Effects of temperature on the life cycle, thermal requirements and estimates of the number of annual generations of *Aedes aegypti* (Diptera, Culicidae)

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ABSTRACT. Effects of temperature on life cicle, thermal exigency and number of generations per year estimation of *Aedes aegypti* (Diptera, Culicidae). The present work aims at estimating, based on a biological study, the thermal exigencies to the development and the number of generations per year of *Aedes aegypti* (Linnaeus, 1762) (Diptera, Culicidae) in field. The life cycle of the *A. aegypti* populations has been studied at constant temperatures of 18, 22, 26, 28, 32 and 34 ± 2°C, and 12 hours photophase. The low threshold temperature of development (Tb) and the thermal constant (K) have been determined. The number of generations per year in laboratory and field has also been estimated. The favourable temperature to the *A. aegypti* development its between 22°C and 32ºC, and to the longevity and fecundity *A. aegypti* adult its between 22°C and 28ºC. The egg to adult basal temperature, thermal constant and the number of generations in field were, in order, 11.33; 8.99 and 13.61 ºC, 192.3; 213.2 and 116.5 graus-days, and 23; 24.6 and 30.3 generations to *A. aegypti* populations from Boqueirão (07º29'27''S, 36º08'09''W), Campina Grande (07º13'32''S, 35º54'15''W) and Remígio (06º58'1''S, 35º47'29''W).

KEYWORDS. Insecta, Aedini, biology, thermal requirements.

SUMMARY. The objective of this work was to evaluate the effect of temperature on the life cycle of *Aedes aegypti* (Linnaeus, 1762), to determine the thermal requirements for development and to estimate the number of annual generations of the insect in the field. The life cycle of *A. aegypti* populations was studied at temperatures of 18, 22, 26, 28, 32 and 34 ± 2°C and a 12-hour photophase, also determining the lower thermal limits of development (Tb) and the thermal constants (K) and estimated the number of annual generations of the insect in the laboratory and in the field. The favorable temperature for the development of *A. aegypti* is between 22°C and 32°C, and for longevity and adult fecundity between 22°C and 28°C. The Tb, Ks from egg to adult, and the number of annual generations in the field were 11.33; 8.99 and 13.61°C, 192.3; 213.2 and 116.5 degree days, and 23; 24.6 and 30.3 generations for populations of *A. aegypti* from Boqueirão (07º29'27"S, 36º08'09"W), Campina Grande (07º13'32"S, 35º54'15"W) and Remígio (06º58'1"S, 35º47'29"W), respectively.

KEY WORDS. Insecta, Aedini, biology, thermal requirements.

Aedes (Stegomyia) aegypti (Linnaeus, 1762) is the most important mosquito in the transmission of yellow fever and the four serotypes of the dengue virus (LOZOVEI, 2001; ALDAMA & GARCIA, 2001; FORATTINI, 2002). It is a cosmopolitan insect, well adapted to the urban environment, distributed in tropical and subtropical areas, located between 45º North latitude and 40º South latitude (LOZOVEI, 2001; FORATTINI, 2002).

Aedes aegypti developed a strictly synanthropic and anthropophilic behavior in its evolutionary trajectory, being recognized among Culicidae as the species most associated with man (NATAL, 2002).

There are multiple factors involved in the dispersal of domiciled Culicidae. The geographical expansion of *A. aegypti* populations is influenced by social and environmental factors, including population density, economic activity and climate. The influence of climate on the distribution and abundance of insects and on the epidemiology of areas of occurrence of diseases transmitted by vectors in several continents and their aggravation had, among other determinants, the increase in the temperature of the planet, especially in the last 100 years (GLASSER & GOMES , 2002).

