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# Parasitism Rate of Egg Parasitoid *Anastatus orientalis* (Hymenoptera: Eupelmidae) on *Lycorma delicatula* (Hemiptera: Fulgoridae) in China

Man-Young Choi*, Zhong-qi Yang[1], Xiao-yi Wang[1], Yan-long Tang[1], Zhen-rong Hou[1], Jeong Hwan Kim[2] and Young Woong Byeon[3]

National Institute of Crop Science (NICS), Rural Development Administration (RDA),
[1]Key Laboratory of Forest Protection SFA; Research Institute of Forest Ecology, Environment and Protection, Chinese Academy of Forestry, Beijing 100091, China
[2]National Academy of Agricultural Science (NAAS), Rural Development Administration (RDA)
[3]Rural Development Administration, RDA

# 중국에서 알기생봉 *Anastatus orientalis* (Hymenoptera: Eupelmidae)의 꽃매미 *Lycorma delicatula* (Hemiptera: Fulgoridae) 알에 대한 기생율

최만영* · Zhong-qi Yang[1] · Xiao-yi Wang[1] · Yan-long Tang[1] · Zhen-rong Hou[1] · 김정환[2] · 변영웅[3]

농촌진흥청 국립식량과학원 벼맥류부 간척지농업과
[1]Key Laboratory of Forest Protection SFA; Research Institute of Forest Ecology, Environment and Protection, Chinese Academy of Forestry, Beijing100091, China
[2]국립농업과학원 농산물안전성부 작물보호과
[3]농촌진흥청 연구정책국

**ABSTRACT:** *Anastatus orientalis* Yang *et* Gibson(Hymenoptera : Eupelmidae) is the egg parasitoid of lantern-fly *Lycorma delicatula*. The natural parasitism showed that: (1)the highest parasitism rate of egg masses was 68.96% in Yantai Shandong; (2)the highest parasitism rate of eggs was 32.98% in Haidian Beijing; (3)the eggs of parasitoids hatched and emerged earliest in Yangling Shaanxi; emergence time of different populations in Yantai, Guangang Tianjin, Qinhuangdao Hebei and Haidian was similar; (4) the sex ratios were various among the populations ranging from 1.92 to 1.94; (5) parasitism rates of egg masses on *Populus* sp., *Salix* sp. and *Toona sinensis* were not significantly different, the highest parasitism rate of egg masses was 64.3% on *T. sinensis*, and the lowest rate was 27.4% on *Ailanthus altissima*; (6)parasitism rates of eggs on *Populus* sp., *Salix* sp., *T. sinensis* and *A. altissima* were not significantly different, about 30% averagely.

**Key words:** *Lycorma delicatula*, *Anastatus orientalis*, Parasitism rate

**초 록:** 꽃매미(*Lycorma delicatula*)의 천적인 벼룩좀벌 일종(*Anastatus orientalis* Yang *et* Gibson(Hymenoptera : Eupelmidae))의 자연 상태에서 기생율을 조사한 결과: (1) 산동성 Yantai 에서 가장 높은 69.0%의 꽃매미 난괴가 기생 당하였고; (2) 최고 기생율은 33.0%로 북경시 하이디엔(Haidian) 지역에서 관찰되었고; (3) 기생봉의 알은 산시성의 양링(Yangling)에서 가장 빨리 부화하였으며, 천진시의 옌타이(Yantai)와 광앙(Guangang) 지역, 하북성의 친황다오(Qinhuangdao), 하이디엔(Haidian)에서 약간의 차이를 보였으며; (4) 성비는 채집된 지역에 따라 1.3에서 1.9로 다양하였고; (5) 꽃매미 난괴에 대한 기생율은 기주식물인 *Populus* sp., *Salix* sp. *Toona sinensis*에서 유의할 만한 차이가 관찰되지 않았으며, 최고기생율은 *T. sinensis*에서 64.3%로 나타났고, *Ailanthus altissima*에서는 27.4%로 가장 낮았다. (6) 꽃매미 알에 대해서도 꽃매미 알이 발견된 기주식물별로 차이가 없었고, 평균 30.0%의 기생율을 나타냈다.

**검색어:** 꽃매미, 벼룩좀벌 일종, 기생율

***Corresponding author:** choimyas@korea.kr
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*Lycorma delicatus* (White, 1845) (Homoptera, Fulgoridae) is a serious pest of *Alianthus altissima*, *Toona sinensis*, *Melia azedarach*, *Robinia pseudoacacia*, *Populus* sp., *Salix* sp., *Vitis vinifera*, and *Malus* sp. *etc.* (Xiao, 1992; Zhang, 1993). This pest distributes widely in China as an indigenous species. However, it causes no economic damage on host plant due to the control effect of native natural enemies. *L. delicatula* had not been harmful on agricultural crops since its introduction into Republic of Korea in 1930s. Recently, however, this pest was reported causing a serious damage in grapevine yards, arbores and fruit trees in Korea (Xing et al, 2000; Kim et al, 2011). The increased abundance is considered by reason of the climate warming and lack of native natural enemies (Han et al, 2008; Park et al, 2009; Kim et al, 2011).

