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PARASITISM, ADULT EMERGENCE, SEX RATIO, AND SIZE OF *APHIDIUS COLEMANI* (HYMENOPTERA: APHIDIIDAE) ON SEVERAL APHID SPECIESN. C. Elliott,<sup>1</sup> B. W. French, J. D. Burd, S. D. Kindler, and D. K. Reed

## ABSTRACT

*Aphidius colemani* Viereck parasitizes several economically important aphid pests of small grain crops including the greenbug, *Schizaphis graminum* and the Russian wheat aphid, *Diuraphis noxia*. The ability of *A. colemani* to switch from *S. graminum* to several species of aphids common to agricultural and associated non-agricultural ecosystems in the Great Plains, and the effects of host-change on several biological parameters that influence population growth rate were determined. Female *A. colemani* parasitized and developed to adulthood in nine of 14 aphid species to which they were exposed in the laboratory. All small grain feeding aphids except *Sipha flava* were parasitized. Two sunflower feeding species (*Aphis nerii* and *A. helianthi*) and two crucifer feeding species (*Lipaphis erysimi* and *Brevicoryne brassicae*) were parasitized, as was the cotton aphid, *Aphis gossypii*. The average percentage of aphids parasitized differed significantly among host aphid species, as did the percentage of parasitoids surviving from the mummy to the adult stage and the time required for immature development. The sex ratio of adults that eclosed from the various hosts did not differ significantly among species. Dry weights of adult parasitoids differed significantly among host species. Adults from *S. graminum* weighed most (0.054 mg) while those emerging from *A. helianthi* weighed least (0.020 mg). Results are discussed in terms of strategies for classical biological control of aphid pests of cereals.

*Aphidius colemani* Viereck is widely distributed in Asia, southern Europe, Africa, South America, and Australia, and broadly oligophagous on Aphididae (Stary 1975). Although its host range differs geographically (Stary 1975), *A. colemani* is known to parasitize several economically important aphid pests of cereals, including the greenbug, *Schizaphis graminum* (Ron-dani) and the Russian wheat aphid, *Diuraphis noxia* (Mordvilko) (Stary 1975, Aalbersberg et al. 1988). Although *A. colemani* is an important parasitoid of several aphid pests of cereals, it appears unable to maintain pest aphid populations below the economically damaging levels (Aalbersberg 1988, Gerding et al. 1989, Prinsloo 1990).

Even though published information yields no evidence that establishment of *A. colemani* in the Great Plains of the United States would, by itself, result in effective biological control of *D. noxia*, *S. graminum*, or other aphid pests of cereals, the parasitoid could contribute to multilateral control (c.f. Stary 1972). In the multilateral control concept, the interaction among natural enemy communities in an agricultural landscape is optimized to reduce popu-

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lations of target pests in crops. For aphids like *D. noxia* and *S. graminum*, whose populations are ephemeral in space and time, generalist natural enemies that can persist in reservoirs at times when target pests are unavailable may play an important role in biological control. Alternate hosts may also play an important role during the process of establishing natural enemies in classical biological control programs by providing reservoirs for natural enemies, or by providing alternate hosts on which natural enemies could be released at times when the target pest is unavailable (Eikenbary and Rogers 1974).

Some polyphagous aphidiids show reluctance to switch to alternate hosts in the laboratory, and exhibit phenotypic differences among subpopulations associated with different hosts in the field, thus suggesting the existence of specialized host races (Powell and Li 1983, Cameron et al. 1984, Nemeček and Stary 1983). Thus, our objective was to determine the ability of *A. colemani* to switch from a particular host, *S. graminum* to several species of aphids common to agricultural and associated non-agricultural ecosystems in the Great Plains, and to determine the effects of such host-change on several biological parameters that may influence the population growth rate of the parasitoid.

## MATERIALS AND METHODS

The *A. colemani* colony used in this study was obtained by D. K. Reed and K. S. Pike from Argentina in September, 1990. The parasitoid had been maintained in laboratory culture on *S. graminum* for approximately 12 generations when the study was initiated.

Mated female *A. colemani* reared from *S. graminum* were exposed to nymphs of 14 aphid species for 24-h to determine if they would successfully parasitize the aphids when they had no previous exposure to them. A laboratory colony of each aphid species was established from aphids collected from plants in the field during 1991, or obtained from R. W. Kieckhefer, USDA, ARS, Brookings, South Dakota (*Rhopalosiphum padi* [L.], *S. graminum*, and *R. maidis* [Fitch]) or B. W. Cartwright, Oklahoma State University, Lane, Oklahoma (*B. brassicae* L.). Aphids were maintained in the laboratory on the host plant species from which they were originally obtained or on a suitable alternative species (Table 1). Seedling plants of the species used to maintain an aphid colony were also used as experimental plants.

