THERMAL REQUIREMENTS OF *Dermanyssus gallinae* (DE GEER, 1778) (ACARI: DERMANYSSIDAE)

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ABSTRACT:-TUCCI, E.C.; PRADO, A.P. DO; ARAÚJO, R.P. DE **Thermal requirements of *Dermanyssus gallinae* (De Geer, 1778) (Acari: Dermanyssidae)** [Necessidades térmicas de *Dermanyssus gallinae* (De Geer, 1778) (Acari: Dermanyssidae)]. *Revista Brasileira de Parasitologia Veterinária*, v. 17, n. 2, p. 67-72, 2008. Instituto Biológico, Centro de Pesquisa e Desenvolvimento em Sanidade Animal, Av. Conselheiro Rodrigues Alves, 1252. 04014-002, São Paulo, Brazil. E-mail: tucci@biologico.sp.gov.br

The thermal requirements for development of *Dermanyssus gallinae* were studied under laboratory conditions at 15, 20, 25, 30 and 35°C, a 12h photoperiod and 60-85% RH. The thermal requirements for *D. gallinae* were as follows. Preoviposition: base temperature 3.4°C, thermal constant (k) 562.85 degree-hours, determination coefficient (R^2) 0.59, regression equation: Y= -0.006035 + 0.001777 x. Egg: base temperature 10.60°C, thermal constant (k) 689.65 degree-hours, determination coefficient (R^2) 0.94, regression equation: Y= -0.015367 + 0.001450 x. Larva: base temperature 9.82°C, thermal constant (k) 464.91 degree-hours, determination coefficient R^2 0.87, regression equation: Y= -0.021123+0.002151 x. Protonymph: base temperature 10.17°C, thermal constant (k) 504.49 degree-hours, determination coefficient (R^2) 0.90, regression equation: Y= -0.020152 + 0.001982 x. Deutonymph: base temperature 11.80°C, thermal constant (k) 501.11 degree-hours, determination coefficient (R^2) 0.99, regression equation: Y= -0.023555 + 0.001996 x. The results obtained showed that 15 to 42 generations of *Dermanyssus gallinae* may occur during the year in the State of São Paulo, as estimated based on isotherm charts. *Dermanyssus gallinae* may develop continually in the State of São Paulo, with a population decrease in the winter. There were differences between the developmental stages of *D. gallinae* in relation to thermal requirements.

KEY WORDS: poultry mites, development, degree-hours, base temperature.

RESUMO

Experimentos de laboratório foram realizados visando estimar as exigências térmicas de *Dermanyssus gallinae*. Para isso, o desenvolvimento do ácaro foi estudado em condições de laboratório usando-se câmaras climatizadas reguladas a 15, 20, 25, 30 e 35°C, fotofase de 12h e UR de 60-85%. As exigências térmicas determinadas para *D. gallinae* foram: Pré-oviposição: temperatura base de 3,4 °C, constante térmica (k) igual a 562,85 graus-hora, coeficiente de determinação (R^2) igual a 0,59, equação de regressão: Y= -0,006035 + 0,001777 x. Ovo. Temperatura base de 10,60 °C, constante térmica (k) igual a 689,65 graus-hora, coeficiente de determinação (R^2) igual a 0,94, equação de regressão: Y= -0,015367 + 0,001450 x. Larva. Temperatura base 9,82 °C, constante térmica (k) igual a 464,91 graus-hora, R^2 igual a 0,87, equação de regressão: Y= -0,021123+0,002151x. Protoninfa. Temperatura de 10,17 °C, constante térmica (k) igual a 504,49 graus-hora, coeficiente de determinação (R^2) igual a 0,90, equação de regressão: Y= -0,020152 + 0,001982 x. Deutoninfa. Temperatura de 11,80 °C, constante (k) térmica igual a 501,11 graus-hora, coeficiente de determinação (R^2) igual a 0,99, equação de regressão: Y= -0,023555 + 0,001996 x. Os resultados obtidos permitem concluir que no Estado de São Paulo podem ocorrem de 15 a 42 gerações/ano de *D. gallinae*, em estimativa baseada em isotermas. *Dermanyssus gallinae* pode se desenvolver continuamente no Estado de São Paulo, com diminuição da população no inverno. Existem diferenças entre os estágios de desenvolvimento de *D. gallinae* com relação às exigências térmicas.

