

TEMPERATURE RESPONSE OF TWO STRAINS OF *CERANISUS MENES* (HYMENOPTERA: EULOPHIDAE) REARED ON *THRIPS PALMI* (THYSANOPTERA: THIRIPIDAE)

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ABSTRACT

The development response to temperature of a Japanese uniparental strain and a Thai biparental strain of *Ceranisus menes* (Walker) (Hymenoptera: Eulophidae) was studied. The parasitoids were reared on first instar *Thrips palmi* larvae in incubators at constant temperatures of 21, 23, 25, 27 and 29°C. Total developmental time decreased with the increase of temperature from 35.1 to 21.9 days in females and from 33.4 to 18.8 days in males. Lowest mortality (12%) was recorded in both strains at 23°C and highest (95%) in the Japanese strain at 29°C. Seventy-three percent of the Thai parasitoids survived at 29°C, but 39% mortality was observed at 21°C. Percent parasitism ranged from 23.8 to 28.9% at 25-29°C, but decreased to 11.5% at 21°C. The sex ratio (male:female) was not affected by temperature and averaged 1:1.9. A thermal constant of 500 degree-days and a developmental threshold of 8°C (from egg to adult emergence) were obtained for both Japanese and Thai females. For the Thai males, the thermal constant was 333.3 degree-days and the minimum threshold was 13.7°C.

Key Words: *Ceranisus menes*, development, parasitism, mortality, *Thrips palmi*, biological control.

RESUMEN

Fue estudiada la respuesta a la temperatura en una cepa uniparental japonesa y en una cepa biparental tailandesa de *Ceranisus menes* (Walker) (Hymenoptera: Eulophidae), un parasitoide de *Thrips palmi* Karny (Thysanoptera: Thripidae). Los parasitoides fueron criados en incubadoras a temperatura constante de 21, 23, 25, 27 y 29°C. La duración del desarrollo disminuyó con la temperatura de 35.1 a 21.9 días en las hembras, y de 33.4 a 18.8 días en los machos. La más baja mortalidad (12%) fue registrada en ambas cepas a 23°C y la más alta (95%) en la cepa japonesa a 29°C. El 73% de los parasitoides tailandeses sobrevivió a 29°C, pero a 21°C fue observado un 39% de mortalidad. El porcentaje de parasitismo estuvo en el rango de 23.8 a 28.9%, pero bajó hasta el 11.5% a 21°C. La relación sexual (macho:hembra) no fue afectada por la temperatura y promedió 1:1.9. Se obtuvo una constante térmica de 500 grados-días y un umbral de desarrollo de 8°C (desde el huevo hasta la emergencia del adulto) en las hembras de ambas cepas. En los machos tailandeses la constante térmica fue de 333.3 grados-días y el umbral mínimo de 13.7°C.

Since its first detection in 1990, *Thrips palmi* Karny has become an important pest of eggplant, potato, beans, peppers and cucurbits in South Florida (Seal et al. 1992). The eulophid wasp *Ceranisus menes* (Walker) was selected as a possible biological control agent for suppression of *T. palmi*. In 1992-93, *C. menes* strains were introduced from Japan and Thailand into Dade County, Florida.

Ceranisus menes is an endoparasitoid of Thysanoptera with worldwide distribution (Loomans 1995). Life cycle length of *C. menes* changes with temperature and host (Loomans 1995). The duration of the egg-larval stage of *C. menes* is 14 days and adult emergence occurs at 37 days at 20°C when reared on *T. palmi* (Tagashira 1992). When reared on *Thrips tabaci* Lind. at 21-22°C, the egg-larval stage takes 11 days and adults emerge at 18 days (Sakimura 1937).

Under laboratory conditions, 80% parasitism by *C. menes* of *Frankliniella intonsa* (Trybom) has been obtained (Murai 1990). A maximum of 75% field parasitism of *T. palmi* was reported in Japan (Hirose et al. 1992).

