

Potential Host Range of the Newly Introduced Aphid Parasitoid *Aphidius transcaspicus* (Hymenoptera: Braconidae) in Hawaii

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Abstract. *Aphidius transcaspicus* Telenga, a mealy plum aphid (*Hyalopterus pruni* Geoffroy) parasitoid from the Mediterranean, was recently introduced into Hawaii for control of invasive aphids. Under laboratory conditions the parasitoid successfully attacked several important aphid pests in Hawaii, including the melon aphid *Aphis gossypii* Glover, the banana aphid *Pentalonia nigronervosa* (Coquerel), the green peach aphid *Myzus persicae* (Sulzer), the corn leaf aphid *Rhopalosiphum maidis* (Fitch), and the cowpea aphid *Aphis craccivora* Koch. It could not successfully parasitize the turnip aphid *Lipaphis pseudobrassicae* Kalt or the black citrus aphid *Toxoptera aurantii* (Boyer de Fonscolombe). Field cage tests with *P. nigronervosa* and *M. persicae* also showed that *A. transcaspicus* successfully attacked both host species under semi-natural conditions, and preferred *M. persicae* over *P. nigronervosa*.

Key words: aphids, *Aphidius transcaspicus*, host range, parasitoids, *Pentalonia nigronervosa*

Introduction

Aphidius transcaspicus Telenga (Hymenoptera: Braconidae: Aphidiidae) is a mealy plum aphid *Hyalopterus pruni* Geoffroy parasitoid from the Mediterranean (Mackauer and Stary 1967, Kavallieratos and Lykouressis 1999). The parasitoid's host range is thought to be restricted to *Hyalopterus* and closely related aphid genera under field conditions (Mackauer and Stary 1967). However, in the laboratory it has been successfully reared on the cowpea aphid, *Aphis craccivora* Koch (Mackauer and Stary 1967), and on the black bean aphid, *Aphis fabae* Scopoli (Stary 1970, Li and Mills 2004).

More than 90 exotic aphid species have invaded Hawaii (Mondor et al. 2006). Some species: such as the melon aphid, *Aphis gossypii* Glover, and the banana aphid, *Pentalonia nigronervosa* (Coquerel), have become economically important pests. *A. gossypii* is the most abundant aphid in the islands, feeding on more than 40 plant species, many of which are commercially important (Timberlake 1924, Messing and Klungness 2001). *P. nigronervosa* is a vector of banana bunchy top virus, a devastating disease of bananas (Ferreira et al. 1997). Other commonly occurring aphid species in Hawaii include the green peach aphid *Myzus persicae* (Sulzer), the corn leaf aphid *Rhopalosiphum maidis* (Fitch), the cowpea aphid *Aphis craccivora* Koch, the turnip aphid *Lipaphis pseudobrassicae* Kalt, and the black citrus aphid *Toxoptera aurantii* (Boyer de Fonscolombe) (Beardsley 1979, Wright 2005).

Only a few aphid parasitoids have been deliberately introduced into Hawaii for biological control (Beardsley 1961, Funasaki et al. 1988). Of them, *Aphidius colemani* Viereck, and *Lysiphlebus testaceipes* Cresson (Hymenoptera: Aphidiidae) are two well-established

parasitoids attacking *A. gossypii* (Messing and Klungness 2001). Although only a few studies have evaluated the impact of natural enemies on aphids in Hawaii (Messing and Klungness 2001, van Elsen et al. 2003, Rhoads and Messing 2005, Young and Wright 2005), it appears there may be potential to improve biological control using additional imported parasitoids. Because there are no endemic, indigenous or beneficial aphids in the Hawaii archipelago (Beardsley 1979, Mondor et al. 2006), classical biocontrol can be conducted with minimal non-target risk.

As a part of a biocontrol program, we introduced *A. transcaspicus* into Hawaii via California, and tested its potential host range in laboratory and field cages. It was originally introduced from Greece into California for biological control of the mealy plum aphid *H. pruni* on prunes (Mills 2002).

Materials and Methods

Parasitoids. A laboratory population of *A. transcaspicus* was established from cohorts imported from the University of California at Berkeley, where the parasitoid was reared on *A. fabae*. It was maintained on *M. persicae* on cabbage at the Kauai Agricultural Research Center (KARC), Kapaa, Hawaii, under laboratory conditions (22 ± 2 °C, 60–90% RH, with natural light available through transparent glass windows, and fluorescent cool white light available during daytime).

