Effects of Temperature on the Development of Podisus nigrispinus (Heteroptera: Pentatomidae): Implications for Mass Rearing

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Effects of temperature on the development of *Podisus nigrispinus* (Heteroptera: Pentatomidae): implications for mass rearing

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Abstract

Predatory stinkbugs such as *Podisus nigrispinus* (Dallas) (Heteroptera: Pentatomidae) have been mass-reared in the laboratory and released for use in integrated pest management programs. However, the rearing of this natural enemy may not coincide with pest outbreaks in the field, which indicates the need for techniques to manipulate the life cycle of the predator. The objective of this study was to evaluate the effect of different temperatures on the development and other biological characteristics of the stinkbug predator *P. nigrispinus*. Six temperatures were used (13, 17, 21, 25, 29, and 33 °C ± 0.2 °C), and the following parameters were evaluated: duration of egg and nymphal stages; survival rate of nymphal stages and newly emerged adults; adult longevity; number of eggs per female; pre-oviposition, oviposition, and post-oviposition periods; and adult weight. At 4 temperatures it was possible to obtain survival at all nymphal stages. Longer adult longevity, pre-oviposition, oviposition, and post-oviposition periods were obtained at 17 °C. However, the number of eggs, weight, and size were negatively affected by this cooler temperature. Temperatures of 21 and 25 °C were the most appropriate for the development of the predator; however, the temperatures 17 and 29 °C allowed delay or acceleration of the predator’s life cycle, thereby facilitating release of the predators when they are needed in the field for biological suppression of pests.

Key Words: insect; Asophinae; biological control; stinkbug predator

Resumen

Percevejos predadores, como el *Podisus nigrispinus* (Dallas) (Heteroptera: Pentatomidae), han sido criados masivamente en laboratorio y liberados en programas de Manejo Integrado de Pragas. No obstante, la producción de inimigos naturales puede no coincidir con el surto de plagas en el campo, lo que indica la necesidad de técnicas para manipular el ciclo de vida del percevejo. El objetivo de este estudio fue evaluar el efecto de diferentes temperaturas en el desarrollo y otras características biológicas del percevejo *Podisus nigrispinus*. Seis temperaturas se utilizaron (13, 17, 21, 25, 29, y 33 °C ± 0.2), y los parámetros evaluados fueron: duración de los estadios de la fase de ovo y las etapas ninfales; supervivencia; longevidad de adultos; número de huevos por fêmea; periodo de pre-oviposición, oviposición y post-oviposición; peso y tamaño de adultos. En cuatro temperaturas fue posible obtener supervivencia en todos los estadios ninfales. La longevidad de los adultos y periodo de pre-oviposición, oviposición y post-oviposición fueron afectados adversamente. Las temperaturas de 21 y 25 °C han sido las más apropiadas para el desarrollo del percevejo. Por otro lado, las temperaturas de 17 y 29 °C han permitido retardar o acelerar el ciclo de vida del percevejo mediante la necesidad de inimigos naturales en el campo.

Palabras Clave: insecto; Asophinae; control biológico; percevejo predator

*Podisus nigrispinus* (Dallas) (Heteroptera: Pentatomidae) is a generalist predator found in temperate and tropical regions (Neves et al. 2010; Inayat et al. 2011). It is an efficient predator on several pests, such as *Alabama argillacea* Hübner (Lepidoptera: Noctuidae), *Anti-carsia gemmatalis* Hübner (Lepidoptera: Noctuidae), and *Spodoptera exigua* Hübner (Lepidoptera: Noctuidae), in crops such as cotton (Malvaceae), tomato (Solanaceae), soybean (Fabaceae), and eucalyptus (Myrtaceae) (Matos-Neto et al. 2002; Oliveira et al. 2002; Torres et al. 2002; Zanuncio et al. 2002). This predator has been mass-reared in the laboratory and then released for biological control in integrated pest management programs (Zanuncio et al. 2002; Bottega et al. 2014). Although laboratory mass-rearing produces a large number of natural enemies, the production of predators may not coincide with pest outbreaks in the field (Costa et al. 2016), which generates costs once the prey is created to continuously sustain production throughout the year (Neves et al. 2010). The lack of timing in the production schedule of natural enemies with the appearance of pests in the field indicates the need for storage techniques (Colinet & Hance 2010) or methods that manipulate the life cycle of the biological control agent.