PALAVRAS-CHAVE: ácaros das galinhas, desenvolvimento, graus hora, temperatura base.

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INTRODUCTION

Dermanyssus gallinae is the most serious ectoparasites of poultry in the State of São Paulo, Brazil (TUCCI et al., 1997). It is known as Chicken Mite or Poultry Red Mite and is hematophagous, widely distributed, being more abundant in the tropics (LANCASTER JR.; MEISH, 1986). *Dermanyssus gallinae* is a temporary ectoparasite. The mites attack the resting host at night, and after a blood meal returning to hide in the cracks and crevices of the poultry house (HARRISON, 1960). Heavy infestations cause anemia, decrease egg production, and some cases even death if the parasite will not be controlled (KIRKWOOD, 1963).

Several studies, mainly in agriculture, have been developed in order to understand the biology of pests. The results of these studies, in degree-days, have aided the development of models, which have been used in Integrated Pest Management programs, so as to predict the occurrence of population peaks under field conditions, and determine the most adequate period for sampling and control measures, providing a better understanding about population dynamics of pest insects and their natural enemies (WEST; LAING, 1984; HIGLEY et al., 1986; MILLER, 1992).

Temperature controls the speed of growth of several poikilothermal organisms, which require a given amount of heat to go from a certain point in their cycle to the next stage. Physiological time is given by the measurement of accumulated heat, and is expressed in units called degree-days. The lower threshold is the point at which insect development stops. The amount of heat required for an organism to complete development does not vary; it is always the same combination of time and temperature. These lower and higher thresholds were determined for some organisms by means of controlled field and laboratory trials (PEDIGO, 1991; ARNOLD, 1959).

Each population has its own thermal requirement that determines its developmental speed and prolificacy. Knowledge on the thermal requirements of organisms is fundamental information and the most favorable region for population growth can also be determined based on meteorological characteristics (SILVEIRA-NETO et al., 1976).

In Brazil, studies on the biology of *D. gallinae* are limited, as well as those related to population dynamics. Thus, the objective of the present study was to determine the thermal requirements for *D. gallinae*, under laboratory conditions. These data may help to predict the development and activity of the species, increasing the efficiency of integrated pest management programs, establishing the best periods for treatment, intervals between applications, and strategic control programs for each region of the State of São Paulo.

MATERIAL AND METHODS

Stock colony. Mites were collected from a commercial poultry farm with caged laying hens naturally infested by *D. gallinae*, located in Ibiuna (S 23°39’20’’; W 047°13’30’’), State of São Paulo. In order to collect specimens, traps described by Tucci et al. (1989) were placed in the housing facilities. The traps were sent to the laboratory in sealed plastic bags in an insulated box kept at room temperature. Stock colony was kept in the laboratory according to Tucci (1997). The mites were allowed to feed on young laying hens up to 20 days of age at the end of the afternoon and recovered next morning. The mites were aspired into Pasteur pipettes, with the wide end closed with a nylon mesh cloth (50µm) and the narrow end sealed in Bunsen burner. The pipettes were kept in climatic chambers. The stock colony was maintained in the laboratory until the end of the study.

***Dermanyssus gallinae* life cycle.** Studies on *D. gallinae* life cycle were carried out in the Parasitology Laboratory at Centro de Pesquisa e Desenvolvimento em Sanidade Animal, Instituto Biológico de São Paulo, at 15, 20, 25, 30, and 35°C, 70-85% relative humidity and at 12:12 h photoperiod (L:D).

