



Short Communication

Discovery of an egg parasitoid of *Lycorma delicatula* (Hemiptera: Fulgoridae) an invasive species in South KoreaIl-Kwon Kim¹, Sang-Hyun Koh, Jung-Su Lee, Won Il Choi^{*}, Sang-Chul Shin

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ABSTRACT

Anastatus sp. (Hymenoptera: Eupelmidae) is reported as the first chalcidoid wasp which parasitizes eggs of *Lycorma delicatula*, an invasive species spreading rapidly in South Korea. The wasp appears to be a solitary endoparasitoid. The present paper also describes its oviposition and host feeding behaviour.

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Introduction

Lycorma delicatula (White) (Hemiptera: Fulgoridae) was officially reported in western Korea in 2008 (Han et al., 2008). Since then, it has expanded rapidly throughout the country (Park et al., 2009). It is thought to have been accidentally introduced from China and has successfully established based on its high population in several locations in western Korea in 2006 (Han et al., 2008). In efforts to find efficient control measures to this fulgorid pest, researches were conducted on its life cycle, mortality of overwintering eggs, behavioral characteristics of nymphs and control effects of several insecticides (e.g. Park et al., 2009; Choi et al., 2011; Lee et al., 2011).

Only a few parasitoids are known to parasitize immature stages of fulgorids (Swezey, 1903): one species of Encyrtidae (Chalcidoidea) on eggs and four species of Dryinidae (Chrysoidea) on nymphs. *Dryinus browni* Ashmead is the only known dryinid parasitoid of *L. delicatula* nymphs from China (Yang, 1994; He and Xu, 2002). No chalcidoid or dryinid parasitoids of this fulgorid have been reported from Korea.

The new discovery of an egg parasitoid of *L. delicatula* is reported here, with a brief description of its oviposition and host feeding behaviour.

Materials and methods

Collection and rearing

Overwintering *L. delicatula* egg masses on grape, *Vitis vinifera* L., were collected from Cheongwon-gun, Chungcheongbuk-do (N36°38', E127°29') on 16 April 2010. Individual egg mass attached to a branch was kept in an insect rearing sleeve (20 × 40 cm, Bioquip, CA) at room temperature (20–25 °C). After emergence, the wasps were kept in a small rearing cage (Φ95 mm, H 40 mm, SPL Life Sciences, Seoul) with the egg mass and were provided with a droplet of diluted honey daily on the inner wall of the cage.

Parasitoid identification

The parasitoid was identified as *Anastatus* using the annotated keys to the genera of Nearctic Chalcidoidea (Gibson et al., 1997) and the key to world genera of Eupelminae (Gibson, 1995). The key to the Palearctic species of the genus *Anastatus* by Kalina (1981) was referred for species identification of the parasitoid. The preliminary result of the identification was confirmed by G. Gibson (CNC, Canada).

Observation and illustration

Wasp behaviours were observed under a stereoscope (SZX 12, Olympus, Japan). Pictures were taken using a QICAM FAST (Qimaging, Canada) digital imaging system attached to the stereoscope. Adobe Photoshop CS3 was used to modify only the brightness and contrast.

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Results and discussion

Identification of the parasitoid

Two eupelmid wasps emerged from the overwintering eggs of *L. delicatula* on 3 May 2010 (Fig. 1A–B). The parasitoid is inferred to be a solitary endoparasitoid by the presence of a single emergence hole on two different host eggs. The parasitism rate of this parasitoid seems to be extremely low, with only two of approximately 1000 host eggs being parasitized.

The two parasitoid females key to *Anastatus japonicus* (Ashmead) using Kalina (1981), in part because the frontovertex is as wide as the eye in the dorsal view. The original description of *A. japonicus* (Ashmead, 1904) was also referred to confirm the identity of the species. Unfortunately, the species description was based mostly on coloration so it is not as useful for a morphological comparison. Even

though our parasitoids appear to be very similar morphologically to *A. japonicus*, they have unusually dark legs (Fig. 1B–E). It is unclear at present whether this might be a species level difference between our parasitoids and *A. japonicus* (Gibson, pers. comm.). As it was shown for another eupelmine species, slight differences in colour might indicate the existence of cryptic species (Fusu, 2010). However, further comparative study of morphology can occur only when a sufficient number of specimens have been collected.

