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# Primary parasitoids and hyperparasitoids of the soybean aphid, *Aphis glycines* Matsumura (Homoptera: Aphididae).

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## ABSTRACT

Mummification, host selection and biological characteristics of primary parasitoids and hyperparasitoids in the soybean aphid, Aphis glycines, were studied. The soybean aphid mummies which were infected by primary parasitoids or hyperpa23rasitoids were collected at Taejon area from May to September in 1987. Primary parasitoids and hyperparasitoids were emerged 27.1% and 50.3%, from 177 collected mummies, respectively. Aphidius cingulatus , Ephedrus persicae and Ephedrus plagiator could be effective primary parasitoids against the soybean aphid. Among the hyperparasitoids, Asaphes vulgaris and Ardilea convexa might be dominant species to primary parasitoids of the soybean aphid. Charips brasicae was recorded for the first time in Korea. E. plagiator was less parasitized than any other primary parasitoid by hyperparasitoids. E. plagiator might be higher than A. cingulatus in the ability of parasitism. Life span of hyperparasitoid and primary parasitoid was estimated to be 3-29 days and 1-4 days, respectively.

## INTRODUCTION

*Aphis glycine* Matsumura is a cosmopolitan pest infesting primary on leguminous plants such as soybean, red-bean, pea and acacia. Its distribution has been reported in Korean, Japan, India, China and Europe. Its population growth is so fast that it covers the whole plant, resulting in inhibition of photosynthesis and consequent yield reduction. Also the damage by aphids and honey due induce secondary infection of many fungal diseases. It also transmits various virus diseases. Proper control tactic has not been developed that farmers solely relied on chemical spray for the control of soybean aphid which is somewhat economic burden for farmers and causes other problems such as reduction of beneficial natural enemies and environmental pollution

(Hwang et al. 1981)

Biological control agents of soybean aphid can be categorized into predatory natural enemies such as coccinellids, and parasitic wasps. About 310 parasitoids of aphids have been reported in the world (Narayanan et al. 1960, 1962). Among those, a few have been studied in Korea by Stay and Schliger (1967), Paik (1975,1976), and Chang and Youn (1983a, 1983b, 1986). This paper reports the parasitoid species of soybean aphid and their life history to obtain the basic information for further use in biological control of soybean aphid.

## MATERIALS AND METHOD

To investigate the parasitoid species, field collections were carried out weekly from May 1987 to September 1987 from soybean fields in Taejon, Korea. Mummified soybean aphids were collected, stored in gelatin capsule individually, and checked the emergence rate. Emerged adult was transferred into a vial (2.2x4.5 cm) provided honey due as food source, and then checked the adult period. After the death of an adult individual, specimen was identified into species level under a dissecting microscope. To study the relationship between primary parasitoids and hyperparasitoids, one mated adult female of primary parasitoid and 5 hyperparasitoids (each of 5 hyperparasitic species) were released into a box-cage in which soybean aphids are sufficiently infested on soybean, under 25$^{o}$C. After certain time, mummified soybean aphids were collected and the rate of hyperparasitism were investigated. During the course of study, two species (*A. cingulatus* and *E. plagiator*) were determined as dominant primary parasitoid species, and *A. vularis* as the dominant hyperparasitoid (see Table 2). To assess the parasitic activity and its timing, a pair of mated adult females of each species (a primary parasitoid and a hyperparasitoid) were introduced into the box-case (see above), and checked the parasitism and emergence of primary parasitoids and hyperparasitoids, respectively. This was replicated 5 times.

## RESULTS AND DISCUSSION

Out of total 177 mummies, 137 were emerged as either primary parasitoids or hyperparasitoids (Table 1).

Table 1. Percentage of primary parasitoids, hyperparasitoids and non-emerged mummies collected from *Aphis glycines* in the field

| | Number | Percentage(%) |
|---|---|---|
| Primary parasitoids | 48 | 27.1 |
| Hyperparasitoids | 89 | 50.3 |
| Non-emerged mummies | 40 | 22.6 |

| | | |
|---|---|---|
| Total | 177 | 100.0 |

Emergence rate (77.4%) was comparably lower than that of 88% investigated on cowpea aphid, *Aphis craccivora* Koch and green peach aphid, *Myzus persicae* (Sulzer) (Chang and Youn, 1983a, 1986). Among the emerged from the mummies, 27.1% was primary parasitoids which was lower than 44.8% from cowpea aphids and 38.3% from green peach aphids. However, hyperparasitism (50.3%) was somewhat higher than those of 42.8 and 44.3% from cowpea aphids and green peach aphids, respectively. This indicates that hyperparasitism significantly influence the primary parasitoid activity of soybean aphid.

