

# The Great Lakes Entomologist

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Volume 28  
Numbers 3 & 4 -- Fall/Winter 1995 *Numbers 3 &  
4 -- Fall/Winter 1995*

Article 1

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January 1995

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### Recommended Citation

Elliot, N. C.; Burd, J. D.; Kindler, S. D.; and Lee, J. H. 1995. "Temperature Effects on Development of Three Cereal Aphid Parasitoids (Hymenoptera: Aphidiidae)," *The Great Lakes Entomologist*, vol 28 (3)  
Available at: <https://scholar.valpo.edu/tgle/vol28/iss3/1>

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TEMPERATURE EFFECTS ON DEVELOPMENT OF THREE CEREAL  
APHID PARASITOIDS (HYMENOPTERA: APHIDIIDAE)N. C. Elliott<sup>1</sup>, J. D. Burd, S. D. Kindler, and J. H. Lee

## ABSTRACT

Temperature is an important climatological variable that influences the biology and ecology of insects. Poor climatic adaptation can limit the effectiveness of parasitic insects in biological control. Two exotic parasites (Syrian *Diaeretiella rapae* (M'Intosh) and Argentinean *Aphidius colemani* Viereck) imported for biological control of the Russian wheat aphid, *Diuraphis noxia* (Mordvilko), and one native parasite (*Diaeretiella rapae*) were reared in growth chambers in three fluctuating temperature regimes with average daily temperatures of 12, 18, and 24°C. Estimates of temperature thresholds for immature development were 3.3, 3.5, and 2.8°C, for Oklahoman *D. rapae*, Syrian *D. rapae*, and *A. colemani*, respectively. Estimates of thermal requirements for development from egg to adult were 297, 278, and 301 degree-days for the three parasitoids. Dry weights of adults reared in different fluctuating temperature regimes did not differ significantly among sexes, but adults from regimes with low average temperatures of 12 and 18°C had significantly greater weights than those reared in a regime with an average temperature of 24°C. Results suggest that developmental response to temperature will not limit the effectiveness of the exotic parasites in biological control.

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*Diaeretiella rapae* M'Intosh is a cosmopolitan aphidiid that commonly parasitizes a wide range of hosts in agroecosystems (Mackauer and Stary 1967). *Aphidius colemani* Viereck is widely distributed in the southern hemisphere and broadly oligophagous on Aphididae (Stary 1975). Both species parasitize several economically important aphid pests of small grain crops including the greenbug, *Schizaphis graminum* (Rondani), and Russian wheat aphid, *Diuraphis noxia* (Mordvilko) (Mackauer and Stary 1967, Stary 1975). Both *A. colemani* and *D. rapae* were imported into the United States for classical biological control of the Russian wheat aphid in the Southern Great Plains and elsewhere in the western US (Gould and Prokrym 1994).

Temperature is an important abiotic variable that influences insect populations in the field. Temperature can influence insect population growth through its effects on development rate, survival, fecundity, and dispersal (Ratte 1984, Rankin and Singer 1984). Temperature may partially determine the effectiveness of a parasitoid as a biological control agent in a particular region. For example, a parasitoid with a higher developmental threshold temperature than its host may have limited effectiveness in regions where temperatures below the parasitoids developmental threshold but above the hosts

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threshold occur often, because development from birth to maturity, and hence population growth rate would lag behind that of its host (Campbell et al. 1974). Thus, in addition to factors such as searching ability, host preference, and host suitability, knowledge of developmental responses to temperature should be considered when deciding whether to release an exotic parasitoid for biological control (Bernal and Gonzalez 1993).

Estimates of developmental thresholds for *D. rapae* populations from different regions range from 2.1 to 7.0°C (Campbell et al. 1974, Bernal and Gonzalez 1993). The estimates may result from adaptation to geographic differences in climate (Campbell et al. 1974). To the best of our knowledge, the developmental threshold of *A. colemani* has not been reported. The first objective of this study was to determine developmental thresholds and temperature requirements for development of three cereal aphid parasitoids. Two of the parasitoids were imported into the US; *Diaeretiella rapae* was imported from Syria, while *A. colemani* was imported from Argentina. A native Oklahoma population of *D. rapae* was also examined. Because this parasitoid is endemic to the Southern Great Plains, and presumably well adapted to the climate there, estimation of temperature effects on its development may serve as a benchmark against which to assess the exotic parasitoids. The second objective was to determine the influence of temperature during immature stages on adult size. Body size is related to fecundity in aphidiids (Hofsvang 1991) and is therefore an important factor influencing parasitoid population dynamics.