*Anastatus orientalis* (Hymenoptera, Eupelmidae) (Yang et al., 2014) is an egg parasitoid of *L. delicatula* in China and considered to be an important biocontrol agent as its parasitism rates reach up to 80% in some regions (Xiao, 1992; Zhang, 1993).

This study was supported by the cooperative project between the National Academy of Agricultural Science (CAAS) and the Rural Development Administration (RDA) of Korea. We selected *A. orientalis* as a candidate natural enemy for introduction into Korea, and investigated its natural parasitism on the eggs of the lantern fly depending on host trees and regions in order to choose populations with high parasitism rate.

## Materials and Methods

### Collection of lantern-fly egg masses

Egg masses of *L. delicatula* were collected as many as possible from 5 regions in China (Yangling, Qinhuangdao, Yantai, Guangang, Haidian) on April 2011 from the mainly host arbores (*Ailanthus altissima*, *Toona sinensis*, *Populus* sp., and *Salix* sp.). Egg collection was made on the over- wintering eggs of the lanternfly before the eggs begin to emerge, because *A. orientalis* lays eggs in preceding autumn and passes only one generation a year.

Egg mass with bark beneath was cut off together in order to make sure the integrity of each mass, and then put each egg mass in small paper bag. Eggs were collected three times and grouped them as such for data analysis.

### Parasitoids culturing in laboratory

The number of egg masses and individual eggs in it were recorded. Each egg mass was put in one glass test tube gagged with cotton, and then marked the date, and cultured under the conditions of temperature about 25°C, relative humidity about 65% and natural illumination.

### Parasitism rates of the parasitic wasp

Parasitism rate of egg masses: if an egg was parasitized then this mass was recorded as parasitized.

Parasitism rate of eggs: One parasitoid means one egg was parasitized.

The number of parasitoid emerged were checked at 6:00 every day, from late April to December.

### Data analysis

Data was analyzed with Excel 2003 and SAS (Version 9.1.3). Variance was analyzed with one-way (ANOVA) in SAS. Differences among all treatments were compared with least significant difference (LSD) tests.

## Results

### Parasitism rates of egg masses parasitized by *A. orientalis* from different regions

As shown in Fig. 1 (open bar), parasitism rates of egg masses were significantly different ($F$ = 4.942, $df$ = 4, 14, $P$ = 0.0458) among the five different regions. The percentage of the egg messes that have at least one parasitized egg reached 69.0% for those collected from Yantai, whereas it was 33.3% for those from Guangang.

### Parasitism rates of eggs parasitized by *A. orientalis* from different regions

As shown in Fig. 1 (close bar), parasitism rates of eggs were significantly different ($F$ = 3.022, $df$ = 4, 26, $P$ = 0.0396) among the five different regions with the highest parasitism

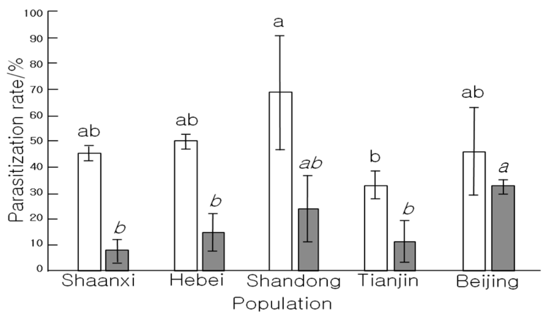


**Fig. 1.** Parasitism rates of egg masses (open bar) and individual eggs (close bar) parasitized by *A. orientalis* from different regions. The same letters above the bars mean no significant difference at level of 5%.

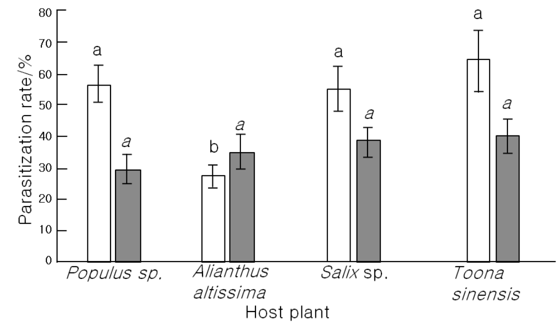


**Fig. 2.** Parasitism rates of egg masses (open bar) and individual eggs (close bar) parasitized by *A. orientalis* from different host trees. The same letters above the bars mean no significant difference at level of 5%.