The trial began in the morning after the colony was fed. Engorged females were isolated in glass pipettes and observed at 24h intervals. Preoviposition period, oviposition period, duration and survival rate of the egg, larval, protonymph, and deutonymph stages was estimated.

Eggs hatch into larvae with subsequent molted to protonymph without feeding. Protonymphs were fed on young chick, isolated in glass pipettes and allowed to molt; the resulting deutonymphs were handled similarly. In all phases observations were made at 24h intervals.

The presence of exuviate in the pipettes was the guarantee that the molt occurred into deutonymph and adult stages.

Thermal requirements. *Dermanyssus gallinae* thermal requirements were determined from the results of the biology trials, using 4 of the 5 temperatures studied, excluding the data obtained at 35°C. Lower threshold temperature(Tb) and thermal constant (k) were determined according to the hyperbole method of Haddad and Parra (1999).

Prediction of occurrence. Prediction of *D. gallinae* occurrence was performed using data from mean annual isotherm charts supplied by *Centro Integrado de Informações Agrometeorológicas* at *Instituto Agronômico* **(CIAGRO –** IAC). They represent the mean monthly and annual temperatures obtained from mean daily temperatures read at 7, 14, and 24 o’clock, in meteorological shelters.

Threshold temperature (Tb) and thermal constant (k) were used to determine the most probable number of *D. gallinae* generations in the preoviposition, egg, larval, protonymph, and deutonymph stages, and the various temperature ranges for each climatic region.

Calculations were made using the following formula (SILVEIRA NETO et al., 1976):

$$Y = \frac{k}{(T^{o}C - Tb)}$$

Where: Y = time required to complete development; K = thermal constant; T°C = mean annual isotherm; Tb = threshold temperature

Calculations were made for each stage (preoviposition, egg, larva, protonymph, deutonymph). The sum of these data was transformed into days and the number of generations per year was calculated.

RESULTS

Thermal requirements. Thermal requirement results are presented in Table 1 and Figure 1.

Table 1. Lower Threshold Temperature for *Dermanyssus gallinae* developmental stages.

Stage	Regression equation	Determination coefficient (r^2)	Thermal constant (k) degrees-hour	Lower Threshold temperature (t) °C
Pre-oviposition	Y = - 0.006035+0.001777 x	0.59	562.85	3.40
Egg	Y = - 0.015367+0.001450 x	0.94	689.65	10.60
Larvae	Y = - 0.021123+0.002151 x	0.87	464.91	9.82
Protonymph	Y = - 0.020152+0.001982 x	0.90	504.49	10.17
Deutonymph	Y = - 0.023555+0.001996 x	0.99	501.11	11.80