#### MATERIALS AND METHODS

The parasitoids used in this study were obtained from three sources. *Diaeretiella rapae* was reared from *Aphis gossypii* Glover on cantaloupe from fields near Lane, Oklahoma in 1991 and collected from *D. noxia* in wheat fields in Syria in 1990. The Syrian collection was designated T90026 at the Texas A&M University quarantine facility to distinguish it from other collections. A colony of *A. colemani* was established from cereal aphids collected in wheat fields in Argentina in 1990. Parasitoid colonies were maintained in plant growth chambers at 20-24°C and 16L:8D using *D. noxia* as host.

Development time from oviposition to adult eclosion was determined for cohorts exposed to three fluctuating temperature regimes in programmable plant growth chambers. Temperature in each of the three regimes oscillated through a sine wave with a 24-h period and an amplitude of 10°C. Mean daily temperatures in the three regimes were 12, 18, and 24°C. Relative humidity was maintained at 50±5% and photoperiod was 16L:8D.

Parasitoid cohorts were established by placing 50 1st-3rd instar *D. noxia* on barley seedlings growing in 10-cm diameter pots (approximately 4 seedlings per pot). Seedlings and nymphs were then covered with a vented plastic cage. Nymphs were allowed to settle on plants for approximately 4-h after which time 10 mated female parasitoids were introduced into the cage. The caged plants, aphids, and parasitoids were held in the laboratory at room temperature (20-22°C) for 4-h to allow ample time for oviposition. Afterwards, adult parasitoids were removed and the caged plant with aphids was placed in a growth chamber programmed for one of the three temperature regimes. Plants were checked daily for mummies which were removed, placed individually in labeled petri dishes (5-cm diameter by 1.4-cm height) and returned to the growth chamber. Petri dishes were shaded to eliminate the effect of irra-

diation from chamber lights on temperature within the dishes. Dishes were checked daily for emergence of adult parasitoids. Adult parasitoids from a cohort were identified to sex, pooled according to sex, and freeze dried using a speed-vac. Dried parasitoids from a cohort of a particular sex were weighed as a group. Approximately 7 cohorts were established per temperature regime for each parasitoid.

Lower developmental thresholds and thermal (degree-day) requirements for immature development were estimated using methods of Campbell et al. 1974. Dry weights and developmental times were subjected to analysis of variance to test for differences among sexes and temperature regimes. All statistical hypotheses were tested at the  $\alpha=0.05$  level of significance.

## RESULTS AND DISCUSSION

The number of days required for development decreased with increasing average temperature for each of the three parasitoids (Table 1). Development times for the three parasitoids were similar at each temperature. For example, development times ranged from 34.6 days for Syrian *D. rapae* and *A. colemani* to 35.9 days for Oklahoman *D. rapae* reared at 12°C; while at 24°C de-

Table 1. Mean number of days ( $\pm$  SE) required for immature development and mean adult dry weight ( $\pm$ SE) of three parasites reared in three fluctuating temperatures regimes.

Species/Location/Sex	Temp. (°C)	No. Individuals	Days	Dry Weight (mg)	
<i>D. rapae</i> - Oklahoma	Female	12	30	35.9 (0.38)	0.046 (0.0012)
		18	31	18.9 (0.41)	0.041 (0.0017)
		24	29	14.5 (0.26)	0.037 (0.0011)
	Male	12	27	35.9 (0.59)	0.040 (0.0019)
		18	32	18.7 (0.33)	0.042 (0.0049)
		24	34	14.8 (0.35)	0.036 (0.0021)
<i>D. Rapae</i> - Syria	Female	12	23	34.6 (0.65)	0.049 (0.0073)
		18	37	18.9 (0.28)	0.039 (0.0067)
		24	41	14.0 (0.28)	0.036 (0.0062)
	Male	12	32	33.5 (0.38)	0.045 (0.0074)
		18	27	17.4 (0.32)	0.041 (0.0048)
		24	26	13.5 (0.43)	0.034 (0.0065)
<i>A. colemani</i> - Argentina	Female	12	13	34.6 (0.68)	0.042 (0.0076)
		18	19	19.3 (0.37)	0.038 (0.0032)
		24	26	14.7 (0.15)	0.028 (0.0066)
	Male	12	15	34.3 (0.95)	0.043 (0.0082)
		18	14	17.9 (0.30)	0.034 (0.0033)
		24	15	14.5 (0.25)	0.029 (0.0066)

velopment times ranged from 13.5 days for Syrian *D. rapae* to 14.8 days for Oklahoman *D. rapae*.

