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Effect of temperature on the development and feeding behavior of *Acanthoscelides obtectus* (Chrysomelidae: Bruchinae) on dry bean (*Phaseolus vulgaris* L.)

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ABSTRACT

The current study investigated the influence of temperature on the biological and reproductive aspects of the bean bruchid beetle, *Acanthoscelides obtectus* (Coleoptera: Bruchinae), in common bean (*Phaseolus vulgaris* cv. Carioca) under laboratory conditions. To determine thermal constants (fecundity, lifespan and seed consumption), we examined egg-to-adult development under five constant temperatures (16–32 °C). The Briere-1 model best explained the relationship between temperature and developmental rate, providing lower, upper and optimal thresholds of 11.1, 36.1 and 30.3 °C, for both sexes. The thermal constant for total insect development was 687.5 degree-days. Developmental time from egg to adult decreased with increasing temperature >20 °C. Increasing temperature reduced adult lifespan and increased fecundity over the range 24–28 °C. Adult emergence was maximized over the range 20–28 °C, but prolonged at 16 °C and shortened at 32 °C, resulting in fewer emerged adults overall. Beetles consumed less at ≥28 °C, whereas their dry weight was not influenced by the temperature range tested here. These results provide useful knowledge on the biology and thermotolerance of this Brazilian population of *A. obtectus* in stored beans.

1. Introduction

Bruchids encompass a group of approximately 1700 insect species (Johnson et al., 2004). Cross-infestation is a common feature related to this group whereby storage infestations result from field infestations and *vice-versa* (Southgate, 1979). Quantitative and qualitative damage of stored seeds arise from the combination of feeding behavior and fecal contamination by larvae, which promotes growth of microorganisms and thus resulting in reduction of their nutritional and commercial value (Baier and Webster, 1992; Barbosa et al., 1999). Sanitary measures in facilities, which include minimizing duration of storage and adoption of a limited range of post-harvest insecticides, are used to keep storage pests below economic thresholds (Schöller et al., 1997).

Acanthoscelides obtectus (Say) (Coleoptera: Chrysomelidae: Bruchinae), a beetle of Mesoamerican origin (Oliveira et al., 2013), is a serious post-harvest and field pest of the common bean *Phaseolus vulgaris* L. (Fabaceae) and other pulses in Africa (Masolwa and Nchimbi, 1991), Australia (Keals et al., 2000), Europe (Nadir et al., 2005), the Americas (Oliveira et al., 2013), and Asia (Thakur, 2012). Since *A. obtectus*, like other bruchids, possesses a short life cycle and high reproductive potential in warm climates, it can produce several generations per year under favorable conditions. Studies regarding control methods to suppress bruchid populations in field and storage include chemical and physical control, biocontrol agents, and pheromone traps (Armitage et al., 1994). However, information regarding the developmental biology and feeding behavior of *A. obtectus* is needed for the design of better control strategies and predictive models of population dynamics.

Understanding the effect of temperature on the developmental biology and reproduction of *A. obtectus* is of paramount importance for determining its geographical distribution, number of

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Table 1
Models used to describe the relationship between temperature and developmental rates of *Acanthoscelides obtectus* in dry bean seeds under laboratory conditions.

Model	Parameters	Equation[a]	Reference
Linear (common)	2	$a + bX$	Bonhomme (2000)
Briere-1	3	$aT(T - T_0) \times \sqrt{(T_L - T)}$	Briere et al. (1999)
Briere-2	4	$aT(T - T_0) \times (T_L - T)^{1/m}$	Briere et al. (1999)
Quadratic (2nd order)	3	$aT^2 + bT + c$	Lamb et al. (1984)
Lactin-2	4	$\exp(\rho T) - \exp\{\rho T_L - [(T_L - T)/\Delta]\} + \lambda$	Lactin et al. (1995)

[a] In the linear model, *a* and *b* were constants and $T_0 = -a/b$ and degree-days was estimated through $K = 1/b$; where T is rearing temperature (°C). T_0 is lower threshold. T_L is upper threshold. T_{opt} is optimum temperature and *a. b. c* are empirical constants. In Lactin-2, Δ is difference between optimal and upper threshold and ρ is rate of increase at optimal thresholds.