In the state of São Paulo, a strong association was verified between the average temperature in July and the establishment of A. aegypti populations , with the speed of occupation of new municipalities being greater the greater the temperature range. In regions with temperatures above 16-18ºC, in less than 2 years after the establishment of the vector, 10% of the municipalities were infested, rising to 90% after five years, such as the mesoregions of Araçatuba, Presidente Prudente, Ribeirão Preto and São José do Rio Preto where the July isotherms were above 18ºC (GLASSER & GOMES, 2002). In Nova Iguaçu (Rio de Janeiro), the frequency of *A. aegypti* was higher in the months of December and February, which were the hottest months, with average temperatures above 25º and higher rainfall in the summer, with the lowest period of occurrence the winter months (HONORIO & LOURENÇO-DE-OLIVEIRA, 2001). In the state of Paraíba, the temperature range favorable to the life cycle of *A. aegypti* populations is between 22°C and 30°C, and under these conditions it may occur over twenty generations of the insect throughout the year (BESERRA *et* al., 2006) .

Temperature is an important ecological factor that influences the establishment of insect populations, either directly through their development, or indirectly through their feeding (SILVEIRA-NETO *et* al., 1976). Based on temperature studies that determine the thermal requirements for the development of *A. aegypti* and climatic representations of the different regions where the mosquito occurs through climatological normals, it is possible to have a better understanding of its population dynamics and to predict the number of generations annuals, as well as the periods of greatest occurrence in the areas of infestation. Thus, the development of bioecological studies that help in understanding the population dynamics of the mosquito is essential, so that predictive models of the occurrence of A. aegypti *in* areas vulnerable to infestations can be developed. This research aimed to evaluate the effect of temperature on the life cycle of *A. aegypti,* determine the thermal requirements for its development and estimate the number of annual generations of the insect in the field.

MATERIAL AND METHODS

The rearing of the *A. aegypti* populations and the laboratory bioassays were conducted in the Biological Control laboratory belonging to the Integrated Pest Management Nucleus of the State University of Paraíba, using the first generation of laboratory samples of three populations of the vector collected in the municipalities of Boqueirão (07º29'27''S, 36º08'09''W), Campina Grande (07º13'32''S, 35º54'15''W) and Remígio (06º58'1''S, 35º47'29 ''W) (Fig. 1). Samples of mosquito populations were obtained from eggs collected in ovitrap traps installed inside and outside the home of residences randomly chosen in ten blocks, with 50 traps being installed in Bairro do Pedegral (Campina Grande) and 30 traps in Bairro Bela vista in Boqueirão and at the Remigio Center.

The eucatex straws from the ovitrap traps containing *A. aegypti* field eggs were placed to dry for a period of 48 hours and then placed in white plastic trays measuring 40 cm long x 27 cm wide x 7.5 cm deep with one-third of its capacity filled with dechlorinated water. After hatching, diet for ornamental fish was offered in the proportion of 100 mg/tray every three days and trays covered with a fine mesh screen. The pupae were sexed according to FORATTINI (2002) and later transferred in 250 ml disposable cups to the adult rearing cages. These cages, made of a wooden frame and organza fabric measuring 40 cm x 40 cm x 20 cm in depth, received 100 individuals, in the proportion of one male for each female. Adults were offered a 20% honey solution and females were allowed a blood meal on quails, *Coturnix japonica* (Temminck & Schlegel, 1849) for thirty minutes, three times a week. After the meal, a 250 ml disposable cup with dechlorinated water was placed in each cage, with a plastic funnel lined with filter paper to serve as an oviposition substrate.

Life cycle of *A. aegypti* at six constant temperatures. The biological cycle of each population was studied in climatized chambers set at 18 ± 2°C, 22 ± 2°C, 26 ± 2°C, 28 ± 2°C, 32 ± 2°C and 34 ± 2°C and photophase of 12 hours. For the study of larval development, 5 polyethylene cups of 250 ml were placed for each temperature, containing 10 larvae (F_1) of the 1st instar of each population, repeated five times. For the larvae, 10 mg of fish food was offered daily. Twice a day, the temperature of the water in the glasses was measured, using a mercury thermometer with a range of 0°C to 60°C. The adults were kept in wired wooden cages (20 cm^3) containing twenty couples, in five replications, being offered a 20% honey solution, in addition to allowing the females to have a blood meal on quails for 20 minutes, three times a week. For the egg stage, the first 20 postures of each treatment were evaluated. These postures were placed in a glass Petri dish (15 cm in diameter x 2.5 cm in depth) with dechlorinated water, considering eggs that had not hatched until the 20th day. The period of development and the viability of the egg, larva and pupa stages, the sex ratio and the longevity and fecundity of the adult stage were evaluated.