It is known that the development and survival of an insect may vary in response to biotic and abiotic factors (Couret et al. 2014). In addition, temperature is the principal factor that explains the develop-
ment was initiated with 25 replicate Petri dishes, each with 20 eggs. After hatching, the nymphs were kept in the same Petri dishes and fed with T. molitor pupae.

After completing the nymphal stage, 20 pairs (1 male and 1 female) of newly emerged adults were separated in acrylic boxes and maintained in the same conditions as described previously (temperatures, relative humidity, and photoperiod). A wet cotton ball was deposited on the top of the acrylic box in order to maintain humidity, and the insects were fed with T. molitor pupae.

Daily observations were made in order to maintain an adequate water supply, as well as to make observations (by the usage of a stereoscopic microscope) of the evaluated parameters that consisted of (a) duration of egg and nymphal stages (determined by changes in morphology of the insects); (b) survival rate on the nymphal stages and newly emerged adults; (c) male and female longevity; (d) number of eggs (per female); (e) pre-oviposition, oviposition, and post-oviposition periods; and (f) weight of newly emerged males and females.

**STATISTICAL ANALYSES**

All parameters were evaluated with analysis of variance (1-way ANOVA) and then to regression analysis, with the non-linear model selected according to the significance of the regression coefficients (t, \( P < 0.05 \)) and the coefficient of determination (\( R^2 \)). The statistical analyses were conducted using SISVAR 5.0 software (Ferreira 2014).

**Results**

The duration of the egg stage was longest and shortest when maintained at 13 and 33 °C, respectively. However, these temperatures did not allow the development of the nymph to the second instar. Thus, based only on the temperatures that allowed complete development, the longest and shortest duration in P. nigrispinus developmental periods occurred at 17 and 29 °C. The mean (±SE) total development times (egg to adult) were 65.3 ± 2.0; 38.4 ± 0.5; 21.5 ± 0.4; and 17.4 ± 0.3 when reared at 17, 21, 25, and 29 °C, respectively (Fig. 1).

Higher levels of P. nigrispinus survival were obtained between 21 and 25 °C. The survival rates of the first instar were reduced at extreme temperatures (13 and 33 °C). In the other instars there was no survival at 13 and 33 °C; however, at 17 and 29 °C the survival rate decreased as well. This trend was evident when the quadratic regression equations were evaluated (Fig. 2).

In the nymph and adult stages, the maximum survival rates occurred between 21 and 25 °C. However, the survival rate diminished over time, with the proportion surviving highest during the first instar (75 to 90%), and lowest during the adult stage (25 to 50%) (Fig. 2A and 2F).

The longevity of P. nigrispinus, both male and female, decreased as the temperature increased independent of the temperature, females had a shorter longevity than males (Fig. 3A). With respect to egg production, insects reared at 17 °C produced a low number of eggs per female (13.5 ± 6.6), whereas maximum egg production per female (208.1) occurred at 24.38 °C (Fig. 3B).

The pre-oviposition period of P. nigrispinus was 27.6 ± 0.9, 8.4 ± 0.9, 8.0 ± 0.5, and 7.5 ± 0.3 d for insects reared at 17, 21, 25, and 29 °C, respectively. The oviposition and post-oviposition periods also decreased with increasing temperature (Fig. 4).

Rearing temperatures also affected the weight of both males and females. The weight of P. nigrispinus males was higher with increasing temperature; however, the weight of females at extreme temperatures (17 and 29 °C) decreased. It also was observed that females were on average 17.5 mg heavier than males (Fig. 5).
Fig. 1. Duration (d) of the egg stage (A), nymphal stages (B, C, D, E, and F), and total development of nymphal stage (G) of *Podisus nigrispinus* (Heteroptera: Pentatomidae) subjected to constant temperatures (13, 17, 21, 25, 29, and 33 ± 0.2 °C).
Discussion

The development period of insects tends to increase with the decreasing temperature up to a certain limit, due to the reduction of metabolic rates (Hodkova & Hodek 2004), and this also was observed in all stages of the life cycle of *Podisus nigrispinus*. Although there were some negative aspects to rearing the insects at lower temperatures, this procedure of rearing at lower temperatures might allow increased production of predators in the absence of pest insects in the field.