Females generally required slightly longer to develop than males, but the differences were small and not significant for any of the parasitoid species. Therefore, development times of the sexes were pooled for each species for the purpose of determining developmental thresholds and thermal requirements.

Developmental thresholds were 3.3, 3.5, and 2.8°C for Oklahoman *D. rapae*, Syrian *D. rapae*, and *A. colemani*, respectively. Thermal requirements for immature development were 293, 273, and 300 degree-days for Oklahoman *D. rapae*, Syrian *D. rapae*, and *A. colemani*, respectively.

Previously reported estimates of the developmental threshold temperature for *D. rapae* from various locations range from 2.1 to 7.0°C (Campbell et al. 1974, Bernal and Gonzalez 1993). Our estimates for *D. rapae* from Oklahoma and Syria are within the range of those previously reported.

A parasitoid with a thermal threshold that differs markedly from that of its host may be ineffective in biological control due to poor temporal synchrony in population growth rates of host and parasitoid caused by differences in development rates from birth to maturity (Campbell et al. 1974, Bernal and Gonzalez 1993). Estimates of developmental thresholds for known cereal aphid host species of *D. rapae* and *A. colemani* range from 0.9-6.1°C (Elliott et al. 1988, Elliott and Kieckhefer 1989, Kieckhefer and Elliott 1989, Kieckhefer et al. 1989, Honek and Kocourek 1990). Thus, it appears that developmental thresholds for Syrian *D. rapae* and *A. colemani* are within the range of developmental thresholds previously reported for their hosts in cereal agroecosystems, suggesting that biological control of cereal aphids in the Great Plains by these exotic parasitoids may not be limited by differential developmental responses to temperature.

It should be mentioned that thermal thresholds were estimated from populations of aphid species from widely divergent regions, and while several estimates were from cereal aphid populations from the Northern Great Plains, none were from aphids collected from the Southern Great Plains. Some studies of geographical variation in thermal thresholds of aphids indicate that populations from cooler climates have lower thresholds (Campbell et al. 1974, Hutchison and Hogg 1984), while others fail to detect differences in thresholds among geographic populations (Lamb et al. 1987). Thus, we cannot provide conclusive evidence that these parasitoids are well adapted for exploiting cereal aphids in the Southern Great Plains in terms of their developmental responses to temperature. However, the similarity of developmental thresholds and thermal development requirements for *D. rapae* native to Oklahoma, which is presumably well adapted to the climate there, and Syrian *D. rapae* and *A. colemani* suggests that these exotic parasitoids are adapted to the climate of the Southern Great Plains, at least with respect to temperature effects on immature development.

Dry weights of adult females were generally slightly greater than males at a given temperature (Table 1), but differences in weights did not differ significantly among sexes for any of the parasitoids. Dry weights generally decreased with increasing average rearing temperature from approximately 0.045 mg at 12°C to approximately 0.035 mg at 24°C for *D. rapae* from both locations, and from approximately 0.042 mg at 12°C to 0.029 mg at 24°C for *A. colemani* (Table 1). For Oklahoman *D. rapae* and *A. colemani*, weights of individuals reared at 12°C were significantly greater than those reared at 24°C; for Syrian *D. rapae* significant differences in weight were evident among all temperature regimes. Larger body size is generally associated with

greater fecundity in aphidiid species (Hofsvang 1991). Thus, temperature may influence fecundity, and therefore rates of population growth, of *D. rapae* and *A. colemani* indirectly through its affect on adult size. However, the size of all three parasitoids appears to be affected similarly by variation in temperature, so that reduced size at higher temperatures is a characteristic of both the exotic and native aphidiids studied.