Members of *Anastatus* parasitize a wide variety of eggs of Blattaria, Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera and Orthoptera (Gibson, 1995; Noyes, 2003). Even though some species of the genus attack eggs of some hemipteran families, no species of Eupelmidae is known to parasitize eggs of Fulgoridae. Furthermore, *A. japonicus* has only been recorded as a parasitoid of various lepidopteran eggs and of Pentatomidae (Hemiptera) eggs (Noyes, 2003).

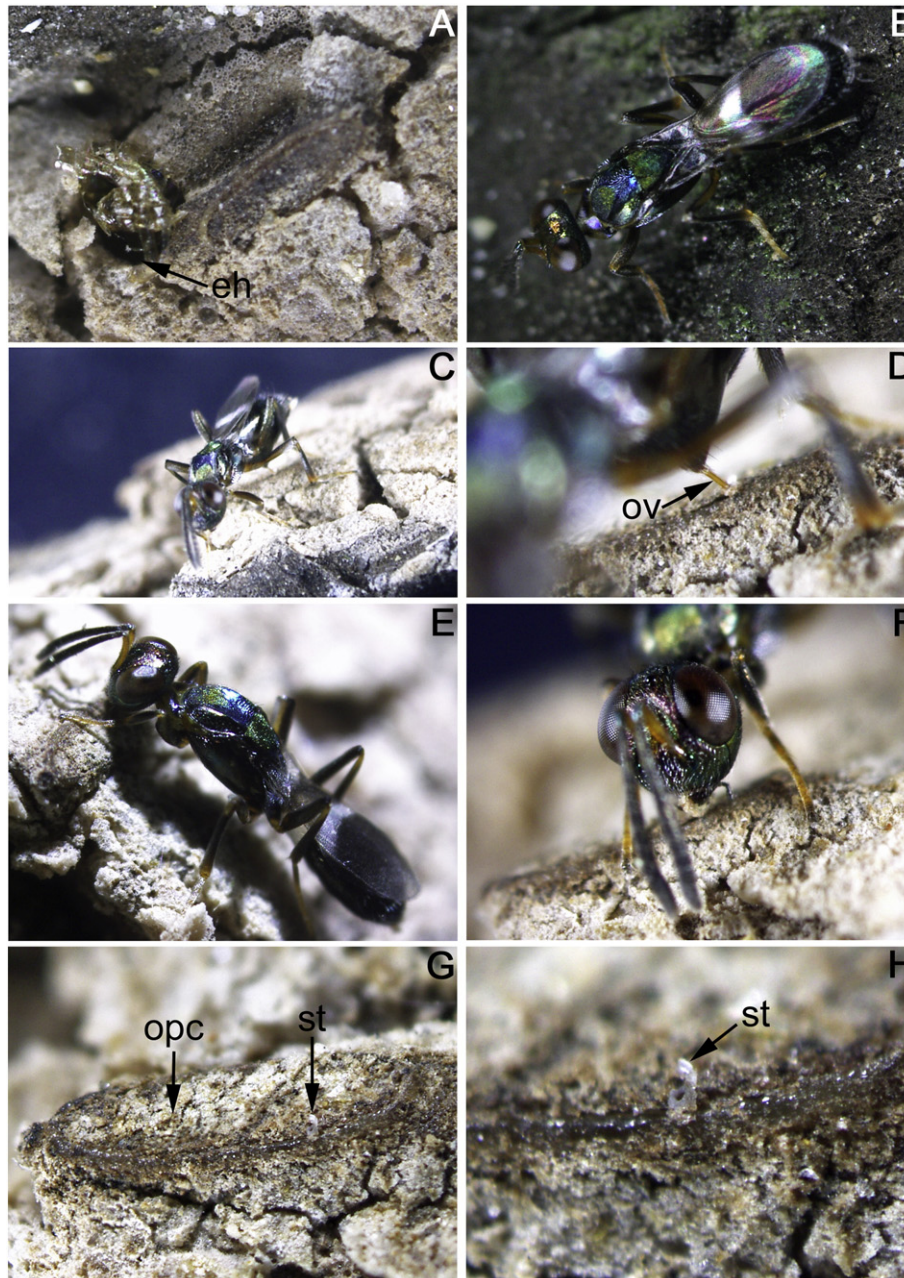


Fig. 1. Oviposition and host feeding of *Anastatus* sp., ♀: A. emergence hole; B. habitus, ♀, latero-dorsal view; C–D. female drilling on an egg of *Lycorma delicatula*; E–F. host feeding; G–H. stalk left after oviposition; eh, emergence hole; ov, ovipositor; opc, operculum; st, stalk.