A replicate of the experiment for each of the 14 aphid species was established by transferring 50 1st-3rd instar nymphs of that species from the laboratory colony to an aphid-free host plant growing in a 10-cm diameter plastic pot. Aphids were allowed to settle for 4 h at which time four mated female *A. colemani* were introduced into the cage. The caged plant was then placed in a growth chamber maintained at 16:8 h (L:D) and 22°C ( $\pm 0.5^\circ\text{C}$ ). After 24 hours the adult parasitoids were removed and the caged plant was returned to the growth chamber. The plant was watered every 1-2 days, and inspected each day for the presence of mummies. Mummies that formed were removed, placed in plastic petri dishes (4-cm diam. by 1.4 cm height), and returned to the growth chamber. All mummies that formed during the three days following formation of the first mummy were weighed as a group on a Mettler AE-240 balance. Mummies were checked each day to determine the number of adults that enclosed during the previous 24 hr. A plant was discarded after one month whether or not mummies formed.

Three or four replicates were established for each of the 14 aphid species. *Schizaphis graminum* was included as one of the 14 species to allow comparison of parasitization of this species, on which *A. colemani* had been reared for

Table 1. Aphid species used in studies of host-change by *Aphidius colemani* and the host plant species used for colony maintenance and in the experiment.

Aphid Species/Common Name	Laboratory Host Plant/Common name
<i>Diuraphis noxia</i> (Mordvilko) Russian wheat aphid	<i>Hordeum vulgare</i> – barley
<i>Schizaphis graminum</i> (Rondani) greenbug	<i>Hordeum vulgare</i>
<i>Rhopalosiphum padi</i> (L.) bird cherry-oat aphid	<i>Hordeum vulgare</i>
<i>Rhopalosiphum maidis</i> (Fitch) corn leaf aphid	<i>Hordeum vulgare</i>
<i>Sipha flava</i> (Forbes) yellow sugarcane aphid	<i>Hordeum vulgare</i>
<i>Aphis helianthi</i> Monell	<i>Helianthus annuus</i> – common sunflower
<i>Aphis nerii</i> Boyer de Fonscolombe Oleander aphid	<i>Helianthus annuus</i>
<i>Dactynotus helianthicola</i> Olive	<i>Helianthus annuus</i>
<i>Dactynotus</i> spp.	<i>Helianthus annuus</i>
<i>Therioaphis trifolii</i> (Monell) clover aphid	<i>Trifolium pratense</i> – red clover
<i>Acyrtosiphon pisum</i> (Harris) pea aphid	<i>Vicia faba</i> -faba bean
<i>Aphis gossypii</i> Glover cotton aphid	<i>Gossypium hirsutum</i> – cotton
<i>Brevicoryne brassicae</i> (L.) cabbage aphid	<i>Brassica oleracea</i> – cabbage
<i>Lipaphis erysimi</i> (Kaltenbach) turnip aphid	<i>Brassica napus</i> – canola

several generations, with that of species to which it had not been exposed. Six variables were measured for each replicate: the proportion of aphids parasitized during 24 hr (proportion of mummies formed); the proportion of individuals surviving from the mummy stage to adulthood; the sex ratio of eclosed adults (proportion female); the median number of days required from parasitization to adult eclosion; and average adult dry weight. Parasitoids were allowed to air dry at room temperature for three months prior to weighing. Adult dry weights were measured by pooling individuals of a particular sex from a replicate and weighing them on a Mettler UM-3 balance. Average adult dry weight was estimated by taking the weighted average (weighted by the number of individuals of each sex) of the male and female weights. Analysis of variance and the least significant difference test were used to compare means of the variables across aphid species. The arcsine transformation was applied to proportional data prior to conducting analysis of variance.

Table 2. The proportion of aphids parasitized during 24-h (proportion of mummies formed), proportion of individuals surviving from the mummy stage to adulthood, sex ratio of eclosed adults (proportion female), median number of days required from parasitization to adult eclosion, average dry weight per adult for 14 aphid species exposed to mated female *Aphidius colemani* for 24 hours as nymphs.