The experimental design was completely randomized, with data analyzed in a 3 x 6 factorial scheme, three populations and six temperatures, for the stages of egg, larva, pupa and adult of A. aegypti . The evaluated biological variables were submitted to analysis of variance and means compared by Tukey's test ($p < 0.05$).

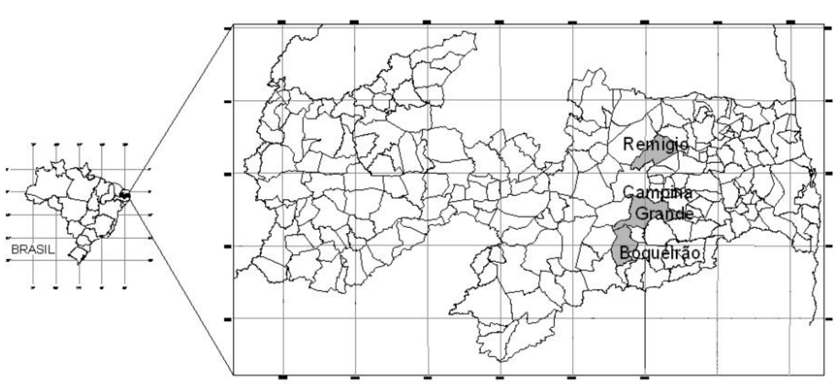

Figure 1. Map of the State of Paraíba indicating the collection sites for *Aedes aegypti* (Linnaeus, 1762).

Thermal requirements for the development and estimation of the number of annual generations of *A. aegypti.* Based on the duration of immature development and the total cycle obtained at 18 ± 2°C, 22 ± 2°C, 26 ± 2°C, 28 ± 2°C, 32 ± 2°C and 34 ± 2°C were determined the lower thermal limits of development (tb) and the thermal constants (K) through the hyperbole method (HADDAD & PARRA, 1984) given by the equation K= y (t - tb) where: K is the thermal constant, y the time of development (days), t ambient temperature (ºC), and tb developmental threshold temperature. From the biological data obtained at the temperature at which the cycle was completed in the shortest time and as a function of the thermal constant of the biological cycle, the total number of degrees days available for development and the thermal normals of the study areas, the number of annual generations of the insect, in the laboratory and in the field. The number of annual generations of the insect was estimated based on its thermal requirements, through the equation NG = T(tc – tb)/K, where T is the time considered in years and tc the monthly average temperatures of the study regions, being K and tb the parameters already defined previously.

RESULTS

Life cycle of *A. aegypti* at six constant temperatures. The average temperatures of the waters in which the development of the larval stage occurred in the three populations of *A. aegypti* studied ranged from 17.5°C to 17.7°C; 21°C to 21.4°C; 25°C to 25.5°C; 27°C to 27.8°C; 31°C to 31.5°C and 32.5°C to 33°C for ambient temperatures of 18°C, 22°C, 26°C, 28°C, 32°C and 34°C respectively.

The duration and viability of the stages of egg, larva, pupa, from egg to adult emergence, the longevity of adults and the fecundity of females were dependent on the joint effect of population and temperature, revealing that these populations are distinct in terms of their development patterns and reproduction with respect to temperature (Tabs. I-IV).

The periods of development from egg, larva, pupa and from egg to adult decreased with the temperature rise, with the longest and shortest periods of development being recorded at extreme temperatures (18 and 34°C), respectively (Tabs. I and III). . The incubation period of eggs from *A. aegypti* populations ranged from 13.66 days at 18°C to 2.93 days at 34°C.

However, it should be noted that, although there was a significant interaction between population and temperature, in overall, there were no significant differences regarding the period of embryonic development, which was 6.19; 5.73 and 6.44 days for the populations of Boqueirão, Campina Grande and Remígio, respectively. For these populations there were only significant differences regarding the period of embryonic development at temperatures of 32° and 34°C (Table I).

