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Non-Reproductive Host Killing Caused by *Aphelinus asychis* (Hymenoptera: Aphelinidae), A Parasitoid of Cotton Aphid, *Aphis gossypii* (Homoptera: Aphididae)

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Aphelinus asychis Walker (Hymenoptera: Aphelinidae) is a solitary endoparasitoid that parasitizes and host–feeds more than 40 aphid species, and has been considered a potential biological control agent of aphids. In many species of hymenopterous parasitoid, female wasps cause important additional mortality by non–reproductive killing (e.g., host–feeding and stinging behaviour). Host mortality caused by non–reproductive host killing of *A. asychis* was studied on cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) when infesting cucumber (*Cucumis sativus* L.), in the laboratory at 25 °C and photoperiod of 16L: 8D. The females killed 3.3 aphids per day and 73.9 aphids until they died by host–feeding and stinging during an average of 21.3 days. Peak age–specific aphid mortality (5.2 aphids per day) was observed on the fifth day after parasitoid emergence. *A. asychis* females continued non–reproductive host killing until died.

INTRODUCTION

The cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae), is one of the main insect pests on several vegetables including cucurbitaceous and solanaceous crops. This aphid sucks plant sap on underside of leaves and shoots, and transmits viruses resulting in reduced fruit production (Rabasse and Wyatt, 1985; Minks and Harrewijn, 1987; van Lenteren, 1991; Parrella *et al.*, 1999; Rabasse and van Steenis, 1999). Insecticides have generally been used for control of cotton aphid (van Lenteren and Woet, 1988; Goh *et al.*, 2002). Unfortunately, owing to continuous use of insecticide, cotton aphid has developed resistant against insecticides. For these reasons, several attempts were tried to control cotton aphids with aphidiine parasitoid such as *Aphidius colemani* Viereck (Hymenoptera: Braconidae) and *Aphidius matricariae* Haliday (Hymenoptera: Braconidae), and gall midge, *Aphidoletes aphidimyza* (Diptera: Cecidomyiidae). However, more studies are needed for other biological control agents of cotton aphid because control efficacy of aphidiine parasitoids and predatory gall midge against aphids was not always high in the greenhouses (van Steenis and El–Khawass, 1995; Sengonca *et al.*, 2008; van Driesche *et al.*, 2008).

Aphelinus asychis Walker (Hymenoptera: Aphelinidae) is native to Old World (e.g., Europe, Asia and Africa) and a solitay endoparasitoid of aphid. These species were imported into the United States from Asia, Europe and Africa for classical biological control of the Russian wheat aphid (Elliott *et al.*, 1999). *A. asychis* female parasitizes and host–feeds on more than 40 aphid species including *A. gossypii* (Japoshvili and Abrantes, 2006; Li *et al.*, 2007) and was also found in new countries (e.g., Nepal, Portugal, Japan and Republic of Korea: Hayat, 1991; Japoshvili and Abrantes, 2006; Takada, 2002; Li *et al.*, 2007). Recently, Tatsumi and Takada (2005) have suggested that *A. asychis* is potential biological control agent of four aphid species: cotton aphid, *Aphis gossypii*; green peach aphid, Myzus persicae (Sulzer); foxglove aphid, *Aulacorthum solani* (Kaltenbach); potato aphid, *Macrosiphum euphorbiae* (Thomas).

For pre–introductory evaluation of biological control agent, studies on biological characteristics such as temperature–dependent development of immature stages, age–specific fecundity and host mortality caused by host–feeding and stinging behaviour of parasitoid species are principally required for understanding its potential as a biological control agent. Many of the studies have focused on parasitoid fecundity and searching behaviour (Schlinger and Hall, 1959; Force and Messenger, 1968; Raney *et al.*, 1971; Bai and Mackauer, 1990; Tatsumi and Takada, 2005). However, in many species of hymenopterous parasitoid including *A. asychis*, female wasps cause important additional mortality by host–feeding and stinging behaviour, and moreover host–feeding plays a crucial role in egg maturation of synovigenic parasitoids (DeBach, 1943; Flanders, 1953; Cate *et al.*, 1973; Sandlan, 1979; Walter, 1988)

Although host–feeding and stining behaviour is crucial for cause host mortality and egg maturation, there have been a few studies on non–reproductive host–killing by *A. asychis* in East Asian countries. Therefore, the

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present study aimed at describing age–specific host mortality caused by non–reproductive host killing behaviour of *A. asychis*. In addition, we discuss host–feeding parameter in comparison with geographical strains of *A. asychis* and other *Aphelinus* species.