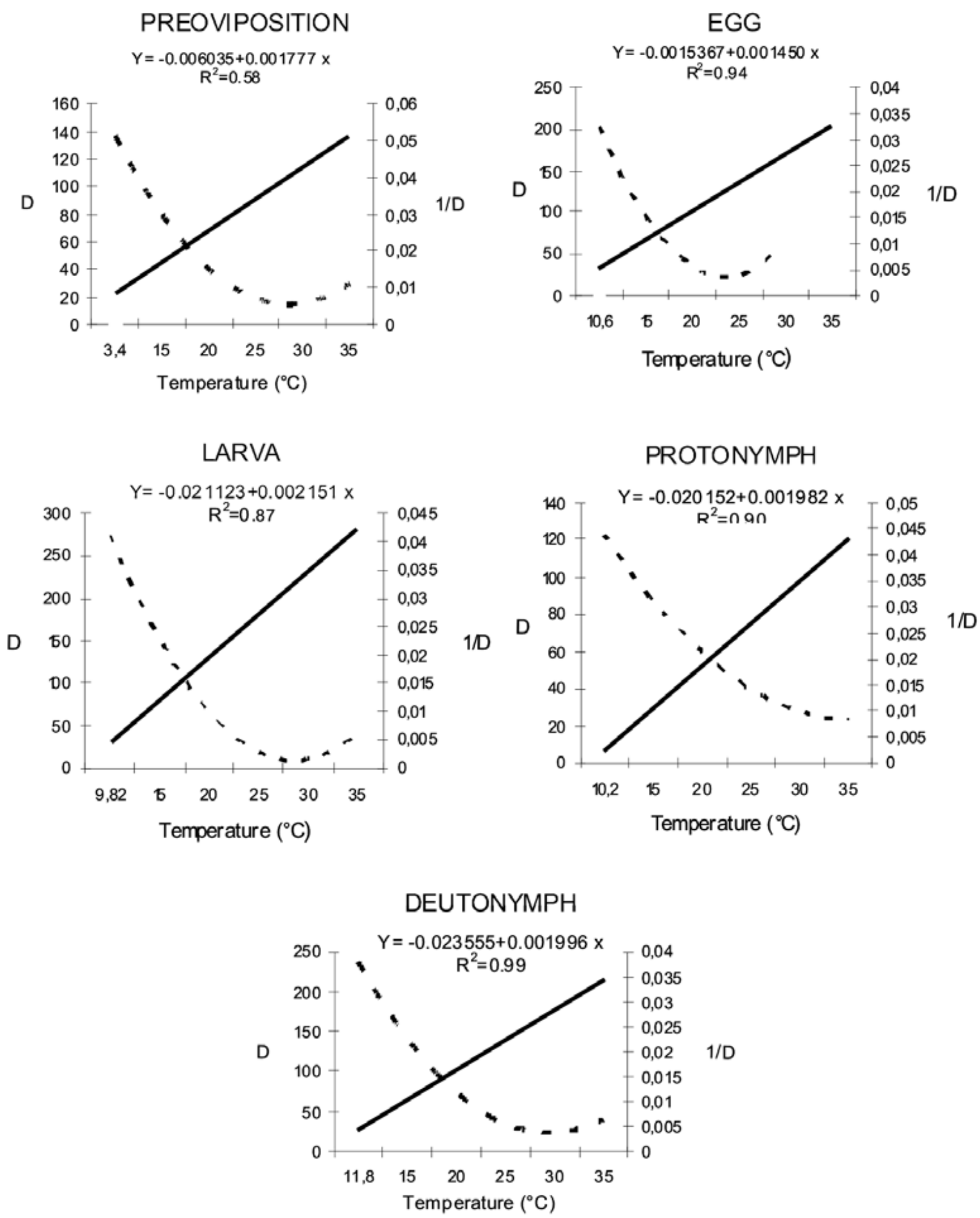

Figure 1. Relationship between temperature (°C), time in hours (D) and developmental time (1/D) of *Dermanyssus gallinae.*

Prediction of occurrence. The isotherm chart and number of *D. gallinae* generations per region in the State of São Paulo are presented in Figure 2.

The prediction of the number of *D. gallinae* generations showed that all regions of the State of São Paulo have favorable conditions for mite development throughout the year, with 15 to 42 generations per year. During the last 4 years, 2 and even 4 generations may have occurred in a month, with a maximum of 50 generations in a year (Table 2).

The main poultry breeding region of the state, located in northeast São Paulo, involving cities such as Bastos, Assis, Guararapes, and Araçatuba (Figure 3), is very adequate for mite development, since 32.7 to more than 429.6 generations may occur in one year.

DISCUSSION

Isotherm charts indicate the geographical distribution of temperatures and allowed to predict the occurrence of *D. gallinae* in the State of São Paulo.

Based on mean temperatures, which mainly vary due to altitude and latitude, Pinto et al. (1972) developed regression equations that allowed precise estimations of monthly and annual temperatures for the entire State of São Paulo, except on the coast, using the location's latitude and altitude. On the coast, altitude decidedly affects mean temperature. Thus, isotherms were drawn using the variation in altitude alone. Temperatures were higher in the north and northeast parts of the state and decreased towards the south and southeast, with minimum values obtained in mountain ranges, and again increasing towards the coast.