Although no significant differences were detected in relation to the period of embryonic development of the populations of Boqueirão, Campina Grande and Remígio, it was found that the development time for the stages from larva, pupa and egg to adult differed significantly between these in all temperatures evaluated, with the shortest periods observed for the population of Campina Grande (with a general average of 4.69; 1.87 and 9.27 for the stages from larva, pupa and egg to adult, respectively) (Tab. III).

The viability of the egg stage of *A. aegypti* in the population of Remígio was the most affected by the extreme temperatures of 18ºC and 34ºC, with an average of 45.4% and 43.1% of survival, respectively. For the population of Campina Grande, survival was above 70%, with an overall average of 78.7% (Table II). Although temperature affected the embryonic development of *A. aegypti,* it had little effect on the viability of the larval and pupal stages and, with the exception of the 57.6% viability observed for the pupal stage of the Campina Grande population at 28° C, at all other temperatures survival was high, above 80%, with a general average of 90.7%; 99.8% and 99.4% for the larval stages and 95.1%; 85.9% and 95.9% for the pupal stage of the populations of Boqueirão, Campina Grande and Remígio, respectively (Tab. II).

Significant interactions were found between population and temperature with respect to longevity and fecundity of adults, with a decrease in longevity with increasing temperature from 28°C onwards, being significantly higher at 26°C for females and at 22° and 26°C for the males of the three populations. Considering the general average of longevity in all treatments, no significant differences were detected between the populations, which was 21.2; 21.1 and 22.6 for females and 20.1; 22.3 and 21.7 for males from the populations of Boqueirão, Campina Grande and Remígio, respectively (Table IV). The temperature extremes of 18ºC and 34ºC considerably reduced the number of eggs per female, mainly for the population of Campina Grande. In this location, the lowest number of eggs/female was obtained, with an average of 3.9 eggs at 18°C and 3.4 eggs at 34°C, with a general average of 52

Table I. Duration (days) (X ± EP) of embryonic development of populations of *Aedes aegypti* (Linnaeus, 1762) from the municipalities of Boqueirão, Campina Grande and Remígio in Paraíba, at six temperatures and a 12-hour photophase (1 , original means ; for the purpose of statistical analysis, the data were transformed into $\sqrt{x + 0.5}$; means followed by the same lowercase letter in the rows and uppercase in the columns, do not differ from each other by Tukey's test (p < 0.05)).

Population	Embryonic development (days)/Temperature1;2						
	18ºC	22ºC	26ºC	28°C	32ºC	34ºC	Overall Average
mouthful	13.66±0.41aA	6.99±0.54bA	6.12±0.25bA	3.17±0.27dA	2.94±0.17dB	4.24±0.32cdB	6.19±0.13A
Campina Grande	11.32aA	8.82±0.64aA	4.77±0.20bA	3.11±0.19bA	3.43±0.43bB	2.93±0.77bB	5.73±0.19A
Remigio	11.15±0.70aA	8 ,45±0.64aA	5.52±0.52cA	3.43±0.21cA	4.51±0.39cA	5.63±0.84bcA	6.44±0.35A
CV (%) = 14,20							

Table II. Viability (%) . in the lines and capital letters in the columns do not differ according to the Tukey test (p < 0.05) , variation in the temperature of the water in which the larval development of *Aedes aegypti occurred;*

, room temperature).