Our study suggests that the two exotic aphidiids studied are adapted to the climate of the Southern Great Plains, at least with respect to the influence of temperature on immature development. Furthermore, normal fluctuations in climate, such as seasonal variation in temperature, may influence population growth rates of the aphidiids in an obvious way, through effects on immature development, and in a less obvious way through effects on fecundity related to variation in adult size.

#### ACKNOWLEDGMENTS

We thank Wade French, Tim Johnson, and Perry Shelby for technical assistance. Mention of a proprietary product does not constitute endorsement for its use by the USDA. We also thank Dave Reed and Keith Pike for foreign explorations resulting in collection of the exotic parasitoids used in this study, and Bob Cartwright for supplying native parasitoids.

#### LITERATURE CITED

- Bernal, J., and D. Gonzalez. 1993. Temperature requirements of four parasites of the Russian wheat aphid *Diuraphis noxia*. Entomol. Exp. Appl. 69:173-182.
- Campbell, A., B. D. Frazier, N. Gilbert, A. P. Gutierrez, and M. Mackauer. 1974. Temperature requirements of some aphids and their parasites. J. Appl. Ecol. 11:431-438.
- Elliott, N. C., R. W. Kieckhefer, and D. D. Walgenbach. 1988. Effects of constant and fluctuating temperatures on developmental rates and demographic statistics for the corn leaf aphid (Homoptera: Aphididae). J. Econ. Entomol. 81:1383-1389.
- Elliott, N. C., and R. W. Kieckhefer. 1989. Effects of constant and fluctuating temperatures on immature development and age-specific life tables of *Rhopalosiphum padi* (L.) (Homoptera: Aphididae). Can. Entomol. 121:131-140.
- Gould, J. R. and D. Prokrym.. 1994. APHIS project summary: Russian wheat aphid biological control project. Pages 9-15, Proc. 6th Russian Wheat Aphid Workshop, January 23-25, Ft. Collins, Colorado. 268 pp.
- Hofsvang, T. 1991. Fecundity of aphid parasitoids in the family Aphidiidae (Hymenoptera). (A review). in: L. Polgar, R. J. Chambers, A. F. G. Dixon, and I. Hodek (Eds.), Behaviour and Impact of Aphidophaga. SPB Academic Publishing bv, The Hague. 350 pp.
- Honek, A. and F. Kocourek. 1990. Temperature and development time in insects: A general relationship between thermal constants. Zool. Jb. Syst. 117:401-439.
- Hutchison, W. D., and D. B. Hogg. 1984. Demographic statistics for the pea aphid (Homoptera: Aphididae) in Wisconsin and a comparison with other populations. Env. Entomol. 13:1173-1181.
- Kieckhefer, R. W., and N. C. Elliott. 1989. Effect of fluctuating temperatures on development of immature Russian wheat aphid (Homoptera: Aphididae) and demographic statistics. J. Econ. Entomol. 82:119-122.
- Kieckhefer, R. W., N. C. Elliott, and D. D. Walgenbach. 1989. Effects of constant and

- fluctuating temperatures on developmental rates and demographic statistics of the English grain aphid (Homoptera: Aphididae). *Ann. Entomol. Soc. Amer.* 82:701-706.
- Lamb, R. J., P. A. MacKay, and G. H. Gerber. 1987. Are development and growth of pea aphids, *Acyrtosiphon pisum*, in North America adapted to local temperatures. *Oecologia* 72:170-177.
- Mackauer, M. and P. Stary. 1967. Hym. Ichneumonoidea, World Aphidiidae. *in*: V. Delucchi and G. Remaudiere (Eds.), *Index of Entomophagous Insects*. Le Francois, Paris, 167 pp.
- Rankin, M. A. and M. C. Singer. 1984. Insect movement: mechanisms and effects. *in*: C. B. Huffaker and R. L. Rabb (Eds.), *Ecological Entomology*. John Wiley & Sons, New York. 844 pp.
- Ratte, H. T. 1984. Temperature and insect development. *In*: K. H. Hoffmann (Ed.), *Environmental Physiology and Biochemistry of Insects*. Springer Verlag, Berlin. 296 pp.
- Stary, P. 1975. *Aphidius colemani* Viereck: its taxonomy, distribution and host range (Hymenoptera, Aphidiidae). *Acta Entomol. Bohemoslov.* 72:156-163.