The prediction of generations is not an absolute result, since *D. gallinae* populations under field conditions are not regulated exclusively by temperature. Although this is an important regulator of mite population fluctuation, other factors may influence the evolution of populations of the pest, such as parasites and predators.

The results obtained in the present study demonstrated that the State of São Paulo has, in all of its regions, and most of the

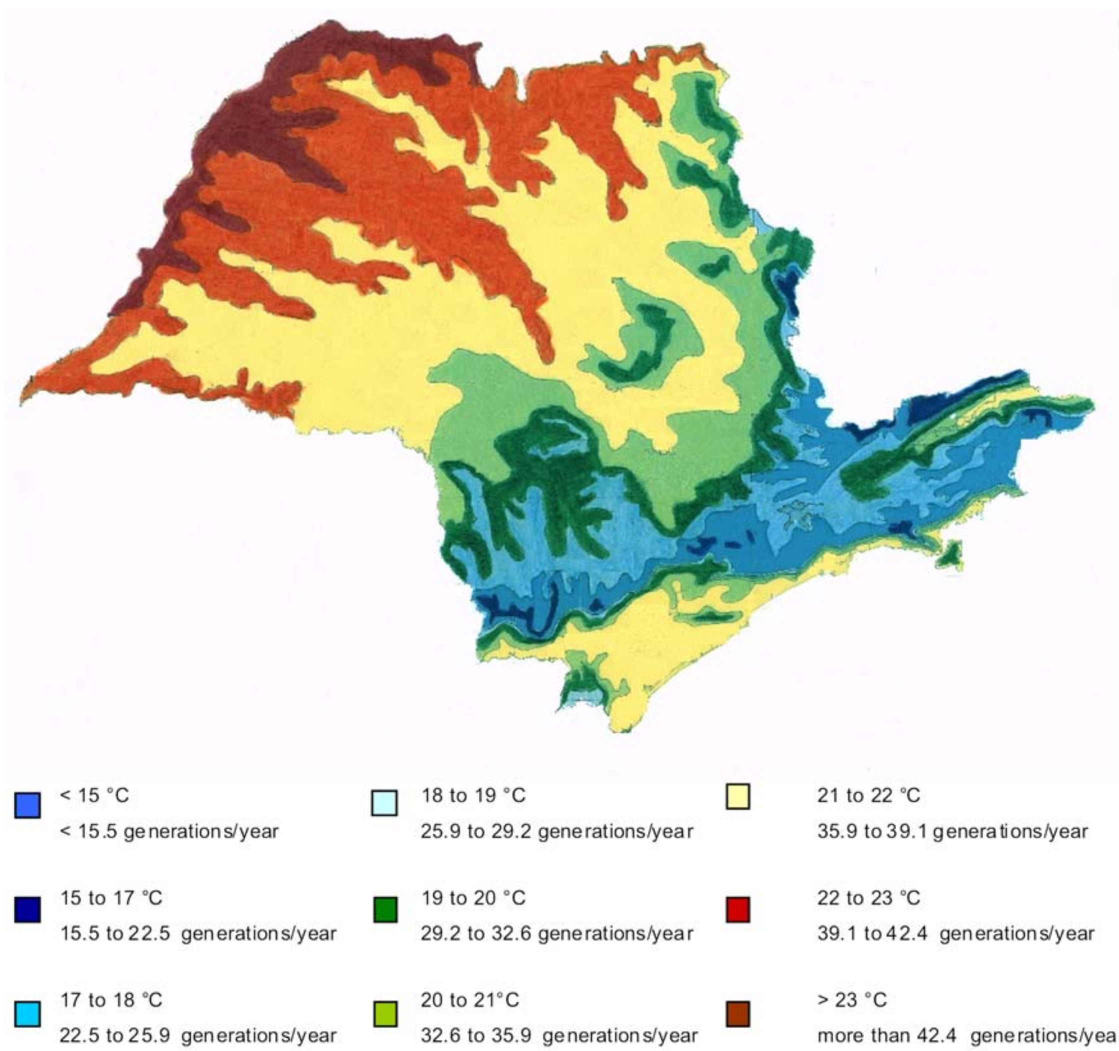

Figure 2. Number of generations of *Dermanyssus gallinae* for isotherm based on thermal requirements and annual temperatures.

Table 2. Estimate of the number of *Dermanyssus gallinae* generations per month, per year and per administrative region of the state of Sao Paulo, based on the thermal requirements of the mite and the mean monthly and annual temperatures, in 2004, 2005, 2006 and 2007.