Population	18ºC	22ºC	26ºC	28°C	32ºC	34ºC	Overall Average		
	Viability (%)/temperature1								
	Phase this								
mouthful	42,07±7,9cB	53,75±7,5bcA	89,98±3,1abA	100aA	97.35±0.97aA	70.01±4.8abcA	75.52±2.02A	79.42±5aA	
Campina Grande	76.76±aA	93.71±4.14aA	87.82±5.9aA	64.81±10.7aB	70.0 ±23.80aA	78.75±2.99A	45.46±8.56bB	69.66±5.8abA	84.26±4.42aA
Remigio	90.39±4.89aA	69.73±6abAB	43.12±14, 6bB	67,10±2,61A					
CV = 33,66%									
	Larval phase								
	(17,5-17,7o C)2	(21,0-21,4o C)	(25,0-25,5o C)	(27,0-27,8o C)	(31,0-31,5o C)	(32,5-33,0o C)2			
Boqueirão	98.33±1.3abA	99.33±0.42aA	96.16±0.6abA	91.33±2.6bcB	72.00±6.3dB	87.53±2.1cB	90.75±1.95B		
Campina Grande	100aA	99.66±0.33aA	99.66±0.3aA	100aA	99.88±0.77A	100aA	100aA		
Remigio	99.66±0.33aA	100aA	98.33±0.8aA	100aA	99.00±0.44aA	99.66±0.33aA	99.44±4.39A		
CV = 4,44%									
	Stern panels								
Boqueirão	92,12±3,2aA	94,86±1,5aAB	96,23±1,6aA	99,62±1,8aA	92,88±2,3aA	92,88±2,3aA	95,19±0,8a		
Campina Grande	94,00±1,2aA	88,66±1,9aB	94,00±1,2aA	57,66±0,9bB	92,16±1,7aA	89,00±3,4aA	85,91±2, 3b		
Remígio	93.33±1.6aA	96.33±0.6aA	97.61±0.9aA	99.00±0.6aA	97.33±0.8aA	92.33±1.6aA	95.99±0.5A		
CV = 5,18%									

Table III. Duration (days) from larval, pupal and egg stages to adult emergence of populations of *Aedes aegypti* (Linnaeus, 1762) from the municipalities of Boqueirão, Campina Grande and Remígio in Paraíba at six temperatures and a 12-hour photophase (1 , averages followed by the same lowercase letter in the rows and capital letters in the columns, do not differ from each other by the Tukey test (p < 0.05; , variation in the temperature of the water in which the larval development of Aedes aegypti occurred).

Population	18ºC	22ºC	26ºC	28°C	32ºC	34ºC	Overall Average			
	Development phases/temperature1									
	(17,5-17,7o C)2	(21,0-21,4o C)	(25,0-25,5o C)	(27,0-27,8o C)	(31,0-31,5o C)	(32,5-33,0o C)				
	larval stage									
mouthful	12.69±0.15aB	7.53±0.24bA	5.69±0.29cA	5.43±0.05cA	4.67±0.23dA	3.68±0.06cA	6.62±0.5A			
Campina Grande	7.41±0.08aC	6.14±0.01bB	4.48±0.05cB	4.14±0.15cB	3.01±0.20dC	3.00±0.01dB	4.69±0, 24C			
Remedy	14.12±1.4aA	7.65±0.10bA	5.27±0.04cA	3.93±0.04dB	3.59±0.03dB	3.52±0.09dA	6.35±0.70B			
CV = 6,03%										
	Stern panels									
mouthful	5,86±0,06aA	3,60±0,04bA	2,06±0,02cA	2,0±0,004cA	1,72±0,04cdA	1,49±0,01dA	2,79±0,25A	1,2±0,11cB	1,11±0,02cB	1,50±0,09cA
Campina Grande	3.46±0.14aB	2.79±0.27bB	1,16±0,10cB	1,87±0,16C	5,61±0,25aA	3,30±0,03bA	1,91±0,07cA	1,8±0,03cdA		
Remigio	1,60±0,04cdB	1,35±0,06dA	2,59±0,25B							
CV = 11,21%										
	This-adult									
mouthful	33.38±1.79aA	18.39±0.91bA	14.08±0.6bcA	10.19±0.14cA	9.39±0.40cA	9.53±0.59cAB	15.82±1.30A			
Campina Grande	7.49±0.002bB	17.55±0.68aA	10.38±0.38bA	7.38±0.38bA	6.50±0.36bA	6.33±1.10bB	9.27±0.95B			
Remigio	29.95±0.79aA	18.81±0.70bA	12.15±0.60cA	8.98±0.20cA	9.18±0.41cA	10.58±0.87cA	16.94±1.13A			
CV = 19,35%										

eggs/females. The highest number of eggs/female was found at 26°C for females from the population of Boqueirão, with an average of 610.6 eggs. Considering the overall average number of eggs/female for all populations, females from the Boqueirão population, with 156.7 eggs/female, were more fecund (Table IV).

