BIOLOGICAL CONTROL

Host Instar Preference of *Peleteria robusta* (Wiedman) (Diptera: Tachinidae) and Development in Relation to Temperature

Luís A. Foerster and Augusta K. Doetzer

Depto. Zoologia, Universidade Federal do Paraná, C. postal 19.020, 81531-990, Curitiba, PR
e-mail: foerster@bio.ufpr.br

Preferência Pelo Ínstar do Hospedeiro de *Peleteria robusta* (Wiedman) (Diptera: Tachinidae) e Desenvolvimento em Relação à Temperatura

RESUMO - O efeito de quatro temperaturas no desenvolvimento do endoparasitóide larval *Peleteria robusta* (Wiedman), e a preferência do parasitóide por diferentes ínstares de seu hospedeiro, a lagarta do trigo *Mythmina* (*Pseudaletia*) *sequax* Franclemont foram avaliados. Fêmeas de *P. robusta* depositaram mais de um ovo sobre o corpo da lagarta hospedeira, porém apenas uma larva conseguiu completar o seu desenvolvimento e empupar dentro do corpo da lagarta. O parasitóide completou o seu desenvolvimento apenas em lagartas de quarto a sexto instar de *M. sequax*, com preferência pelo quarto e quinto ínstares. Lagartas de primeiro ao terceiro ínstar expostas a fêmeas de *P. robusta* não produziram parasitóides. O parasitóide completou seu desenvolvimento até o estágio adulto em todas as temperaturas e o período de incubação foi inferior a 24h nas quatro temperaturas avaliadas. A porcentagem de adultos de *P. robusta* emergidos foi significativamente maior a 20ºC (56,2%) e 25ºC (70,0%) em comparação a 15ºC (29,2%) e 30ºC (9,5%). O tempo de desenvolvimento desde a oviposição até a emergência dos adultos variou de 23,8 dias a 30ºC até 90,3 dias a 15ºC. As constantes térmicas calculadas para os estágios de ovo+larva, pupa e para o período entre a oviposição e a emergência dos adultos foram de 266,9; 235,5 e 457,5 graus-dia, a partir de temperaturas base de 6,7ºC, 9,7ºC e 9,3ºC, respectivamente. A 20ºC e 25ºC, o tempo de desenvolvimento foi significativamente menor para os machos em relação às fêmeas. Juntamente com outros parasitóides já descritos, *P. robusta* é mais um componente de um complexo de espécies que, em conjunto, causam um impacto significativo na redução de populações da lagarta do trigo.

PALAVRAS-CHAVE: Insecta, parasitóide, controle biológico, *Mythmina sequax*, exigência térmica.

ABSTRACT - The effect of four temperatures on the development of the larval endoparasitoid *Peleteria robusta* (Wiedman) as well as its preference for different instars of the host, the armyworm *Mythmina* (*Pseudaletia*) *sequax* Franclemont were evaluated. Females of *P. robusta* laid more than one egg outside the cuticle of the caterpillars, however only one parasitoid developed and pupated within the host. Females of *P. robusta* successfully parasitized the fourth- to sixth-instars of *M. sequax*, with preference for the fourth and fifth instars of the host. No parasitoids emerged from caterpillars exposed to *P. robusta* females between the first and third instars. The development of *P. robusta* to the adult stage was completed in the range between 15ºC and 30ºC, and the incubation period lasted less than 24h in all temperatures evaluated. Successful parasitism, as indicated by percentage of adult emergence, was significantly higher at 20ºC (56.2%) and 25ºC (70.0%), as compared to 15ºC (29.5%) or 30ºC (9.5%). Developmental time from oviposition to adult emergence ranged from 23.8 days at 30ºC to 90.3 days at 15ºC. At 20ºC and 25ºC, developmental time was significantly shorter for males as compared to females. The thermal constant for the egg + larval stages was 266.9 degree-days (DD) above a lower threshold of 6.7ºC; the pupal stage required 235.5 DD above 9.7ºC; and the development from oviposition to adult emergence was completed in 457.5 DD above a lower limit of 9.3ºC. Together with other parasitoids already described, *P. robusta* is another member of a complex of species that may have considerable importance in the natural control of the wheat armyworm.