MATERIALS AND METHODS

Insect culture

The aphid parasitoids, *A. asychis*, were collected from the mummies of green peach aphids, *Myzus persicae* Sulzer (Homoptera: Aphididae), on Chinese cabbage in Hoengseong, Republic of Korea and were identified as *A. asychis* (Li *et al.*, 2007). Stock cultures of the parasitoids were reared on greenbug, *Schizaphis graminum* (Rondani) (Homoptera: Aphididae), cultured on barley. The cotton aphids, *A. gossypii*, were maintained on cucumber (*Cucumis sativus* L.). All insects used in the present study were reared in air–conditioned insectaries at an average 24–27 °C, a photoperiod 16L: 8D and 50–70% RH. Potted barley (20–30 cm in height with about 50 barleys per one pot) had been infested with mixed stages of 200–300 greenbugs. About 100 parasitoids were introduced into barley infested with greenbugs in an acrylic cage (27×27×50 cm) for parasitization. After 24 h, parasitoids were removed and barleys infested with greenbugs were maintained until mummy formation. Newly emerged parasitoid adults were obtained by isolating aphid mummies singly in size 0 gelatin capsules (Bioquip, USA). Upon emergence, gender was determined by observation of genitalia and antennae. When mated female parasitoids were needed, one female was transferred into plastic tubes (26×67 mm) with two males for at least 4 h.

Age–specific non–reproductive host killing

Non–reproductive killing, i.e., host–feeding or stinging, of *A. asychis* was estimated by using a cohort of 12 *A. asychis* females that were 12 h old. Each female was caged with two males for 4 h, after which the female was transferred into experimental arena containing 7 cm cucumber leaf disks infested with 50 2nd or 3rd–instar cotton aphids. The experimental arena consisted of a 7 cm cucumber leaf disk placed ventral–side–up on water–saturated cotton in Petri dish (9.3×4 cm) with 4 cm diameter gauze on the lid for ventilation. The Petri dishes were replaced with new ones containing 50 cotton aphids every 24 h until parasitoid died and were kept until aphid mummified at 25 °C, photoperiod 16L: 8D in an incubator.

RESULTS

Age–specific non–reproductive host killing

When *A. asychis* female encountered host aphid, *A. gossypii*, it touched *A. gossypii* with its antennae before inserting its oviopsitor for host–feeding or oviopsiting. When 50 2nd or 3rd instar cotton aphids were supplied with *A. asychis* everyday, the number of aphid killed by non–reproductive activities (i.e., host–feeding and stinging) of *A. asychis* was 3.3 aphids per day and 73.9 aphids in its life span (Table 1).

Table 1. Aphid mortality caused by non–reproductive killing (number of dead aphids) of *A. asychis* females on *A. gossypii* at 25 °C (n=12)

	Mean ± SE	Range
Host mortality per day	3.3±0.2	2.5–4.2
Host mortality until parasitoid died	73.9±4.8	35–95
n	12	

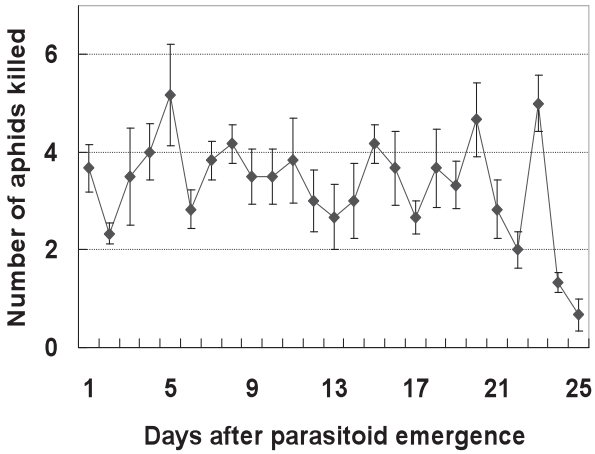

Fig. 1. Daily aphid mortality caused by non–reproductive killing of *A. asychis* female when provided with 50 *A. gossypii* (2nd or 3rd–instar) per day at 25 °C.

Peak age–specific host mortality caused by non–reproductive killing (5.2±0.7 aphids/female/day) was observed on the fifth day after parasitoid introduction and declined gradually thereafter (Fig. 1). After *A. asychis* females emerged, they continued non–reproductive host killing until died (Fig. 1).