Therefore, the identity of the parasitoid must remain as *Anastatus* sp. cf. *A. japonicus* until *Anastatus* and its host specificity are revised for the region.

Host feeding and oviposition behaviours

Drilling, host feeding and a possible ovipositional event were observed in female parasitoids. For the first few drilling events, the two parasitoid females withdrew their ovipositors after a short time of the drilling process. For the drilling location the females chose a site on the opercular line that delimits the exit-lid (= operculum) (Fig. 1C–D). Host feeding (Fig. 1E–F) lasted less than 10 s and feeding tubes were not constructed. One female returned after a short time and reinserted the ovipositor in the site where it had previously fed. It inserted its ovipositor almost completely into the egg and wiggled its abdomen a few times with the ovipositor still inserted (i.e. probing behaviour before oviposition). The female then became motionless while its abdomen contracted very slightly a few times, as if pushing eggs through its ovipositor. A stalk, which was white and slightly curved apically to a side, was left on the site after the female withdrew its ovipositor (Fig. 1G–H). The second female also engaged in host feeding, also without constructing a feeding tube. It did not return to the egg later to oviposition.

A. axiagasti Ferrière females display similar behaviours. They feed on a host egg and wander away, but then return to the egg and reinsert the ovipositor to lay eggs (Lever, 1934). *Anastatus* sp. seems to be a concurrent host-feeder that feeds from the same host as it uses for oviposition (Jervis and Kidd, 1986).

In some cases, the withdrawal of the ovipositor during drilling may be related to formation of a feeding tube (Clausen, 1940); however, there was no tube formed in association with the host feeding of this *Anastatus* sp. Often, a parasitoid pierces the host for host feeding, which kills that host, but does not oviposit into it. This results in more host kills than through oviposition (DeBach, 1943). Considering the extremely low parasitism rate, it is possible that *Anastatus* sp. was using the fulgorid eggs simply for feeding to obtain nutrients and as a non-preferred host for oviposition. This could explain the very low parasitism rate of the parasitoid.

One female appeared to have oviposited in a host egg. However, no *Anastatus* was successfully reared from the parasitized egg, even after several months. It may be because the first instar nymphs of the host were almost fully developed inside of the host eggs at the time of parasitisation. This is probably not a favourable condition for the parasitoid immature stages to grow. This merits further studies on host acceptance, oviposition and rearing of the *Anastatus* sp.

Prospect of natural control of *L. delicatula* by the eupelmid parasitoid

The current discovery of an egg parasitoid of *L. delicatula* may signify the beginning of adaptation of Korean indigenous parasitoids to a new, exotic host. Will the eupelmid wasp adapt to this invasive fulgorid and be able to control its population size?

We can speculate that more fulgorid eggs will be parasitized by the *Anastatus* sp. in the following years. However, it may not be able to achieve high enough percentage of parasitism to control the population size of the host insect because of the low parasitism rate and wide host range of *Anastatus* species in the field. The parasitism

rate by *A. japonicus* on eggs of the litchi stink bug was 3.2% to 18.4% in IPM-managed litchi orchards (Liu et al., 2000). Also, the parasitism rate by *A. japonicus* on gypsy moth eggs was 0.09% to 11.88% in Korea and Japan (Schaefer et al., 1988). Members of *Anastatus* parasitize about 80 insect species. For example, *A. japonicus*, which may be the closest relative to our *Anastatus* sp., attacks 4 species of Hemiptera and 12 species of Lepidoptera. In other words, it is not a specialist of which host range is very specific. Therefore, the parasitism rate of *Anastatus* sp. is likely to remain too low to efficiently control the population size of the fulgorid, even if the parasitoid successfully adapts to the new host.

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