Table 2. A list of primary parasitoid species from *Aphis glycines* at Taejon in 1987

| | Female | Male | Total | Percentage(%) |
|---|---|---|---|---|
| *Aphidius cingulatus* | 15 | 7 | 22 | 45.8 |
| *Ephedrus persicae* | 7 | 4 | 11 | 22.9 |
| *Lysiphlebia japonica* | 3 | 1 | 4 | 8.3 |
| *Ephedrus plagiator* | 2 | 2 | 4 | 8.3 |
| *Aphidius salicis* | 1 | 2 | 3 | 6.3 |
| *Aphidius absinthii* | 1 | 1 | 2 | 4.3 |
| *Ephedrus validrus* | - | 1 | 1 | 2.1 |
| *Lypolexis gracillis* | - | 1 | 1 | 2.1 |
| Total | 29 | 19 | 48 | 100.0 |

Table 2 showed the list of 8 species identified from the mummies of soybean aphid. Among those, two species were dominant; 22 individuals of *Aphidius cingulatus*, 11 of *Ephedrus persicae*. Remaining 6 species including *Lysiphlebia japoinia* accounted less than 10% occurrence. Chang and Youn (1983a, 1986) reported that *Lysiphlebus ambiguas*, *L. salicaphis* and *L. japonica* were dominant parasitoids of cowpea aphid, and *L. japonica*, *L.* sp. and *A. delhiansis* were major parasitoids of green peach aphid. This seemingly implies that there are host specific associations of aphid-parasitoids. primary parasitoids attacking soybean aphid and green peach aphid are *A. cingulatus*, *E. persicae*, *L. japonica* and *A. absinthii*.  And primary parasitoids attacking soybean aphid and cowpea aphid are *L. japonica* and *L. gracillis*. While primary parasitoid attacking three host aphids is only *L. japonica*, implying this species has a broad host range.

Table 3. Ratio of hyperparasitoids emerged from mummies collected in *Aphis glycines*

| | Female | Male | Total | Percentage(%) |
|---|---|---|---|---|
| *Asaphes vulgaris* | 13 | 19 | 37 | 41.6 |
| *Ardilea convexa* | 18 | 3 | 16 | 18.0 |
| *Gastrancitrus* sp. | 8 | 7 | 15 | 16.9 |
| *Lygocerus testaceimonus* | 9 | 6 | 15 | 16.9 |
| *Charips brasicae** | 3 | 1 | 4 | 4.4 |
| *Protaphelinus nikolskajae* | 2 | 0 | 2 | 2.2 |
| Total | 53 | 36 | 89 | 100.0 |

* First recorded species in Korea

From the mummies of soybean aphid, 6 species of hyperparasitoids were identified (Table 3). *A. vulgaris* was the most abundant followed by *A. convexa*, *Gastrancitrus* sp. and *Lygocerus testaceimonus*. In this paper, we report *Charips brasicae* for the first time in Korea. Except *C. brasicae*, above-mentioned 5 species are also reported as hyperparasitoids of cowpea aphid and green peach aphid (Chang and Youn, 1983a, 1986), implying host specific association of hyperparasitoids to their primary host might be weak.

Table 4. Analysis on parasitoid-hyperparasitoid interrelationship in *Aphis glycines*

| | Hyperparasitoids | | | | |
|---|---|---|---|---|---|
| Primary parasitoids | *Asaphes vulgaris* | *Ardilea convexa* | *Gastrancitrus* sp. | *Lygocerus testaceimonus* | *Protaphelinus nikolskajae* |
| *Aphidius cingulatus* | ++ | ++ | ++ | ++ | ++ |
| *Ephedrus plagiator* | + | ++ | + | + | ++ |
| *Lysiphlebia japonica* | ++ | ++ | ++ | ++ | ++ |
| *Lypolexis gracillis* | ++ | ++ | ++ | ++ | ++ |

+, ++: Hyperparasitism

Table 4 shows the pair-wise comparison of parasitoid-hyperparasitoid relationship. Only *E. plagiator* showed less hyperparasitic influence. Further study on primary parasitoid-hyperparasitoid interaction will provide better insight to biological control application.

In the laboratory, parasitism, hyperparasitism and its interaction were studied.

Table 5 shows *A. cingulatus* produced 288.4 mummies and *E. plagiator* did 276.4. From those only 9.0% emerged to *A. cingulatus*, but 75% to *E. plagiator*. The low emergence rate of *A. cingulatus* was primarily due to hyperparasitism by *A. vulgaris*, and *E. plagiator* was less influenced by *A. vulgaris* as was noted from field observation (see Table 4). Thus *E. plagiator* could be considered for field implementation of biological control of soybean aphid rather than *A. cingulatus*.