KEY WORDS: Insecta, parasitoid, biological control, *Mythmina sequax*, thermal requirement.

The armyworm *Mythmina* (*Pseudaletia*) *sequax* Franclemont is the most important chewing species on winter cereals in Southern Brazil. The caterpillars are parasitized by more than ten species of Hymenoptera and Diptera, which altogether have an important role in the natural control of the armyworm (Gassen 1986). Despite the diversity of natural enemies, chemical control remains as the dominant method for controlling armyworm, largely due to the lack of knowledge about the impact of parasitism on the biology of the host. Yamamoto *et al*. (1998) and Doetzer & Foerster (1998) evaluated the effect of hymenopterous parasitoids on food consumption of the larval stage of *M. sequax* and thermal requirements for the development of the eulophid *Euplectrus ronnai* (Brèthes) and the braconid *Glyptapanteles muesebecki* (Blanchard) developing on larvae of *M. sequax* were established by Yamamoto *et al*. (1998) and Foerster *et al*. (1999).

The Tachinidae *Peleteria robusta* (Wiedman) is one of four species of *Peleteria* cited by Guimarães (1962) as occurring in Brazil. There are no references about the biology of *P. robusta*, although data are available for other tachinids parasitizing lepidopterous larvae (Gross & Rogers 1995, Reitz 1996, Rodriguez-del-Bosque & Smith, 1996, Cardoza *et al*. 1997). In this paper, results on the effect of different temperatures on the development of *P. robusta*, as well as on the parasitoid preference for the host instar are reported.

Material and Methods

The experiments were conducted in the Laboratório de Controle Integrado de Insetos do Departamento de Zoologia, Universidade Federal do Paraná, Brazil. Adults of *P. robusta* were obtained from laboratory reared parasitized *M. sequax* caterpillars that had been collected from wheat in Lapa County, Southern Paraná State, Brazil. Adults were fed with a 50% honey/water solution and kept in climatic chambers at 20ºC temperature, 70 ± 10% relative humidity and 12h photophase. To determine the hosts instar range of *P. robusta*, 15-day-old mated females were exposed for 24h to first through sixth instars *M. sequax* in free choice tests. The pre-oviposition period of *P. robusta* lasted ca. 15 days, as previously recorded for *L. jalisco* on *E. loftini* (Dyar) (Rodriguez-del-Bosque & Smith 1996). Three caterpillars of each instar were placed in a 14 cm diameter petri dish with a female of *P. robusta* and fed with kicuyo grass (*Pennisetum clandestinum* Hochts.). The treatment was repeated eight times. At the end of the exposure time, the females were discarded and the number of parasitized caterpillars for each instar was counted. The results were submitted to analysis of variance (ANOVA) and the means classified by theTukey's test.

After host instar preference determination, the developmental time of *P. robusta* was evaluated at constant temperatures of 15ºC, 20ºC, 25ºC and 30ºC ± 1ºC, 70 ± 10% relative humidity and 12h photophase. Fifth instar hosts were exposed to *P. robusta* females for 24h and then the caterpillars were kept individually and reared according to Foerster (1996). The number of parasitized caterpillars and successful adult emergence, as well as the developmental time between oviposition and pupation and from pupation to adult emergence of *P. robusta* was recorded for each temperature.

The thermal constant (K) and the lower threshold temperature (T_0) were calculated by the linear equation regression method for the egg + larval and pupal stages, as well as for the entire developmental period, from oviposition to adult emergence. The standard error for K and T_0 was calculated according to Campbell *et al*. (1974). Results for developmental time in relation to temperature were submitted to ANOVA and the means classified by Tukey's test (P<0.05). Successful adult emergence among the temperatures was compared by the c^2 (Chi-square)test (P<0.05). At 20ºC and 25ºC, developmental time was evaluated separately for males and females and the results were submitted to analysis of variance (ANOVA) and the means classified by Tukey's test (P<0.05).