DISCUSSION

Many of the studies have focused on parasitoid fecundity and searching behaviour (Force and Messenger, 1968; Raney *et al.*, 1971; Schlinger and Hall, 1959; Bai and Mackauer, 1990; Perng and Liu, 2002; Tatsumi and Takada, 2005). However, in many species of hymenopterous parasitoid, female wasps cause important additional mortality by non–reproductive killing behaviour (e.g., host feeding and stinging behaviour) (DeBach, 1943; Flanders, 1953; Cate *et al.*, 1973; Sandlan, 1979; Walter, 1988; Tran and Takagi, 2006). Our observations showed that host mortalities caused by non–reproductive killing of *A. asychis* were 3.3 aphids per day and 73.9 aphids until parasitoid died. These mortalities may be caused by host feeding and stinging behaviour of *A. asychis*. Host mortality due to non–reproductive killing in the present study was higher than two geographic strains of *A. asychis* (1.5 aphids/female/day at 27 °C, 1 aphid/female/day at 25 °C) reported by Cate *et al.* (1973), and Bai and Mackauer (1990) (Table 2). Also, host mortality by *A.*

Table 2. Comparison of longevity of adult female, numbers of aphids killed by non–reproductive activities of five *Aphelinus* species

Aphelinus species	Temp.	Longevity of female	Mean number of aphids killed		References
			daily	total	
A. flavus	–	27	1.2	28	Hamilton (1973)
A. asychis	26.7 °C	23.4	ca. 1.5	30.4	Cate *et al.* (1973)
A. asychis	25 °C	–	ca. 1	–	Bai and Mackauer (1990)
A. abdominalis	20 °C	51	1.3	–	Hoeller and Haardt (1993)
A. spaericolae	24 °C	17.8	1.9	27.1	Tang and Yokomi (1996)
A. gossypii	18 °C	8	1.5	10.7	Tokumaru and Takada (1996)
A. gossypii	25 °C	26.3	ca. 3–4	87.9	Perng and Liu (2002)
A. asychis	25 °C	32.8	7.5	161.2	Sengonca *et al.* (2008)
A. asychis	25 °C	21.3	3.3	73.9	Present study

asychis in this study was higher than other aphelinid wasps, *A. thomsoni*, *A. abdomonalis* and *A. gossypii* (Table 2). However, aphid mortality caused by non–reproductive host killing was much higher in Kyoto strain of Japan (7.5 aphids/female/day at 25 °C, Sengonca *et al.*, 2008) than other geographic strains of *A. asychis* (Table 2). These differences among geographic strains of *A. asychis* may attribute to different biological characteristics because geographic strains of parasitoids have different fecundity, thermal requirement and host mortality (Elliott *et al.*, 1999; Tokumaru and Takada, 1996).

In our observation, when *A. asychis* encountered a cotton aphid, it touched the host aphid with its antennae before inserting ovipositor for oviopsition or host–feeding. Host feeding behaviour is commonly observed in aphelinid wasps, *A. asychis*, *A. gossypii*, *A. spireacolae* and *A. albipodus* (Cate *et al.*, 1973; Hamilton, 1973; Stary, 1988; Bai and Mackauer, 1990; Tang and Yokomi, 1996; Zhishan and Heimpel, 2007). Various studies have shown that positive relations between host–feeding and oviposition in synovigenic aphelinid wasps (DeBach, 1943; Bai and Mackauer, 1990; Zhishan and Heimpel, 2007). Host–feeding by an adult female wasp can have a strong influence on her egg maturation, with proteinaceous foods being important for maturing egg (Jervis and Kidd, 1986; Heimpel and Collier, 1996; Wheeler, 1996). In our experiment, *A. asychis* showed host feeding and stinging behaviours, and these behaviours caused host mortality.

In the present study, we report the age–specific aphid mortality caused by non–reproductive killing behaviour of *A. asychis* at 25 °C under laboratory conditions. South Korean population of *A. asychis* has caused high mortality by non–reproductive host killing behaviour. These findings imply that this geographical strain of *A. asychis* has potential as a biological control agent of cotton aphid. In addition, for developing successful biological control program for *A. gossypii* or other aphid species using *A. asychis*, additional studies, both experimental and theoretical (c.f., Tuda and Shimada, 1995; Tuda, 1996; Tuda and Shimada, 2005), would be performed on intrinsic rate of increase, searching efficiency, spatial distribution and population dynamics under both laboratory and field (c.f., Tuda and Shima, 2002; Tuda *et al.*, 2006) conditions.