Municipalities	Year							
	2004		2005		2006		2007	
	N° generations		N° generations		N° generations		N° generations	
	Month	Year	Month	Year	Month	Year	Month	Year
Araçatuba	3,9	46,4	4,0	47,9	4,0	47,7	4,1	48,8
Barretos	3,8	45,6	3,9	46,7	3,7	44,3	3,8	45,6
Bauru	3,5	42,1	3,8	45,6	3,7	45,0	3,7	44,8
Campinas	3,0	36,0	3,2	38,5	3,2	38,0	3,3	39,4
Central	3,3	39,0	3,5	41,9	3,4	41,3	3,5	41,9
Franca	3,3	40,2	3,5	42,4	3,4	40,5	3,5	42,3
São Paulo	2,9	35,3	3,2	37,9	3,1	37,7	3,2	38,7
Marília	3,3	40,0	3,6	42,7	3,5	42,5	3,7	44,0
P. Prudente	3,8	45,2	4,0	47,5	3,9	46,5	4,1	49,6
Registro	3,3	39,3	3,4	40,5	3,4	41,2	3,4	40,4
Rib.Preto	3,4	41,2	3,6	43,5	3,6	43,0	3,7	44,9
S.J.R Preto	3,8	45,7	3,9	47,2	3,9	46,8	4,0	48,0
S.J.Campos	2,7	32,7	2,9	35,1	3,1	37,0	3,2	38,4
Sorocaba	2,8	33,1	3,0	35,5	2,9	35,3	3,1	36,9