Table 5. Parasitization by the hyperparasitoid, *Asaphes vulgaris*, on different species of the primary parasitoid, *Aphidius cingulatus* and *Ephedrus plagiator*, in *Aphis glycines*

| Day after infestation | *A. cingulatus* | | *E. plagiator* | | No. of parasited by *A. vulgaris* | |
|---|---|---|---|---|---|---|
| | Mummy | Hatch | Mummy | Hatch | *A. cingulatus* | *E. plagiator* |
| 1 | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - |
| 3 | - | - | - | - | - | - |
| 4 | 45.8 | - | - | - | - | - |
| 5 | 119.8 | - | 36.4 | - | - | - |
| 6 | 40.4 | 2.4 | 57.0 | - | - | - |
| 7 | 27.4 | 3.2 | 70.2 | - | - | - |
| 8 | 17.8 | 6.6 | 36.6 | 0.8 | - | - |
| 9 | 18.8 | 3.6 | 18.8 | 3.4 | - | - |
| 10 | 7.4 | 3.0 | 21.2 | 4.4 | 10.4 | - |
| 11 | 4.4 | 7.2 | 18.8 | 3.6 | 7.4 | - |
| 12 | 5.8 | - | 17.4 | 12.4 | 12.6 | - |
| 13 | 0.8 | - | - | 26.8 | 14.6 | - |
| 14 | - | - | - | 36.2 | 2.2 | - |
| 15 | - | - | - | 64.8 | 38.4 | - |
| 16 | - | - | - | 27.2 | 47.8 | 5.4 |
| 17 | - | - | - | 15.4 | 46.6 | 1.8 |
| 18 | - | - | - | 7.8 | 29.2 | 7.2 |
| 19 | - | - | - | 2.8 | 7.8 | 4.4 |
| 20 | - | - | - | 1.8 | 3.6 | 8.6 |
| 21 | - | - | - | - | 3.2 | 2.8 |
| 22 | - | - | - | - | - | 2.0 |
| Total | 288.4 | 26.0 | 274.6 | 207.4 | 223.8 | 32.2 |
| (%) | 100 | 9.0 | 100 | 75.0 | 77.6 | 11.6 |

Mummification by primary parasitoids ware 4-13d after parasitoid introduction for *A. cingulatus*, but 5-12d for *E. plagiator*, but further controlled study of aphids and parasitoid developmental status is demanded. While the emergence of adult parasitoid, *A. cingulatus* began 6d after introduction (2d after mummification) and lasted for 6d, *E. plagiator*.started to emerge from 8d and lasted for 13d. Emergence of hyperparasitoid, *A. vulgaris* from *A. cingulatus* occurred from 10d, but 16d from *E. plagiator*. Also emergence of *A. vulgaris* continued for 12d from *A. cingulatus*, but only 3-4d from *E.*

*plagiator*. From these facts, it is suggested that *A. cingulatus* is a better host for *A. vulgaris*, and provide more time available for hyperparasitoid attack and development than *E. plagiator*.

This is similar situation to hyperparasitism of *L. japonica* to *Eucola* sp. and *T. hokkaidensis* that in better host, e.g. *Eucola* sp., hyperparasitoids parasites more and longer, and eventually produce more offspring, which in turn reduce the effectiveness of primary parasitism (Chang and Youn, 1986).

Table 6. Longevity of adult primary parasitoids and hyperparasitoids with pure honey

| | Longevity (days) | | |
|---|---|---|---|
| | Min. | Max. | Average |
| Primary parasitoids | | | |
| *Aphidius cingulatus* | 1 | 4 | 2.1 |
| *Ephedrus persicae* | 1 | 3 | 2.2 |
| *Lysiphlebia japonica* | 1 | 3 | 2.2 |
| Hyperparasitoids | | | |
| *Asaphes vulgaris* | 3 | 27 | 14.1 |
| *Ardilea convexa* | 5 | 29 | 16.5 |
| *Gastrancitrus* sp. | 4 | 25 | 12.3 |

Adult longevities of individually reared on honey were 2.1-2.2d for primary parasitoids and 12.3-16.5d for hyperparasitoids (Table 6). Thus it is clear that hyperparasitoids live longer than primary parasitoids but further study may envisage their ovipositional distribution through adulthood and any artifact by providing honey. However, if survivorship and fecundity be proportionate for hyperparasitoids, biological control of aphid by primary parasitoids may substantially impeded by hyperparasitism. In that case, limiting hyperparasitism would be more important for successful biological control of aphids.

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