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REFERENCES

Bai, B. and M. Mackauer 1990 Oviposition and host–feeding patterns in *Aphelinus asychis* (Hymenoptera: Aphelinidae) at different aphid densities. *Ecol. Entomol.*, **15**: 9–16

Cate, R. H., T. L. Archer., R. D. Eikenbary, K. J. Starks and R. D. Morrison 1973 Parasitization of the greenbug by *Aphelinus asychis* and the effect of feeding by the parasitoid on aphid mortality. *Environ. Entomol.*, **2**: 549–553

DeBach, P. 1943 The importance of host–feeding by adult parasites in the reduction of host populations. *J. Eco. Entomol.*, **36**: 647–658

Elliott, N. C., J. H. Lee and S. D. Kindler 1999 Parasitism of several aphid species by *Aphelinus asychis* (Walker) and *Aphelinus albipodus* Hayat and Fatima. *Southwest. Entomol.*, **24**: 5–12

Flanders, S. E. 1953 Predation by the adult hymenopterous parasite and its role in biological control. *J. Eco. Entomol.*, **46**: 514–544

Force, D. C. and P. S. Messenger 1968 The use of laboratory studies of three hymenopterous parasites to evaluate their field potential. *J. Econ. Entomol.*, **61**: 1371–1378

Goh, H. G., J. H. Kim and M. W. Han 2001 Application of *Aphidius colemani* Viereck for control of aphid in greenhouse. *J. Asia–Pacific Entomol.*, **4**: 171–174

Hamilton, P. A. 1973 The biology of *Aphelinus flavus* (Hymenoptera: Aphelinidae), a parasite of the sycamore aphid *Drepanosiphum platanoidis* (Hemiptera: Aphididae). *Entomophaga*, **18**: 449–462

Hayat, M. 1991 Taxonomic studies on *Aphelinus* (Hymenoptera: Aphelinidae). 4. A new and 3 known species from Nepal. *Entomon.*, **16**: 183–186

Heimpel, G. E. and T. R. Collier 1996 The evolution of host–feeding behaviour in insect parasitoids. *Biol. Rev.*, **71**: 373–400

Japoshvili, G. and I. Abrantes 2006 *Aphelinus* species (Hymenoptera: Aphelinidae) from the Iberian Peninsula, with the description

of one new species from Portugal. *J. Nat. Hist.*, **40**: 855–862

Jervis, M. A. and N. A. C. Kidd 1986 Host–feeding strategies in hymenopteran parasitoids. *Biol. Rev.*, **61**: 395–434

Li, C–. D., Y. W. Byeon and B. R. Choi 2007 An Aphelinid Species, *Aphelinus asychis* Walker (Hymenoptera: Aphelinidae) New to Korea. *J. Asia–Pacific Entomol.*, **10**: 13–15

Minks, A. K. and P. Harrewijn 1987 World Crop Pests. *In* "Aphids: Their Biology, Natural Enemies and Control", Vol. 2A, ed. by A. K. Minks and P. Harrewijin, Elsevier, Amsterdam, pp. 700

Parrella, M. P., L. S. Hansen and J. C. Van Lenteren 1999 Handbook of Biological Control. *In* "Glasshouse environments", ed. by T. W. Fisher, T. S. Bellows, L. E. Caltagirone, D. L. Dahlstein and C. B. Huffaker, New York, pp. 819–839

Perng, J. J. and Y. C. Liu 2002 Age–specific survival and fecundity and their effects on the intrinsic rate of increase of *Aphelinus gossypii* (Hym., Aphelinidae), a parasitoid of *Aphis gossypii* (Hom., Aphididae). *J. Appl. Entomol.*, **126**: 484–489

Rabasse, J. M. and I. J. Wyatt 1985 Biology of aphids and their parasites in greenhouses. *In* "Biological pest control: the glasshouse experience", ed. by N. W. Hussey and N. Scopes, Blandford Press Inc., Poole, pp. 66–73

Rabasse, J. M. and M. J. van Steenis 1999 Biological control of aphids. *In* "Integrated pest and disease management in greenhouse crops", ed. by R. Albajes, M. A. Gullino, J. C. van Lenteren and Y. Elad, Kluwer Inc., Dordrecht, pp. 235–297

Raney, J. M., L. W. Coles, R. D. Eikenbary, R. D. Morrison and K. J. Starks 1971 Host preference, longevity, developmental period and sex ratio of *Aphelinus asychis* with three sorghum–fed species of aphids held at controlled temperatures. *Ann. Entomol. Soc. Amer.*, **64**: 169–176

Schlinger, E. I. and J. C. Hall 1959 A synopsis of the biologies of three imported parasites of the spotted alfalfa aphid. *J. Econ. Entomol.*, **52**: 154–157

Sandlan, K. P. 1979 Host–feeding and its effects on the physiology and behaviour of the ichneumonid parasitoid, *Coccygomimus turionellae*. *Physiol. Entomol.*, **4**: 383–392