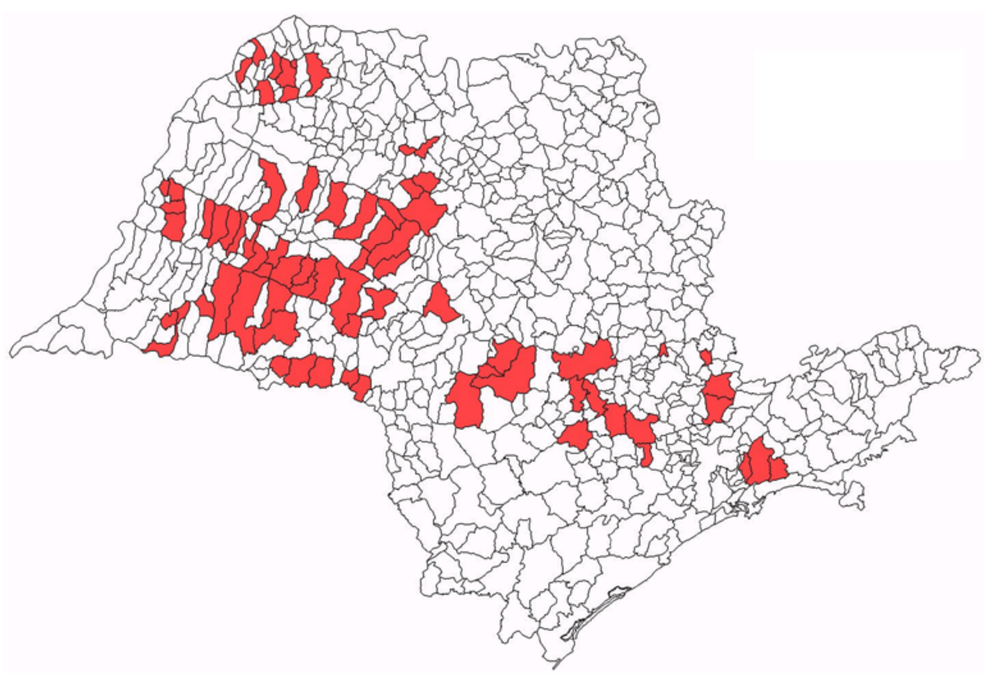

Figure 3. Distribution of poultry farms in São Paulo State (Secretaria de Defesa Agropecuária, São Paulo, Brazil, October, 2004).

time, conditions favorable for the establishment and development of *D. gallinae*. This state concentrates more than 50% of the national laying-hen flock, and is responsible for half of the country's egg production. These data reinforce the importance of this mite in Brazilian poultry breeding, indicating that more studies should be carried out in order to minimize economical losses caused by this parasite.

Threshold temperatures (Tb) were relatively close for egg, larval, protonymph, and deutonymph stages, ranging from 9.82 to 11.80°C. The preoviposition period had the lowest threshold temperature (3.4°C). The mean values for thermal constant (k) in the preoviposition, larval, protonymph and deutonymph stages were relatively close, but were higher for the egg stage.

The results obtained in the present study showed that threshold temperature for egg (10.60°C) and preoviposition period (3.4°C) are in agreement with those reported by Nordenfors et al. (1999), who observed that *D. gallinae* females laid eggs at 5°C. However, eggs kept at this temperature did not hatch, confirming that no embryonic development occurs below this temperature. The authors observed that eggs were shiny and were considered viable. These results indicate that eggs may remain viable for some time in colder temperatures, and develop again when temperature increases. The period of *D. gallinae* eggs remain viable below their lower temperature threshold is unknown, and represents an important line of research to be developed.

Although it is simple to calculate accumulated degree-days at a constant temperature in the laboratory, degree-days for daily variations that occur naturally are more difficult to be calculated. In fact, the occurrence of arthropods under field conditions may be observed before or after the predicted date, and these differences may be associated with errors in the lower temperature threshold (Tb) and thermal constant (k) estimates. Thus, degree-day models are considered adequate to be used in pest management programs if they predict the occurrence of a pest within a margin of error of up to two days (MORALES; HOWER, 1981, WEST; LAING, 1984, HIGLEY et al., 1986; CIVIDANES; BERNAL; GONZÁLEZ, 1993; FIGUEIREDO, 1997).

Ávila et al. (2002) observed that degree-day values accumulated during development of the coleopteran *Diabrotica speciosa* (Chrysomelidae), an agricultural pest, under field conditions, due to fluctuating soil and air temperatures were different from values obtained in the laboratory conditions where constant temperatures were used. The authors also observed that the prediction of occurrence of *D. speciosa* adults under field conditions, using both air and soil temperatures, and the linear degree-day model obtained in the laboratory, were different from the temperatures observed experimentally, and concluded that soil temperature was more adequate than air temperature for this kind of prediction.

Dermanyssus gallinae remain inside the poultry facility for most of their cycle. During a blood meal, mite is in contact with the bird's skin and feathers and receives a certain amount of heat, which is higher than the temperature of the surrounding environment. Thus, when predictions for the occurrence of *D. gallinae* populations are calculated, not only environmental temperature, but also bird temperature, around 41^{o}C, should be considered.

The results obtained in the present study are the first data on thermal requirements of *D. gallinae* and should be used as a basis for future studies on the prediction of occurrence of this species in different regions.

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