Females are more abundant in nature, but sex ratio may change under laboratory rearing conditions due to arrhenotokous parthenogenesis. Uniparental populations have been reported from several countries (Loomans 1995).

The existence of biotypes of *C. menes* with differences in color patterns, temperature response, host acceptance, developmental time, sex ratio and reproduction has been documented (Loomans, 1995). Selection of biotypes adapted to particular conditions of host and climate can improve the efficacy of biological control programs. The objective of this study was to evaluate the effect of temperature on developmental time, percent parasitism and sex ratio of two biotypes of *C. menes* using *T. palmi* as the host. Data on temperature response will be used in laboratory rearing of the parasitoid and in selection of strains for the biological control of *T. palmi* in the field.

MATERIALS AND METHODS

Two strains of *C. menes* were studied, a uniparental strain collected in Kyushu, Japan in 1990 (Tagashira 1992) and a biparental strain collected in Chiang-Mai, Thailand, by R. M. Baranowski and F. D. Bennett (University of Florida) in January 1993. A laboratory reared colony of the uniparental strain was brought into Florida by Y. Hirose (Kyushu University, Japan) in February 1992.

Groups of 20 first instar *T. palmi* were taken from a laboratory colony and placed on 25 mm eggplant leaf discs. The discs with the larvae were held with parafilm at the top of 45 × 25 mm plastic tubes as described by Tagashira (1992). One parasitoid female was placed in every tube and the open end of the tube was sealed with parafilm. In the case of the Thai strain, as unmated females produce only males, pairs of *C. menes* were kept for 6 h at 25°C in daylight in 70 × 10 mm vials to ensure mating before females were placed in the plastic tubes. Tubes were maintained in incubators at 21, 23, 25, 27 and 29°C (± 1°C), and a photoperiod of 12:12 h (L:D). After twenty-four hours, tubes were opened and female parasitoids were removed. Leaf discs with thrips were transferred from the tubes into 500 mm petri dishes having a layer of plaster of Paris in the bottom and covered with humid filter paper. Thrips larvae in the petri dishes were kept in incubators at the conditions described above.

Last instar thrips were considered to be parasitized only when the parasitoid could be clearly recognized through the body wall. Parasitized larvae were counted daily and transferred to 25 × 8 mm moist filter paper strips. Filter paper strips with parasitized larvae were placed in 70 × 10 mm vials. Vials were sealed with parafilm and returned to the incubators. Percent mortality [(number of dead parasitoid larvae and pupae per total parasitized larvae)·100], percent parasitism [(number of parasitized thrips larvae per 20)·100] and sex ratio (male: female) were calculated.

Three replicates of 10 tubes containing a female wasp and 20 thrips larvae were studied at each temperature. Developmental time data were square root transformed. Percent mortality and parasitism data were arcsine transformed. Developmental time data were analyzed using Statistical Analysis System general linear models (SAS 1985) for a balanced ANOVA. Means were separated by Waller-Duncan k-ratio

t-tests. Developmental thresholds were estimated from linear regression equations of the developmental rates against temperature, as described by Varley et al. (1973), using Sigma Stat® statistical software (Kuo et al. 1992).

RESULTS

Parasitoid developmental time decreased with increased temperature only between 21 and 27°C (Tables 1 and 2). Thai males emerged one day before females at 25°C, but at lower or higher temperatures the difference in the dates of emergence increased (Table 2).

Japanese strain percent mortality increased at temperatures above or below 23°C (Table 3). In the Thai strain no significant difference was observed in mortality at 23 and 25°C, but above 25°C and below 23°C mortality increased. Only 4-6% of the Japanese parasitoids survived at 29°C (Table 3). At 21°C and above 25°C pupae were frequently contaminated with fungi.

No statistical differences in percent parasitism were observed between 23 and 29°C in either strain, but parasitism decreased about 50% at 21°C compared with temperatures equal to or above 23°C. (Table 3)

Sex ratios of the Thai strain reared at different temperatures were not significantly different ($F= 0.30$; $df= 4,10$; $p= 0.87$). The mean sex ratio (male:female) was 1:1.9 (± 0.008).

