female: male), and then developed 2-3 generations on the aphids (note from translator: not soybean aphid, but no species name here) on motherwort herb *Leonurus heterophyllus* Sweet. The wasps migrated into the soybean fields from late May to early June, and attacked the soybean aphids with a sex ratio of 3: 2. Then the wasps migrated back to motherwort herb and parasitized the aphids on it in early July after 2-3 generations in the soybean fields. The wasps overwintered in the aphids on motherwort herb beginning in late October.

3. Conservation of parasitoids at low temperature

The late larvae and prepupae of *Lysiphlebia japonica* were the most suitable stages to be conserved at low temperature in terms of their strong resistance to adverse conditions at both stages.

Table 1 Experiments of conserving parasitoid larvae

days °C	5	7	10	15	Notes
0	215	121	0	0	300 mummies per treatment were used. The numbers in the table indicate the wasps emerged.
2	293	273	175	146	
4	297	281	193	181	

The eclosion rates from mummies were higher at 2°C and 4°C (table 1).

Table 2 Experiments of conserving parasitoid adults

days °C	5	7	10	15	Notes
2	91	73	47	0	100 wasps per treatment were stored in dark and 75 % R.H. The numbers in the table indicate the wasps survived.
4	96	91	89	80	
7	100	63	31	0	

The most suitable temperature to preserve the wasps was 4°C in the table 2.

4. Mass rearing of *Lysiphlebia japonica*

The mass rearing of *Lysiphlebia japonica* had 3 steps according to our experiments. (1) Plant hosts of aphids. The soybean and motherwort herb were planted in pots under plastic canopy in late April. The planting of soybean followed standard soybean planting techniques. Two-year old motherwort plants were preferred. The one-year plants were too small to rear the aphids. They needed to be planted 1 year in advance and then only biennial plants were used for experiments. The motherwort herbs were sown in a fertile field in late April. Five plants were planted in 1 square Chi (about 1.2 square feet) of soil/plant. The weeds were removed and fertilizers were applied immediately after the seedlings came out. The plants were transferred to pots with 4-5 plants per pot. The potted plants were put into a groove (1.1 ft in depth) one by one, and covered with corn stalk and straw for winter. The potted plants were transferred into the plastic canopy in mid April next year. (2) Rearing of aphids on motherwort herbs and soybean plants. About 10 soybean aphids were put on the plant when the soybean plant had 3 fully expanded trifoliolate leaves, and *Lysiphlebia japonica* were added 3 d later. About 50-100 aphids were put on each motherwort herb when the herbs were around 0.5 Chi (about 0.55 ft) in height, and the wasps were also added 3 d later. (3) Inoculation of parasitoids. *Lysiphlebia japonica* showed the ability of host choice, and of selection on light, temperature, humidity, environment and plant growing conditions. The optimal conditions were under diffuse light, 19-23°C, 60-80 % R.H., and using 2nd and 3rd instars larvae as hosts and 2 d interval between adjacent inoculations. A. Indoor inoculation: Fluorescent lamps were used as a light source. The inoculation chamber was 45 cm (height) by 50 cm (width) by 115 cm (length). The chamber was made up of nylon screen except wood on the floor and a glass panel on one side for observation. Four fluorescent

lamps were installed with only 2 lamps turned on each time. The technique to inoculate the wasps was as follows. The aphids were put on each plant of soybean and motherwort herb. The wasps were inoculated in the chamber at 19-23°C and 65-85 % R.H. when the aphids were 3rd instars. The proportion of aphids to wasps was 160:1. The wasps were removed 48 h later, and the inoculated plants were retained indoors. B. Outdoor inoculation: One hundred aphids were put on the 1.1 ft high motherwort herb outdoors. The wasps were added when the aphids were 3 instars, and then the plants were covered by nylon screen (the size of screen covers varied). The proportion of wasps to aphids was 1:200. The mummies were collected 5 d after spotted on the plants and released into the soybean fields.

5. Field release of *Lysiphlebia japonica*

The criterion of field release is that early release is better than late release. Generally speaking, the soybean aphids could develop quickly and cause big damage to soybean in a short time if under suitable conditions. Therefore, parasitoids could control the aphids in the early season when released earlier, and enhanced the effectiveness of parasitoids. The suitable time to release the wasps was around June 5th in Tonghua regarding the scattered distribution of soybean aphids in the fields. About 1000 wasps were released in 0.4 ha. The aphids and wasps could develop 5-7 and 3-4 generations respectively from late May to early July. One female aphid produced around 50 offspring. One female wasp could parasitize 200 young aphids. Half of 1000 wasps would be females and parasitize about 100000 aphids. The method to release the wasps in the fields was as follows. (1) Release of adult wasps. 500-700 mummies were stored in a jar and put at 20°C for eclosion. The jars were covered by gauze with several honey streaks (3 water: 1 honey) when wasps were ready to emerge. The wasps were released into the fields 3 d later. (2) Release of mummies: The plant parts were cut with mummies and hung on the soybean plants. Five release spots in 0.4 ha were applied with 200 mummies each spot.

6. Comments on the utilization of *Lysiphlebia japonica*

(1) *Lysiphlebia japonica* has high potential to be a biological agent of soybean aphid because it has a large population, wide distribution and high parasitism rate. (2) It has a short life cycle and a high potential to develop. One generation lasts only 12-15 d under suitable conditions. It could be utilized in a large area, because mass rearing of parasitoids is fast, time- and manpower-saving, and requires simple equipment and little investment. (3) We applied this parasitoid to control soybean aphid only in a short period of time, more experiments are needed to improve the techniques and the utilization of parasitoid in a broader area.