Laboratory cage tests. All laboratory tests were conducted at KARC under the conditions described above. Seven common aphid species in Hawaii were selected for host range testing with *A. transcaspicus*: including *A. gossypii*, *A. craccivora*, *M. persicae*, *P. nigronervosa*, *R. maidis*, *L. pseudobrassicae* and *T. aurantii*. Test procedures were similar for each aphid species, except that different aphids were reared on different host plants. We used eggplant (for *A. gossypii*), cowpea (for *A. craccivora*), cabbage (for *M. persicae* and *L. pseudobrassicae*), taro (for *P. nigronervosa*), corn (for *R. maidis*), and citrus (for *T. aurantii*). All plants for each aphid species were planted in pots (10 cm diameter) at the greenhouse at the KARC, or directly purchased from local nurseries prior to tests.

Wasps reared from *M. persicae* on cabbage plants were used for all tests. For each host plant, 10 apterous adult aphids were collected from the field and released on a single potted host plant in a screened plastic cage (30 x 30 x 30 cm). After five days, the 10 adult aphids were removed from the plant, and all offspring produced by the 10 adults (about 100–200 individuals of mixed stages) were exposed to three mated, 1–2 day old naïve female *A. transcaspicus* for five days in the cage. Water and honey were provided for the wasps *ad libitum*. After 7–8 days, parasitized aphids (mummies) were collected daily and reared to determine the number and sex ratio of emerging wasps. Tests with each host species were repeated 15 times, except for *L. pseudobrassicae* and *T. aurantii*, which were repeated 10 times.

Field cage tests. *P. nigronervosa* and *M. persicae* were selected for further testing in field cages. Two trials were conducted in June and August 2004, in an eggplant field at the KARC. For each trial, five potted cabbage plants and five potted taro plants were randomly placed inside a fine-screen cage (100 x 150 x 100 cm). First, each cabbage plant was infested with *M. persicae* and each taro plant was infested with *P. nigronervosa* in the laboratory, by releasing five apterous adults on each plant for five days (which produced 50–100 aphids of mixed stages on each plant). About 50 mated, 1–2 day old female *A. transcaspicus* reared from *M. persicae* were then released into the cage. Most of the released wasps died after 2–3 days in the field. Starting one week later, all mummies on each plant were collected daily to determine the extent of parasitism on both aphid species.

Data analysis. Although host numbers varied among aphid species in the laboratory

Table 1. Host parasitization and adult emergence of the introduced parasitoid *A. transcaspicus* on different aphid species under laboratory conditions

Host species	Mummies (no.)	Wasps emerged (no.)	Females (%)	Emergence (%)
<i>Aphis gossypii</i>	6.1 ± 1.5 a	5.1 ± 1.4 a	63.4 ± 8.2 a	78.5 ± 4.5 a
<i>Aphis craccivora</i>	9.9 ± 5.6 a	6.7 ± 4.8 a	52.5 ± 4.8 a	74.4 ± 3.6 a
<i>Myzus persicae</i>	29.1 ± 5.8 b	23.0 ± 5.6 b	61.0 ± 4.6 a	80.1 ± 6.2 a
<i>Pentalonia nigronervosa</i>	29.6 ± 6.3 b	19.7 ± 4.1 b	64.6 ± 4.6 a	76.1 ± 3.6 a
<i>Rhopalosiphum maidis</i>	19.4 ± 1.9 b	17.8 ± 1.3 b	34.6 ± 8.9 b	80.3 ± 3.5 a
<i>Lipaphis erysimi</i>	0	-	-	-
<i>Toxoptera aurantii</i>	0	-	-	-

Values (mean ± SE) in the same column followed by the same letter are not significantly different ($P > 0.05$, ANOVA one-way test and multiple mean comparison of Tukey-Kramer HSD).

cage test, host density was abundant relative to wasp density in each test, as many aphids were not parasitized at the end of the exposure. Not a single mummy was found on *L. pseudobrassicae* or *T. aurantii*. Thus, we compared the mean numbers of total mummies and wasps produced on the other five aphid host species by giving the tested wasps unlimited access to hosts. In a few replicates of each of these five treatments, there were no mummies produced nor wasps emerged. Offspring sex ratio and emergence rate were compared among the five different host species treatments based on the actual number of replicates that produced mummies or wasps. All data were analyzed using one-way ANOVA and Tukey's HSD test (JMP 4.1, SAS, Cary, NC). Proportional data were arcsin square root transformed before the tests. For the field cage test, mean number of mummies per plant collected from the two host species were compared for each trial using a Kruskal-Wallis Test (JMP 4.1). Because the results of both trials were almost identical, the data from both are pooled for presentation.