Linear regression models show the effect of temperature on the rates of development of the parasitoids. Coefficients of determination equal to or above 84% were obtained for developmental rates against temperature (Table 4). The Japanese and Thai strains showed different thermal constants in the time periods from egg to pupa, but the number of degree-days needed for pupation and for total development were the same for the females of the two strains. Thai males had lower thermal constants and higher developmental thresholds than the Japanese and Thai females (Table 4).

DISCUSSION

The data in Tables 1 and 2 show that strains responded to temperature by increasing or decreasing their developmental time. Similar results on the duration of the egg-larval and pupal stages at comparable temperatures were reported for a Japanese strain of *C. menes* reared on *T. tabaci* (Sakimura 1937).

TABLE 1. EFFECT OF TEMPERATURE ON THE DEVELOPMENTAL TIME OF THE JAPANESE STRAIN OF *CERANISUS MENES* REARED ON *THRIPS PALMI*.

Temp (°C)	Developmental Time in Days ¹ (Mean ± SD)		
	Egg-pupa	Pupa	Total
21	12.51 ± 0.33 a	22.56 ± 0.07 a	35.07 ± 0.39 a
23	10.71 ± 0.37 b	18.86 ± 0.30 b	29.57 ± 0.09 b
25	9.80 ± 0.26 c	16.94 ± 0.15 c	26.68 ± 0.11 c
27	8.18 ± 0.16 d	14.15 ± 0.06 d	22.45 ± 0.08 d
29	8.59 ± 0.39 d	14.43 ± 0.31 d	22.72 ± 0.33 d

¹Means within a column followed by the same letter are not significantly different according to a Waller-Duncan k-ratio t-test on square root transformed data ($p > 0.001$, k-ratio = 100). Untransformed means are presented.

TABLE 2. EFFECT OF TEMPERATURE ON THE DEVELOPMENTAL TIME OF THE THAI STRAIN OF CERANISUS MENES REARED ON THRIPS PALMI.

Temp (°C)	Developmental Time in Days ¹ (Mean ± SD)					
	Egg-prepupa	Pupa (Female)	Pupa (Male)	Total (Female)	Total (Male)	Total
21	12.22 ± 0.28 a	23.52 ± 0.34 a	21.18 ± 0.26 a	35.74 ± 0.57 a	33.41 ± 0.11 a	33.41 ± 0.11 a
23	10.89 ± 0.04 b	19.04 ± 0.23 b	17.36 ± 0.13 b	29.94 ± 0.18 b	28.21 ± 0.16 b	28.21 ± 0.16 b
25	9.87 ± 0.13 c	16.70 ± 0.06 c	15.80 ± 0.02 c	26.57 ± 0.16 c	25.67 ± 0.13 c	25.67 ± 0.13 c
27	7.80 ± 0.15 d	13.54 ± 0.09 d	11.17 ± 0.50 d	21.34 ± 0.23 d	18.97 ± 0.17 d	18.97 ± 0.17 d
29	8.03 ± 0.16 d	13.89 ± 0.35 d	10.80 ± 0.60 d	21.92 ± 0.39 d	18.83 ± 0.63 d	18.83 ± 0.63 d

¹Means within a column followed by the same letter are not significantly different according to a Waller-Duncan k-ratio t-test on square root transformed data ($p > 0.001$, k-ratio = 100). Untransformed means are presented.

TABLE 3. PERCENT MORTALITY AND PERCENT PARASITISM OF TWO STRAINS OF *CERANISUS MENES* REARED AT DIFFERENT TEMPERATURES ON *THRIPS PALMI*.