Thermal requirements for the development and estimation of the number of annual generations of *A. aegypti.* It was verified that the speed of development as a function of temperature adjusted to the linear model determined through the reciprocal of the hyperbole equation (HADDAD & PARRA, 1984). The lower thermal limits of development (tb) for the egg, larva, pupa and from egg to adult emergence were 9.21; 10.05; 12.12°C and 11.33; 3.54; 11.84; 12.38 and 8.99°C and 14.74; 9.09; 6.73 and 13.61°C for populations of *A. aegypti* from Boqueirão, Campina Grande and Remígio, respectively. Among the vector development stages, the stages from egg and from egg to adult emergence in the Campina Grande population and from larva and pupa in the Remígio population, demonstrated greater tolerance to low temperature, as they had the lowest base temperatures. These phases also showed higher development speeds compared to the development phases of the Boqueirão population, which is evidenced by the higher angular coefficients estimated by the regression equations (Tab. V). The estimated thermal constants for the stages of egg, larva, pupa and from egg to adult emergence were 79.61; 89.76; 32.53 and 192.30 degree days (GD), 117.65; 69.20; 29.15 and 213.20 (GD) and 46.19; 71.89; 29.85 and 116.55 GD for populations of *A. aegypti* from Boqueirão, Campina Grande and Remígio, respectively. The thermal constant represents the sum of the temperatures favorable to the development of insects during this period, that is, the temperatures that are above the base temperature. In this study, 192.3 were required; 213.2 and 116.5 GD to complete the development of the aquatic cycles of *A. aegypti* from Boqueirão, Campina Grande and Remígio, respectively.

Based on the thermal requirements for development and the thermal normals of each region, the number of annual generations in the field is 23; 24.6 and 30.3, and under laboratory conditions, at 26°C, this number is 27.8; 29.1 and 38.8 for the populations of Boqueirão, Campina Grande and Remígio, respectively. Therefore, it was found that in the municipality of Remígio *A. aegypti* has a greater number of annual generations than in other locations. This fact is associated with the greater speed of development of the population of Remígio, as can be seen by the greater angular coefficient of the estimated regression equations (Tab. V), allowing for a greater number of generations throughout the year.

Table IV. Longevity of adults (days) and number of eggs/female of populations of *Aedes aegypti* (Linnaeus, 1762) in the municipalities of Boqueirão, Campina Grande and Remígio in Paraíba at six temperatures and a 12-hour photophase (1 , means followed by the same letter 2 , 3, original means; for the effect of lowercase in rows differ by Tukey's test ($p < 0.05$); statistical analysis data were transformed into log (x+1)). and uppercase in columns, they do not

Population	Temperatura1,2 18ºC	22ºC	26ºC	28°C	32ºC	34ºC	Overall Average
			male longevity				
mouthful	22.50±1.9cAB 29.24±1.5abAB 33.31±1.3aB 14.22±07cdA 10.16±1.3dA 17.94±3.3cdA 21.22±0.76A 33.56 ±2.3aB 19.94±1.4bA 13.28±3.0bcA						
Campina Grande	6.40±1.6bcB 33.22±1.9aA 10.30±0.9cB 21.11±1.90A 47.08±1.9aA 20.64±1.3bA 10.06± 0.7cA 8.84±0.6cB 22.68±2.20A						
Remigio	25.78±2.1bA 23.70±3.4bB						
CV = 11,94%							
			Longevity of females				
Boqueirão	21.90±1.6abA	27.52±2.4aA	25.46±4.2aB	13.81±0.5bB	13.44±0.6bA	13.48±1.2abA	20.10±1.1A
Campina Grande	15.71±2.5cA	27.30±1.9abA	40.54±2.1aA	21.44±1.5bcAB	16.76±3.6cA	12.16±1.4cA	22.31±2, 0A
Remígio	22.67±0.3bA	24.74±1.7abA	38.36±2.7aA	22.36±2.3bA	11.22±1.1cA	10.92±0.7cA	21.71±1.7A
CV = 4,46%							
			Number of eggs/female3				
Boqueirão	46.9±16.2bA	67.4±19.65bA	610.6±121.6bA	66.6±23.15bB	50.6±10.5bA	97.9±16.1bA	156.7±23.35A
Campina Grande	3,9bB	117,9±37,6aA	89,4±24,7aB	3,4±2,8bB	52,0±9,99B	84,1±29,8aAB	13,4±8,7bB
Remigio	69.7±28.4bcA	14.8±7.1cdA	214.7±27.9abAB	389.2±150.8aA	25.3±11.1cdAB	1.8dB	119,2±28,58B
CV = 34,89%							