Results and Discussion

No parasitism was recorded on first to third instar hosts, whereas females of *P. robusta* successfully parasitized caterpillars between the fourth and sixth instar, as observed for other tachinids parasitizing lepidopterous larvae (Gross & Rogers 1995, Reitz 1996, Cardoza *et al*. 1997). The frequency of oviposition on the last three instars of *M. sequax* showed a significant preference for the fourth and fifth instars in comparison to the sixth instar of the host (Fig. 1). Although more caterpillars were parasitized in the fifth than in the fourth instar, the difference was not statistically significant.

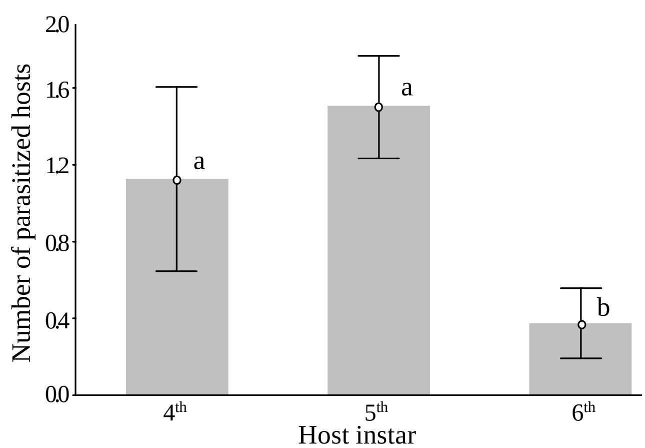

Figure 1. Mean number (± S.E.) of *M. sequax* caterpillars parasitized by *P. robusta* in relation to host instar in free-choice tests. (8 replicates of 3 caterpillars of each instar after 24h with a parasitoid female)

Ovipositions were made on the cuticle of the caterpillars, and up to 28 eggs were recorded on a single host. Within 24h after eclosion, the larvae of *P. robusta* penetrated the integument of the caterpillars, however, only one parasitoid completed its development. A similar condition is described for the tachinid *Lydella jalisco* Woodley parasitizing caterpillars of *Eoreuma loftini* (Dyar) (Rodriguez-del-Bosque & Smith 1996). The pupal stage of *P. robusta* was completed within the host body, during the pre-pupal stage of *M. sequax*, regardless of the instar the caterpillars had been parasitized. This shows that the parasitoid is able to regulate host growth in order to synchronize its development to the stage of development of the host at the time of parasitism (Vinson & Iwantsch 1980).

The highest percentage of adult emergence was obtained at 25ºC (70.0%), followed by 20ºC (56.2%), without statistical difference between the two treatments. Survival to the adult stage was significantly reduced both at 15ºC and 30ºC, with the lowest emergence rate recorded at 30ºC (Table 1). In all temperatures, except at 20ºC mortality was higher in the pupal stage in comparison to the egg + larval stages (Table 1).

Table 1. Mortality of *P. robusta* during the immature stages and percentage of individuals that reached the adult stage at different temperatures.

Temperature (ºC)	N	Mortality (%)		Survival to adult stage (%)
		Larval stage	Pupal stage	
15	24	29.2	41.2	29.2 b
20	48	29.2	20.6	56.2 a
25	30	3.3	27.6	70.0 a
30	42	47.6	81.8	9.5 c

Percentages followed by the same letter do not differ by c^2 test (P<0.05).

Developmental time from oviposition to pupation ranged from 12.6 to 38.6 days at 30ºC and 15ºC, respectively (Table 2). The duration of the pupal stage was similar or longer than the egg + larval stages, depending on the rearing temperature. In the eulophid parasitoid *E. ronnai*, the pupal stage was also longer than the egg + larval stages (Yamamoto *et al*. 1998), while in the braconid *G. muesebecki* the egg + larval stages were twice as long as the pupal stage in the same host (Foerster *et al*. 1999).

Table 2. Developmental time (mean ± S.E.) of the immature stages of *P*. *robusta* on the fifth instar *M. sequax* at different temperatures.

Temperature (ºC)	N	Duration (days)		
		Egg+larva	Pupa	Total
15	17	38.6 ± 1.26a	51.6 ± 1.45a	90.3 ± 3.15a
20	34	18.7 ± 0.38b	20.3 ± 0.33b	38.9 ± 0.67b
25	29	13.3 ± 0.28c	15.6 ± 0.27c	28.7 ± 0.45c
30	22	12.6 ± 0.33c	12.0 ± 0.41d	23.8 ± 0.25d

Means followed by the same letter in the columns do not differ by Tukey's test (P<0.05).