Results and Discussion

A. transcaspicus successfully parasitized and completed development on *A. gossypii*, *A. craccivora*, *M. persicae*, *P. nigronervosa* and *R. maidis*, but not on *L. pseudobrassicae* or *T. aurantii* (Table 1). Mummies of *A. transcaspicus* appeared 7–8 days after wasps were re-released in the laboratory cages. More mummies ($F_{4,70} = 5.2$, $P < 0.001$) and wasps ($F_{4,70} = 4.3$, $P < 0.05$) were produced on *M. persicae*, *P. nigronervosa* and *R. maidis* than on *A. craccivora* or *A. gossypii*. The percentage of females was not significantly different among wasps emerged from *M. persicae*, *A. gossypii*, *P. nigronervosa* or *A. craccivora*, but was significantly lower from *R. maidis* than from the other four aphid species ($F_{4,61} = 4.1$, $P < 0.05$). There was no significant difference in adult parasitoid emergence from mummies among the five host aphid species ($F_{4,70} = 1.6$, $P = 0.19$).

Field cage tests also showed that *A. transcaspicus* successfully attacked *P. nigronervosa* and *M. persicae* under natural conditions, with more mummies produced from *M. persicae* than from *P. nigronervosa* (Figure 1) in both the first trial ($c^2 = 5.9$, $P < 0.05$) and the second

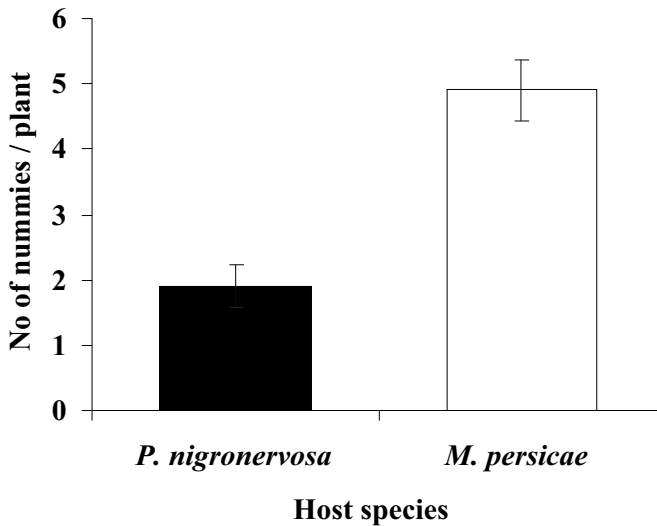


Figure 1. Mean number (\pm SE) of *A. transcaspicus* mummies collected from *M. persicae* on eggplant and *P. nigronevosa* on taro in field cage trials (data pooled from two trials).

trial ($\chi^2 = 6.1$, $P < 0.05$).

This study is the first to report that *A. transcaspicus* can successfully attack *M. persicae*, *A. gossypii*, *P. nigronevosa* and *R. maidis* under laboratory conditions. In particular, *M. persicae* and *P. nigronevosa* appear to be very suitable for the parasitoid, as the field cage tests also confirm parasitism under natural conditions. It is unknown if the parasitoid can also attack *A. gossypii*, *A. craccivora* and *R. maidis* under field conditions; further field tests are needed.

M. persicae and *A. gossypii* are the two most polyphagous aphid species in Hawaii. Both are common in fields as well as in orchards and nurseries, and can cause direct damage as well as indirect damage as a vector of virus diseases. The Aphidiids *L. testaceipes* and *A. colemani* attack *A. gossypii*, while *M. persicae* is attacked by *Aphidius gifuensis* Ashmead (Beardsley 1961) in Hawaii. However, overall rates of parasitism are often low due in part to high levels of hyperparasitism by *Pachyneuron* sp. (Petromalidae: Chalcidoidea) and *Syrphophagus* sp. (Encyrtidae: Chalcidoidea) (Messing and Klungness 2001, Rhains and Messing 2005).

The banana aphid causes substantially greater losses as a vector of bunchy top disease of bananas than that by direct feeding injury. To date, only *A. colemani* and a parasitic fly, *Endaphis maculans* (Diptera: Cecidomyiidae), were recorded to attack *P. nigronevosa* in Hawaii, and the overall level of parasitism in banana plantations is low (van Elsen et al. 2003). Three other aphidiid species: *Ephedrus plagiator* (Nees), *Lysiphlebus fabarum* Marshall and *Ephedrus cerasicola* Stary were identified as potentially suitable parasitoids of *P. nigronevosa* worldwide (Stary 1966, Stary and Stechmann 1990, Voelkl et al. 1990).

L. testaceipes and *A. colemani* were introduced into Tonga for the control of *P. nigronervosa* in 1987 (Stechmann and Voelkl 1988), and in 1990–91 (Wellings et al. 1994). However, there was little evidence that these two parasitoids successfully attacked *P. nigronervosa* in the field. Wellings et al. (1994) speculated that the heavy attendance of ants on *P. nigronervosa* colonies might be preventing attack by the parasitoid. Alternatively, the parasitoid may be demonstrating an inherent preference for aphid species other than *P. nigronervosa*. According to the current study, *A. transcaspicus* also has potential for control of *P. nigronervosa* in Hawaii. However, further field release studies are needed.