Table V. Base temperature (tb), thermal constant (K), intercept (a) and angular coefficient (b) of the regression equation for the speed of development and coefficient of determination (R^2) for the development of populations of Aedes aegypti (Linnaeus , 1762) from the municipalities of Boqueirão, Campina Grande and Remígio in Paraíba and 12-hour photophase.

Population	Development Phases tb (°C)	K (GD)	a ± standard error	b ± standard error	R2
			Egg Stage		
mouthful	9,21	79,61	-0,11570 ± 0,13409	0,01256 ± 0,00492	0,62
Campina Grande	3,54	117,65	-0,03006 ± 0,13077	0,00850 ± 0,00480	0,44
Remigio	14,74	46,19	-0,31917 ± 0,07785	0,02165 ± 0,00260	0,93
			Larva stage		
mouthful	10,05	89,76	-0,11205 ± 0,03488	0,01114 ± 0,00132	0,95
Campina Grande	11,84	69,20	-0,17109 ± 0,04741	0,01445 ± 0,00180	0,94
Remigio	9,09	71,89	-0,12641 ± 0,04071	0,01391 ± 0,00153	0,95
			Stern panels		
mouthful	12,12	32,53	-0.37208 ± 0.07292	0,03074 ± 0,00268	0,97
Campina Grande	12,38	29,15	-0.42477 ± 0.08704	0,03430 ± 0,00320	0,97
Remigio	6,73	29,85	-0.22559 ± 0.41389	0,03350 ± 0,01520	0,55
			This-adult		
mouthful	11,33	192,30	-0,05893 ± 0,01574	0,00520 ± 0,000584	0,95
Campina Grande	8,99	213,20	-0,04226 ± 0,03406	0,00469 ± 0,00127	0,77
Remigio	13,61	116,55	-0,11679 ± 0,02243	0,00858 ± 0,000831	0,96

DISCUSSION

The results showed that the populations of *A. aegypti* from the municipalities of Boqueirão, Campina Grande and Remígio presented different development patterns in relation to temperature and that the development of immature stages, the longevity of adults and the fecundity of females were influenced by temperatures. of 18, 22, 26, 28, 32 and 34 ± 2°C, coinciding with the results of CALADO & NAVARRO-SILVA (2002a) for *Aedes (S.) albopictus* Skuse, 1894. Those authors verified an inverse relationship between time of development and temperature where the shorter periods of duration of the egg, larval and pupal stages occurred with increasing temperature. For the incubation period of the eggs, there was a reduction of approximately 27 days when the eggs were kept at 25°C and 30°C in relation to the temperature of 15°C. These differences, regarding the pattern of development, were also detected for other populations of *A. aegypti* from the municipalities of Boqueirão, Brejo dos Santos, Campina Grande, Itaporanga and Remígio, all in Paraíba, where the differences found regarding the pattern of development were considered inherent to each population, arising as a consequence of ecological adaptations to their regions of origin (BESERRA *et* al., 2006).

In the present study, all temperatures allowed the development of *A. aegypti* populations and no negative effects were observed on the viability of the egg, larval and pupal stages (although they influenced the development of the immature stages). With the exception of the egg viability of the Boqueirão and Remígio populations at 18°, 22° and 34°C and the pupal stage of the Campina Grande population at 28°C, in all other treatments it was observed more than 70% of survival, thus surpassing 90% for the entire larval phase of *A. aegypti* in the populations of Campina Grande and Remígio.