The developmental time was separately evaluated for males and females at 20ºC and 25ºC (Table 3). For both temperatures males developed significantly faster than females; probably sexual maturation in males is slower than in females and the faster rate of development observed in males compensates for their slower sexual maturation in relation to the females. Reitz (1996) also reported faster developmental times for males of the tachinid *Eucelatoria bryani* Sabrosky and *E. rubentis* (Coquillett) parasitizing caterpillars of *Helicoverpa zea* (Boddie).

Table 3. Developmental time (mean ± S.E.) of males and females of *Peleteria robusta* at two temperatures.

Temperature (ºC)	Sex	Duration (days)		
		Egg+larva	Pupa	Total
20	Males	17.2 ± 0.44b	19.0 ± 0.44b	36.2 ± 0.80b
	Females	19.4 ± 0.59a	21.1 ± 0.34a	40.5 ± 0.71a
25	Males	12.4 ± 0.36d	14.8 ± 0.26d	27.2 ± 0.35d
	Females	13.9 ± 0.43c	16.4 ± 0.34c	30.3 ± 0.49c

Means followed by the same letter in the columns do not statistically differ by Tukey's test (P<0.05).

The thermal units required by *P. robusta* to complete the egg + larval stages totaled 266.9 degree-days (DD) above a lower threshold of 6.7ºC, while the pupal stage was completed after 235.5 DD above a lower limit of 9.7ºC (Table 4, Fig. 2). The development from oviposition to adult emergence required 457.5 DD above a lower temperature of 9.3ºC. Compared to hymenopterous parasitoids of *M. sequax*, the developmental rate of *P. robusta* is slower than that of *G. muesebecki* (Foerster *et al*. 1999) and *E. ronnai* (Yamamoto *et al*. 1998). On the other hand, the lower threshold temperature of the egg and larval stages of *P. robusta* (6.7ºC) is ca. 2ºC less than that of *G. muesebecki* and more than 4ºC less than the lower limit of *E. ronnai*, indicating that the egg and larval stages of *P. robusta* are more cold tolerant than these stages of the two hymenopterous parasitoids.

Table 4. Regression equation, regression coefficient (R^2), lower threshold (T_0) and thermal constant (K) of *P. robusta* parasitizing larvae of *M. sequax*.

Stage	Regression equation	R^2	T_0 ±S.E. (ºC)	K ±S.E. (DD)
Egg+larva	y=-0.024980+0.003747	0.80	6.7 ± 0.3	266.9 ± 13.6
Pupa	y=-0.041154+0.004247	0.92	9.7 ± 0.1	235.5 ± 9.2
Cycle	y=-0.020290+0.002186	0.92	9.3 ± 0.2	457.5 ± 17.9

The results showed that the effectiveness of *P. robusta* as a biocontrol agent is partially impaired by the superparasitic behavior, which leads to the development and survival of a single parasitoid. Other tachinids lay supernumerary eggs on their hosts, like *Trichopoda giacomellii* Blanchard and *T. pennipes* (Fabr.) on the green stink bug *Nezara viridula* (L.) (Heteroptera: Pentatomidae). However, unlike *P. robusta*, which kills the host in the larval stage, parasitism by *Trichopoda* species occurs during the adult stage, and the hosts continue to mate and oviposit after parasitism (Harris & Todd 1982, Coombs & Khan 1998).

Together with other parasitoids already described attacking *M. sequax* (Doetzer & Foerster 1998, Foerster *et al*. 1999, Yamamoto *et al*. 1998), *P. robusta* is part of a complex of species, which cause a significant impact on the armyworm population.