Temperatures near the thermal limits of the insect must be avoided (Baek et al. 2014), because this can affect them lethally. For example, although there was some growth at 13 and 33 °C, the insects eventually died in the nymphal stage. The lower limit for *P. nigrispinus* was previously defined as 11.5 °C (Didonet et al. 1995), but in this study 13 °C was lethal.

The most suitable temperature for delaying nymphal development was 17 °C because the developmental cycle was 3.0 and 3.7 times longer than at 25 and 29 °C, respectively (Fig. 1). In a similar study of the development of *P. distinctus* when cultured at temperatures varying from 17 and 33 °C, extension of the nymphal period also was demonstrated, and nymphal development time at 17 °C was 4.5 times longer than at 29 °C (Santos et al. 2004).

Increase in development time caused by the reduction in metabolic rates can cause the energy resources of the insect to be allocated to its survival (Vacari et al. 2014), and this was clearly observed by the decrease of parameters such as nymphal survival (Fig. 2), oviposition (Fig. 4), and weight of newly emerged male and female (Fig. 5). The same trade-off was observed in the storage of *P. nigrispinus* eggs, wherein insects from eggs stored for 17 d at 15 °C displayed a decreased the nymphal period, nymphal viability, and weight (Vacari et al. 2014).

Fig. 2. Survival (%) in nymphal stages (A, B, C, D, and E) and newly emergent adults (F) of *Podisus nigrispinus* (Heteroptera: Pentatomidae) subjected to constant temperatures (13, 17, 21, 25, 29, and 33 ± 0.2 °C).
Temperature affects the development (Baek et al. 2014; Poncio et al. 2016; Johnson et al. 2016) and reproduction of insects (Scriber & Slansky Jr 1981), as can be observed when the insects were cultured at 17 °C, which caused an increase in the longevity of males and females (Fig. 3A). However, this resulted in a reduction in the total number of eggs per females (13.5 ± 6.6 eggs per female) (Fig. 3B) and in mating. Low temperatures can reduce energy reserves of insects due to the low food consumption (Renault et al. 2003), which indicates that both high longevity and low reproduction obtained in this study are associated not only with the allocation of energy expenditure for survival, but also with limited sources of energy.

Higher temperatures also influenced the reproduction of P. nigrispinus, resulting in a decrease in the pre-oviposition, oviposition, and post-oviposition periods (Fig. 4). Results similar to these were found when P. nigrispinus was fed with Alabama argillacea (Hübner) Lepidoptera: Noctuidae under different temperatures (Medeiros et al. 2003). According to the literature, fecundity of P. nigrispinus is high at 25 °C (Medeiros et al. 2003). However, even at ideal temperatures, total egg production per female was low (199.4 ± 35.7 and 176.5 ± 33.0, at 21 and 25 °C, respectively). This may be due to the fact that females that have access to only 1 male may experience a scarcity of spermatozoa (Torres & Zanuncio 2001). However, those that perform the multiple coupling (with several males) may produce a higher number of eggs, which can vary from 350 to 390 (Oliveira et al. 2002, 2011; Espindula et al. 2010).

Until the fourth instar, male and female nymphal weights are not significantly different; however, in the fifth instar females become heavier than males. The greater weight of females as compared to males is due to the accumulation of fat (which is necessary for reproduction) and also due to the development of the ovaries and eggs (Oliveira et al. 2002, 2011).

This study demonstrated that the best developmental conditions for this predator were 21 and 25 °C. At 13 and 33 °C, the nymphs died in the first instar. However, the optimal temperature for mass rearing was 29 °C. Should it be desirable to delay the development of the predators so as to increase availability of predators at a certain time, they can be cultured at 17 °C, although there are trade-off with this temperature, as reflected in reduced survival, number of eggs per female, weight, and size of the predator.

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References Cited


Haddad ML, Parra JRP, Moraes RCB [eds.]. 1999. Métodos para Estimar os Limites Térmicos Inferior e Superior de Desenvolvimento de Insetos. Fundação de Estudos Agrários Luiz de Queiroz (FEALQ), Piracicaba, Brazil.