Sengonca, C., S. Schirmer and P. Blaeser 2008 Life table of the aphid parasitoid *Aphelinus asychis* (Walker) (Hymenoptera, Aphelinidae) parasitizing different age groups of *Aphis gossypii* Glover (Homoptera, Aphididae). *J. Plant Disease Protec.*, **115**: 112–128

Stary, P. 1988 Aphids: their biology, natural enemies and control. *In* "Aphelinidae", Vol. B, ed. by A. K. Minks and P. Harrewijn, Elsevier Inc., New York, pp. 185–188

Takada, H. 2002 Parasitoids (Hymenoptera: Braconidae, Aphidiinae; Aphelinidae) of four principal pest aphids (Homoptera: Aphididae) on greenhouse vegetable crops in Japan. *Appl. Entomol. Zool.*, **37**: 237–249

Tang, Y. Q. and R. K. Yokomi 1996 Biology of *Aphelinus spiraecolae* (Hymenoptera: Aphelinidae), a parasitoid of the spirea aphid (Homoptera: Aphididae). *Environ. Entomol.*, **25**: 519–523

Tatsumi, E. and H. Takada 2005 Evaluation of *Aphelinus asychis* and *A. albipodus* (Hymenoptera: Aphelinidae) as biological control agents against three pest aphids. *Appl. Entomol. Zool.*, 40: 379–385

Tokumaru, S. and H. Takada 1996 Number of Eggs Deposited and Host Feeding in *Aphelinus gossypii* Timberlake (Hymenoptera: Aphelinidae), A Parasitoid of *Aphis gossypii* Glover (Homoptera: Aphididae). *Jpn. J. Appl. Entomol. Zool.* **40**: 242–244 (in Japanese with English abstract)

Tran, D. H. and M. Takagi 2006 Biology of *Neochrysocharis okazakii* (Hymenoptera: Eulophidae), A Parasitoid of Stone Leak Leafminer *Liriomyza chinensis* (Diptera: Agromyzidae). *J. Fac. Agr. Kyushu Univ.*, **51**: 269–273

Tuda, M. 1996 Temporal/spatial structure and the dynamical property of laboratory host–parasitoid systems. *Res. Popul. Ecol.*, **38**: 133–140

Tuda, M. and K. Shima 2002 Relative importance of weather and density dependence on the dispersal and on–plant activity of the predator *Orius minutus*. *Popul. Ecol.*, **44**: 251–257

Tuda, M. and M. Shimada 1995 Developmental schedules and persistence of experimental host–parasitoid systems at two different temperatures. *Oecologia* **103**: 283–291

Tuda, M. and M. Shimada 2005 Complexity, evolution and persistence in host–parasitoid experimental systems, with *Callosobruchus* beetles as the host. *Adv. Ecol. Res.*, **37**: 37–75

Tuda, M., T. Matsumoto, T. Itioka, N. Ishida, M. Takanashi, W. Ashihara, M. Kohyama, and M. Takagi 2006 Climatic and inter–trophic effects detected in 10–year population dynamics of biological control of the arrowhead scale by two parasitoids in southwestern Japan. *Popul. Ecol.* **48**: 59–70

van Drieshe, R. G., S. L. Yon, J. P. Sanderson, K. C. Bennett, E. J. S. Tanek and R. Zhang 2008 Greenhouse Trials of *Aphidius colemani* (Hymenoptera: Braconidae) Banker Plants for Control of Aphids (Hemiptera: Aphididae) in Greenhouse Spring Floral Crops. *Florida Entomol.*, **91**: 583–591

van Lenteren, J. C. and J. Woets 1988 Biological and integrated pest control in greenhouses. *Annu. Rev. Entomol.*, **33**: 239–369

van Lenteren, J. C. 1991 Biological control in a tritrophic system approach. *In* "Proceeding of Aphid–Plant Interactions: Populations to Molecules", ed. by D. C. Peter, J. A. Webster and C. S. Chilouber, Oklahoma Agricultural Experiment Station, Stillwater, pp. 2–28

van Steenis, M. J. and K. A. M. H. El–Khawass 1995 Behavior of *Aphidius colemani* searching for *Aphis gossypii*–Functional–response and reaction to previously searched aphid colonies. *Biocontrol Sci. Techn.*, **5**: 339–347

Walter, G. H. 1988 Activity patterns and egg production in *Coccophagus bartletti*, and aphelinid parasitoid of scale insects. *Ecol. Entomol.*, **13**: 95–105

Wheeler, D. 1996 The role of nourishment in oogenesis. *Ann. Rev. Entomol.*, **41**: 407–431

Zhishan, W. and G. Heimpel 2007 Dynamic egg maturation strategies in an aphid parasitoid. *Physiol. Entomol.*, **32**: 143–149