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Literature Cited

- Beardsley, J.W.** 1961. A review of the Hawaiian Braconidae (Hymenoptera). Proc. Hawaii Entomol. Soc. 17: 333–366.
- Beardsley, J.W.** 1979. The current status of the names of Hawaiian aphids. Proc. Hawaii Entomol. Soc. 13: 45–50.
- Ferreira, S.A., E.E. Trujillo, and D.Y. Oguta.** 1997. Banana bunchy top virus. CTAHR Cooperative Extension Services, University of Hawaii, Dec. 1997.
- Funasaki, G.Y., P.Y. Lai, L.M. Nakahara, J.W. Beardsley, and A.K. Ota.** 1988. A review of biological control introductions in Hawaii: 1890 to 1985. Proc. Hawaii Entomol. Soc. 28: 105–160.
- Li, B., and N. Mills.** 2004. The influence of temperature on size as an indicator of host quality for the development of a solitary koinobiont parasitoid. Entomol. Exp. Appl. 110: 249–256.
- Mackauer, M., and P. Stary.** 1967. Index of Entomophagous Insects. World Aphidiidae. Le Francois, Paris, France.
- Messing, R.H., and L.M. Klungness.** 2001. A two-year survey of the melon aphid, *Aphis gossypii* Glover (Homoptera: Aphididae), on crop plants in Hawaii. Proc. Hawaii Entomol. Soc. 35: 101–111.
- Mills, N.** 2002. Prune aphids: fall migration, biological and their impact on prune production 2001. Prune Research Reports. California Prune Board, Sacramento, CA, USA, pp.18–30.
- Mondor, E.B., M.N. Tremblay, and R.H. Messing** 2006. Morphological and ecological traits promoting aphid colonization of the Hawaiian Islands. Biol. Invasions (*in press*).
- Rhainds, M., and R.M. Messing.** 2005. Spatial and temporal density dependence in a population of melon aphid, *Aphis gossypii* Glover (Homoptera: Aphididae), on established and sentinel taro plants. Appl. Entomol. Zool. 40: 273–282.
- Stary, P.** 1966. Integrated control of aphids attacking bananas. Revista di Agricultura Subtropicae e Tropicale 60: 224–241.
- Stary, P.** 1970. Biology of Aphid Parasites with Respect to Integrated Control. Dr W Junk, The Hague, The Netherlands.
- Stary, P., and D.H. Stechmann.** 1990. *Ephedrus cerasicola* Stary (Hym., Aphidiidae), a new biocontrol agent of the banana aphid, *Pentalonia nigronervosa* Coq. (Hom., Aphididae). J. Appl. Entomol. 109: 457–462.
- Stechmann, D.H., and W. Voelkl.** 1988. Introduction of *Lysiphlebus testaceipes* (Cresson) (Hym.: Aphidiidae) into the Kingdom of Tonga, Oceania, pp. 271–273. In E. Niemczyk and A.F.G. Dixon (eds.), Ecology and Effectiveness of Aphidophaga., SPB Academic Publishing, The Hague, Netherlands.
- Timberlake, P.H.** 1924. Notes on Hawaiian Aphidae, with a list of food plants (Homoptera). Proc. Hawaii Entomol. Soc. 5: 450–460.
- Van Elsen, K., R.H. Messing, and M.G. Wright.** 2003. Parasitism of aphids by *Endaphis maculans*

- (Diptera: Cecidomyiidae) in Hawaii. *In* Entomophagous Insects Workshop. 2003. Abstracts from the XIII International Entomophagous Insects Workshop. 30 pp. *J. Insect Sci.* 3:33.
- Voelkl, W., D.H. Stechmann, and P. Stary.** 1990. Suitability of five species of Aphidiidae (Hymenoptera) for the biological control of the banana aphid *Pentalonia nigronervosa* Coq. (Homoptera, Aphididae) in the South Pacific. *Tropical Pest Management* 36: 249–257.
- Wellings, P.W., P.J. Hart, V. Kami, and D.C. Morneau.** 1994. The introduction and establishment of *Aphidius colemani* Viereck (Hym, Aphidiinae) in Tonga. *J. Appl. Entomol.* 118:419–428.
- Wright, M.G.** 2005. Crop Knowledge Master, <http://www.extento.hawaii.edu/Kbase/crop/crop.htm>. Viewed 25 May 2006.
- Young, C.A., and M.G. Wright.** 2005. Seasonal and spatial distribution of banana aphids in banana plantations on Oahu. *Proc. Hawaii Entomol. Soc.* 37: 73–80.