Temp (°C)	% Mortality ¹ (Mean ± SD)		% Parasitism (Mean ± SD)	
	Japanese Strain	Thai Strain	Japanese Strain	Thai Strain
21	30.16 ± 0.41 b	39.38 ± 0.12 a	11.73 ± 0.83 b	11.53 ± 0.53 b
23	12.17 ± 0.79 e	11.83 ± 0.72 d	24.17 ± 0.72 a	25.50 ± 0.50 a
25	19.70 ± 0.89 d	14.23 ± 1.35 d	28.00 ± 1.15 a	26.56 ± 0.85 a
27	25.86 ± 0.96 c	18.13 ± 0.36 c	26.53 ± 1.11 a	28.56 ± 0.89 a
29	94.97 ± 0.88 a	27.36 ± 1.09 b	23.83 ± 1.58 a	28.90 ± 0.30 a

¹Means within a column followed by the same letter are not significantly different according to a Waller-Duncan k-ratio t-test on arcsine transformed data ($p > 0.001$, k-ratio = 100). Untransformed means are presented.

Percent mortality was high (Table 3). According to Hirose et al. (1993), a high level of mortality occurs between the larval and pupal stages in the laboratory due to handling.

Sakimura (1937) stated that females may kill some of the young host larvae by the insertion of the ovipositor without laying eggs. That could explain the low percent parasitism found in our experiments (Table 3).

Temperature did not affect the sex ratio in the biparental strain, but the mean sex ratio of 1:1.9 was higher than other reports for *C. menes*: 1:1.5 (Sakimura 1937, Daniel 1986) and 1:1 (Murai 1990).

Minimum temperature thresholds of the Japanese parasitoids were between 5 and 8°C (Table 4). Japanese parasitoids developed and pupated at 29°C, but 95% of pupae died (Table 3). Tagashira (1992) observed that wasps of the Japanese uniparental strain reared on *F. intonsa* did not emerge at 30°C. We suggest that the maximum temperature threshold for the Japanese biotype of *C. menes* is near 30°C.

The Thai biotype is probably better adapted to warmer temperatures than the Japanese biotype. Minimum temperature thresholds of this strain ranged from 7.8 to 14.2°C (Table 4). The maximum temperature threshold for the Thai strain seems to be over 29°C. At 29°C mortality was 27.4% and percent parasitism was 28.9% (Table 3). Comparisons of the behavior of the Thai strain with former studies are not possible. These parasitoids were found in Thailand in 1987 and only some field data are available from Hirose et al. (1993).

The best temperature for laboratory rearing of *C. menes* is 25°C. At 25°C development from egg to adult was 26 days for Thai males and 27 days for females of both strains, percent mortality fluctuated between 14-20% and percent parasitism averaged 27%. At 21°C parasitism averaged 12% and above 27°C mortality was generally higher than 18%.

In South Florida, where the average temperature during the growing season (September-April) is 21-28°C, temperature does not appear to be a limiting factor for field establishment of *C. menes*. Considering their response to temperature, both strains are good candidates for biological control of *T. palmi* in the field.

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TABLE 4. PARAMETERS AND R^2 OF THE REGRESSION EQUATIONS FOR DEVELOPMENTAL RATES VS. TEMPERATURE; THERMAL CONSTANTS AND DEVELOPMENTAL THRESHOLDS OF TWO STRAINS OF CERANISUS MENES REARED ON THRIPS PALMI.

	Japanese Strain			Thai Strain				
	Egg-pupa	Pupa	Total	Egg-pupa	Pupa (F)	Pupa (M)	Total (F)	Total (M)
Slope	0.005	0.004	0.002	0.006	0.004	0.006	0.002	0.003
Intercept	-0.025	-0.030	-0.016	-0.047	-0.040	-0.085	-0.016	-0.041
r^2	0.84	0.92	0.95	0.89	0.91	0.91	0.90	0.92
Thermal Constant (Deg-Days)	200.00	250.00	500.00	166.66	250.00	166.66	500.00	333.33
Develop. Threshold	5.00	7.50	8.00	7.83	10.00	14.16	8.00	13.66

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