The effects of temperature on the life cycle of insect vectors have been reported by several authors (COSTA *et.* al., 1994; RIBEIRRO *et.* al., 2001; CALADO & NAVARRO-SILVA, 2002a,b,c; BESERRA *et.* al . ., 2006). Studies with *Culex quiquefasciatus* Say, 1823, demonstrated that embryonic development occurred at temperatures ranging between 10°C and 34°C, but not at 5°C and 40°C, and the period of larval development decreased from 53.7 days at 15°C for 7.4 days at 30°C (COSTA *et.* al., 1994). For this species, egg viability above 97.9% was also observed at temperatures between 15°C and 30°C and a decrease in the period of larval development from 35.7 days at 15°C to 7.5 days at 30°C. °C (RIBEIRRO *et.* al., 2004). However, it should be noted that low temperatures are generally deleterious to the development of insects (eg *A. albopictus,* for which a temperature of 20ºC caused 50% of egg mortalities) (CALADO & NAVARRO-SILVA, 2002c). For *C. quinquefasciatus* and *A. aegypti ,* low infestations were recorded as a result of the low temperatures in the state of São Paulo, probably due to lower female fecundity and the increase in the period of development of the immature stages (GLASSER & GOMES, 2002). In addition, the longer development time may lead to an increase in immature mortality under natural conditions, given the longer exposure time to predation, parasitism and diseases (TRIPS & SHEMANCHUK, 1970).

As observed for the stages of development of immatures of *A. aegypti,* the temperature had an effect on the adult stage and the thermal extremes of 18°C and 34°C reduced the longevity of adults and the fecundity of females. This was also observed for populations of *A. aegypti* from the municipalities of Boqueirão, Brejo dos Santos, Campina Grande, Itaporanga and Remígio (where less longevity of adults and lower fecundity of females were observed when they were subjected to temperatures of 18°C and 34°C) (BESERRA *et.* al., 2006) and for *A. albopictus* whose average longevity was 19.4 and 13.6 days for females and males respectively (CALADO & NAVARRO-SILVA, 2002c).

It was verified that the thermal limits (tb) of development and the respective thermal constants (K), expressed in degree-days (GD), for the stages of egg, larva, pupa and from egg to adult emergence, varied according to with the developmental stages and populations studied, which was also verified for *Ophyra aenescens* Wiedemann 1830 (Diptera: Muscidae) (RIBEIRRO *et.* al., 2001), *A. albopictus* (CALADO & NAVARRO SILVA, 2002b), *C. quinquefasciatus* (RIBEIRRO *et.* al., 2004) and *A. aegypti* (BESERRA *et.* al., 2006). Such variations are consequences of structural and physiological differences inherent to each stage of insect development, which guarantees the species the ability to adapt to environmental variations (CALADO & NAVARRO-SILVA, 2002

In the present research, it was found that the population of Remígio presented the highest base temperature for the development of the insect from egg to emergence of the adult, being the lowest for the population of Campina Grande. Such a factor was not expected because these two municipalities are located in the same biogeographical region, hot northeast with attenuated drought, with normal temperatures averaging 23.3°C (Laboratory of Meteorology, Water Resources and Remote Sensing of Paraíba). However, the results obtained are in line with studies carried out with a population of *A. aegypti* collected in Remígio, for which the lower thermal limit for development from egg to adult was 13.5°C, which is higher than what was observed for other populations such as Boqueirão (9.5°C), Brejo dos Santos (8.5°C), Itaporanga and Campina Grande (3.5°C) (BESERRA *et.* al., 2006).

Based on the time of development and viability of the egg, larva and pupa stages and on the fecundity of the adults, it was found that the temperature favorable to the vector is above 22°C and below 32°C, therefore within the range temperature of their regions of occurrence. The base temperatures for the development of the different stages of the insect's life cycle were lower than the minimum temperatures of each region. Thus, considering the average ambient temperature of each region where the municipalities of Boqueirão, Campina Grande and Remígio are located (approximately 25ºC), all locations present favorable conditions for the development and establishment of populations of A. aegypti, which may *present* above twenty generations throughout the year.

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