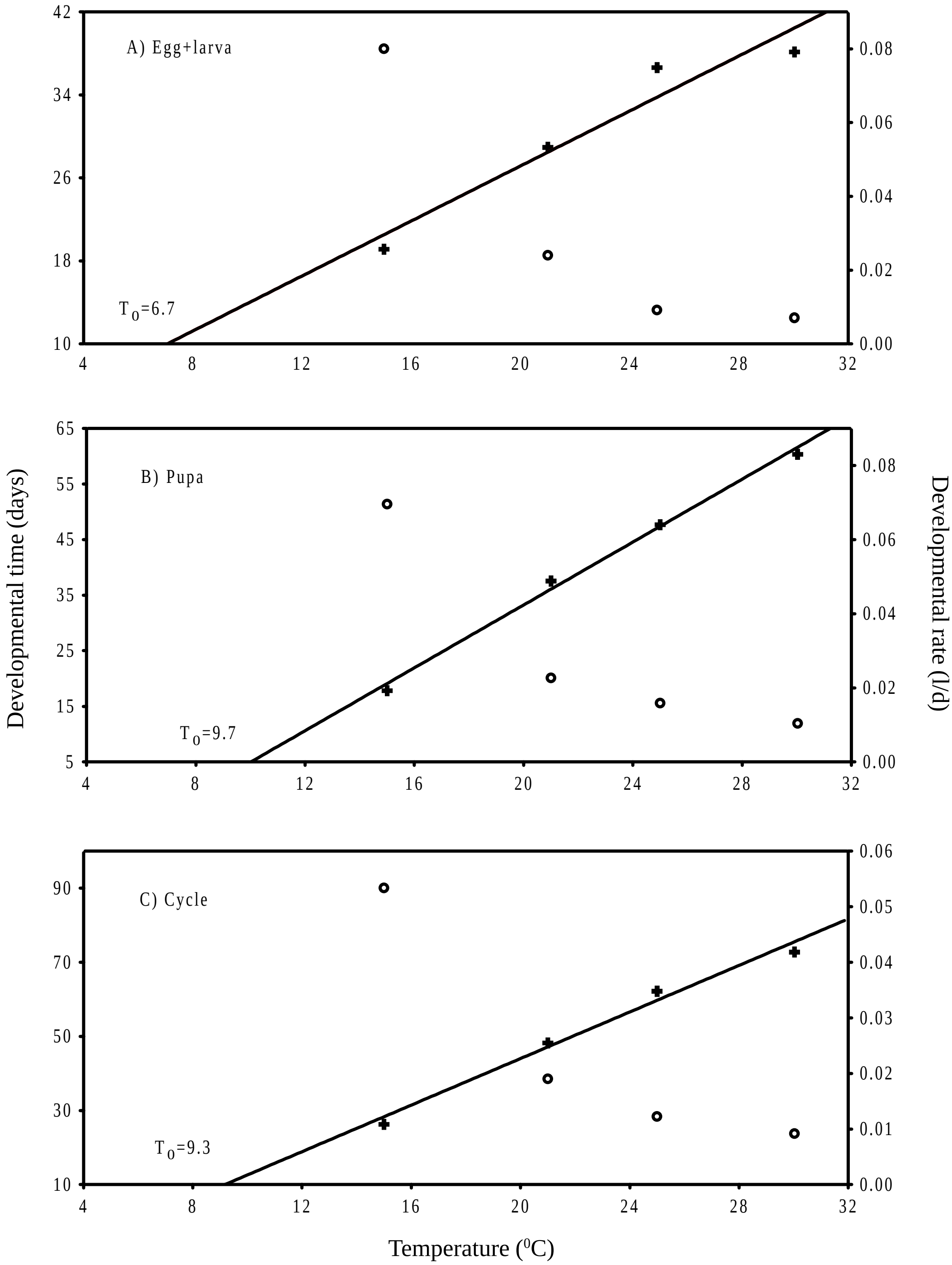

Figure 2. Effect of temperature on developmental time (days) (O) and on developmental rate (1/D) (+) of *P*. *robusta* and thermal requirements of the immature stages of the parasitoid.

Acknowledgments

The authors are grateful to Dr. J.H. Guimarães of the University of São Paulo for the identification of *P. robusta*. Financial support was provided by the Conselho Nacional de Pesquisa e Desenvolvimento (CNPq) and the Fundação Araucária. Voucher specimens of *P. robusta* are deposited in the reference collection of the Laboratório de Controle Integrado de Insetos do Departamento de Zoologia, Universidade Federal do Paraná.

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Received 18/07/01. Accepted 12/08/02.