Aphid Species	Median Days	Proportion Parasitized	Proportion Surviving	Proportion Female	Adult Dry Weight (mg)
<i>D. noxia</i>	15.0 (0.00) <sup>a</sup>	0.71 (0.20) <sup>b</sup>	0.96 (0.037) <sup>d</sup>	0.53 (0.213) <sup>a</sup>	0.029 (0.0012) <sup>bc</sup>
<i>R. maidis</i>	15.0 (0.58) <sup>a</sup>	0.51 (0.013) <sup>ab</sup>	0.73 (0.082) <sup>bcd</sup>	0.28 (0.147) <sup>a</sup>	0.029 (0.0036) <sup>bc</sup>
<i>S. graminum</i>	13.3 (0.33) <sup>a</sup>	0.96 (0.042) <sup>c</sup>	0.95 (0.025) <sup>d</sup>	0.64 (0.157) <sup>a</sup>	0.054 (0.0017) <sup>f</sup>
<i>R. padi</i>	14.7 (0.67) <sup>a</sup>	0.81 (0.064) <sup>bc</sup>	0.86 (0.070) <sup>cd</sup>	0.80 (0.054) <sup>a</sup>	0.036 (0.0013) <sup>cde</sup>
<i>S. flava</i>	—	—	—	—	—
<i>A. pisum</i>	—	—	—	—	—
<i>T. trifolii</i>	—	—	—	—	—
<i>D. helianthicola</i>	—	—	—	—	—
<i>Dactynous</i> sp.	—	—	—	—	—
<i>A. helianthi</i>	20.0 (0.58) <sup>b</sup>	0.51 (0.079) <sup>ab</sup>	0.40 (0.046) <sup>b</sup>	0.69 (0.173) <sup>a</sup>	0.020 (0.0025) <sup>a</sup>
<i>A. nerii</i>	15.7 (1.11) <sup>a</sup>	0.17 (0.040) <sup>a</sup>	0.56 (0.179) <sup>bc</sup>	0.87 (0.125) <sup>a</sup>	0.026 (0.0039) <sup>ab</sup>
<i>L. erysimi</i>	15.0 (0.57) <sup>a</sup>	0.94 (0.063) <sup>c</sup>	0.93 (0.041) <sup>d</sup>	0.63 (0.147) <sup>a</sup>	0.037 (0.0015) <sup>de</sup>
<i>A. gossypii</i>	13.3 (0.33) <sup>a</sup>	0.64 (0.111) <sup>b</sup>	0.96 (0.023) <sup>d</sup>	0.65 (0.089) <sup>a</sup>	0.029 (0.0017) <sup>bcd</sup>
<i>B. brassicae</i>	13.0 (0.05) <sup>a</sup>	0.25 (0.059) <sup>a</sup>	0.05 (0.059) <sup>a</sup>	0.90 (0.050) <sup>a</sup>	0.045 (0.0020) <sup>ef</sup>

Means within columns followed by the same letter are not significantly different ( $P > 0.05$ )

## RESULTS AND DISCUSSION

Female *A. colemani* parasitized and developed to adulthood in nine of 14 aphid species to which they were exposed (Table 2). All small grain feeding aphids except *Sipha flava* (Forbes) were parasitized. Two sunflower feeding species (*Aphis nerii* Boyer de Fonscolombe and *A. helianthi* Monell) and two crucifer feeding species (*Lipaphis erysimi* [Kaltenbach] and *Brevicoryne brassicae* [L.]) were parasitized, as was the cotton aphid, *Aphis gossypii* Glover. Neither of the legume feeding species was successfully parasitized.

The average percentage of aphids parasitized differed significantly among host aphid species ( $F=9.08$ ;  $df=8, 19$ ;  $P=0.0001$ ) and ranged from a low of 17% for *A. nerii* to a high of 96% for *S. graminum*. The percentage of parasitoids surviving from the mummy to the adult stage differed significantly among host species ( $F=8.43$ ;  $df=8, 19$ ;  $P=0.0001$ ). Survival was highest for *D. noxia*, *S. graminum*, and *L. erysimi*, and lowest for *B. brassicae*. The sex ratio of adults that emerged from the various hosts did not differ significantly among species. Development times from oviposition to adult emergence ranged from 13.3 days for *A. colemani* parasitizing *S. graminum* and *A. gossypii*, to 20.0 days for *A. helianthi*. Differences in developmental times were significant ( $F=8.35$ ;  $df=8, 19$ ;  $P=0.0001$ ). Dry weights of adult parasitoids differed significantly among host species ( $F=15.15$ ;  $df=7, 18$ ;  $P=0.0001$ ). Adults that emerged from *S. graminum* weighed most (0.054 mg) while those emerging from *A. helianthi* weighed least (0.020 mg).

Body size is positively correlated with fecundity in many aphidiid species (Hofsvang 1991). Our results suggest that *A. colemani* population growth rate may vary when associated with populations of different host species due to variation in adult size (and presumably fecundity), survival to adulthood, and immature development rate; these three factors are well known for their influence on population growth rate (Birch 1948).

Several authors have observed a reluctance by polyphagous aphid parasitoids reared on a particular host in the laboratory to adapt to an alternate host to which it was exposed in no-choice tests (Powell and Li 1983, Cameron et al. 1984, Nemeč and Stary 1983). We found no evidence to suggest that inability to rapidly accept new hosts will limit *A. colemani* in exploiting alternate hosts in the field. *Aphidius colemani* appeared to more efficiently parasitize *S. graminum*, the species on which it was reared for several generations prior to the experiment, than several other hosts to which it was exposed. However, the parasitoid readily accepted several known alternate hosts (Mackauer and Stary 1967, Stary 1975). Species that were not successfully parasitized had not previously been recorded as hosts of *A. colemani*. *Aphis helianthi* and *L. erysimi*, two species not included on host lists (Mackauer and Stary 1967, Stary 1975), were also parasitized. Whether or not these species serve as hosts in the field depends on behavioral considerations such as the parasitoids propensity to locate the appropriate habitat, locate the aphids food plant within that habitat, and locate aphids on the plant. Our study does not address these behavioral considerations but indicated a lack of physiological barriers to successful parasitization. Choice tests and field studies would be required to provide such information.

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