**Table 1.** Emergence time and sex ratio of *A. orientalis* parasitizing *L. delicatula* from different regions

| Regions | Date for eggs hatching initially | Date for wasps emergence initially | Date for wasps emergence peak | Ratio of ♀:♂ |
|---|---|---|---|---|
| Shaanxi | April 20 | April 26 | April 30 — May 3 | 1.92 |
| Hebei | April 29 | May 1 | May 4 — May 7 | 1.56 |
| Shandong | April 28 | May 6 | May 9 — May 12 | 1.41 |
| Tianjin | April 29 | April 29 | April 30 — May 1 | 1.29 |
| Beijing | April 27 | May 1 | May 3 — May 6 | 1.94 |

rate of 33.0% on the population from Haidian to the lowest of 7.8% from Yangling. A few egg masses collected from Haidian were found parasitized 100%, and 23.6% of the egg masses had eggs parasitized up to 50%.

### Emergence time and sex ratio of *A. orientalis* parasitizing *L. delicatula* from different regions

As shown in Table 1, the lanternfly eggs from Shaanxi began to hatch seven to nine days earlier than those from other four regions, and the parasitoids in it started emerging six days later. The eggs from Hebei, Shandong, Tianjin and Beijing began to hatch almost at the same date, and three to nine days later wasp emergence initiated and completed within 2 to 3 days. Both female or male wasps emerged simultaneously. The sex ratios of the wasps were various among the populations.

### Parasitism rates on the egg masses of *L. delicatula* from different trees

Parasitism rates of *A. orientalis* were significantly different on the egg masses of *L. delicatula* depending on the host trees from which they were collected ($F$ = 15.369, $df$ = 3, 11; $P$ = 0.0011). But to *Populus* sp., *Salix* sp. and *Toona sinensis,* the difference was insignificant (Fig. 2, open bar).

Parasitism rates of *A. orientalis* on the individual eggs in the egg masses from different host trees were not significantly different ($F$ = 2.07, $df$ = 3, 11; $P$ = 0.1051) (Fig. 2, close bar).

## Discussions

The concept "biotype" originally considered based on different populations resulted in geographic diversity, different hosts and environment variation (Walsh, 1864). Diehl and Bush (1984) classified a biotype into one or more of the following categories, including nongenetic polyphenisms, polymorphic or polygenic variation within populations, geographic races, host races, and species.

Wei et al. (2009) found that a parasitic beetle *Dastarcus helophoroides* has different biotypes, one biotype that parasitizing *Massicus raddei* is with higher parasitism rate in parasitizing *Massicus raddei* than in *Anoplophora glabripennis* or other long-horned beetles.

In Australia, different biotypes of *Microctonus aethiopoides* were successfully introduced for controlling *Sitona discoideus* (Aeschlimann, 1983). Different biotypes of *Cotesis sesamian* had been successfully introduced into Cameroon for controlling *Busseola fusca* (Ndemah et al., 2007). So, when choosing natural enemies for biological control program, the different biotypes even from the same species of parasitoid wasp need to be considered carefully.

*A. orientalis* is the egg parasitoid of *L. delicatula*, which is widely distributed in China. It has high parasitism rate in *L. delicatula and is* an important biocontrol agent of the pest (Xiao, 1992; Zhang, 1993). Based on our investigation, the population of *A. orientalis* from Beijing was promising in controlling *L. delicatula*. And parasitism rates were quite different among the host eggs collected from different trees and regions. Parasitism rates both on the individual eggs and the egg masses collected from *T. sinensis* in Shandong were found to be the highest.

Insects choose different reproduction strategies based on host situation, and this is the same with parasitic wasps (Wang et al., 2010). During the investigation, we found that *A. orientalis* from Shandong had two emergence periods per year: some in May and others in September. This phenomena was absent in other regions. Probably there was no other alternative hosts in Yantai. *A. orientalis* choose a gambling strategy in order to keep population quantity when abundant eggs of *L. delicatula* are found. This may be a best strategy to maintain population (Qin, 2009).

Generally, parasitic wasps need five steps to complete parasitizing process: host habitat location, host location, host acceptance, host adaption and host regulation (Wang et al., 2008). During these processes, wasps integrate semiochemicals, vision, olfaction, feeling and hearing. So in the host searching process, pest and its host plant are all involved. During the process of coevolution, plant, pest and natural enemy will form a system with mutual influence and interaction. When plant is damaged by insect pests, some semiochemicals will be released to attract their natural enemies. But insect pests will form a dynamic evolutionary relationship with the purpose of avoiding being parasitized or preyed (Wei et al., 2007a,b).

In this investigation, discrepancies were evident in the parasitism rates of *A. orientalis*. To *Populus* sp., quantity of eggs oviposited by *L. delicatula* was highest, but the parasitism rate of *A. orientalis* on the eggs was lowest, even though *Populus* sp. was not the favorite host tree of *L. delicatula*. So, the tritrophic interaction among the host plants, lantern-fly, parasitic wasp needs further research.

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