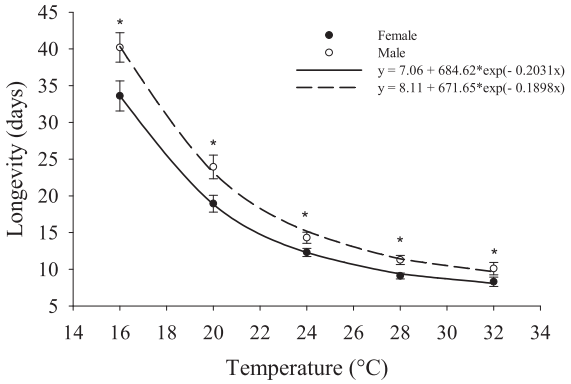

Fig. 2. Lifespan (days) of *Acanthoscelides obtectus* male and female reared on dry beans stored at constant temperatures. Symbol (*) indicates significant difference between means (±95% CI) of male and female in each test temperature (*t*-test, $P < 0.05$).

generations per year in field and stored beans, and to make inferences on the possible effects of climate change on its population growth. Despite the importance of environmental conditions on the biology and pest status of bruchid species (Southgate, 1979; Kistler, 1982), there is little information addressing the impact of temperature on development, reproductive potential, and seed damage related to *A. obtectus*. Here, we report the thermal effects on *A. obtectus* life history parameters and potential damage to stored dry beans under laboratory conditions.

2. Materials and methods

2.1. Insect rearing

Newly emerged adult *A. obtectus* were obtained in June 2011 from bean stores and plantations located adjacent to Embrapa Rice and Beans (National Research Center of Rice and Beans) facility. Colonies of *A. obtectus* were reared on dry bean cv. Jalo Precoce (*P. vulgaris* L.) in glass jars (4 L) maintained in a walk-in controlled environmental room (24–27 °C) under total darkness. The insect density for rearing was 3.3 ± 0.2 g adults (≈300 individuals) per kg

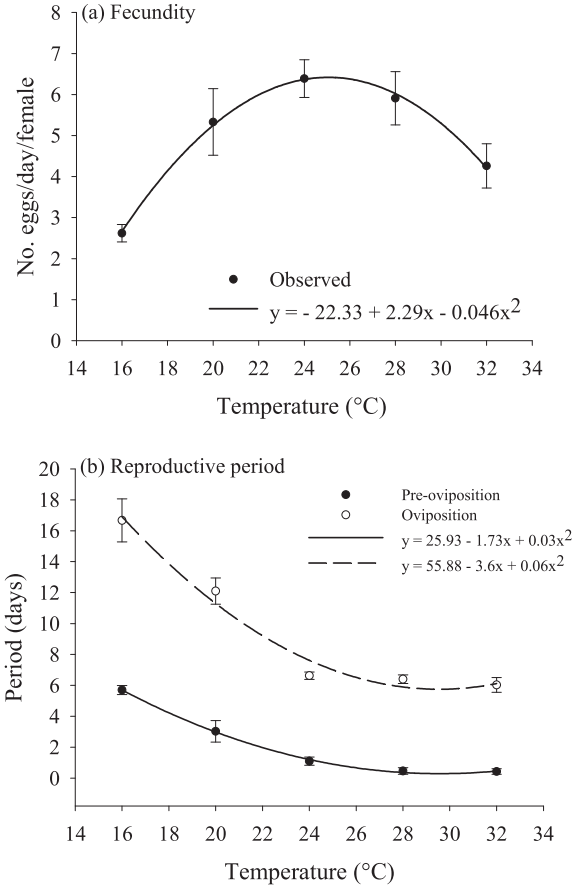

Fig. 1. Effect of temperature on fecundity (a) and reproductive period (b) of *Acanthoscelides obtectus* females under laboratory conditions. Solid and dashed lines represent fitted quadratic models, while dots represent observed means (±95% CI).

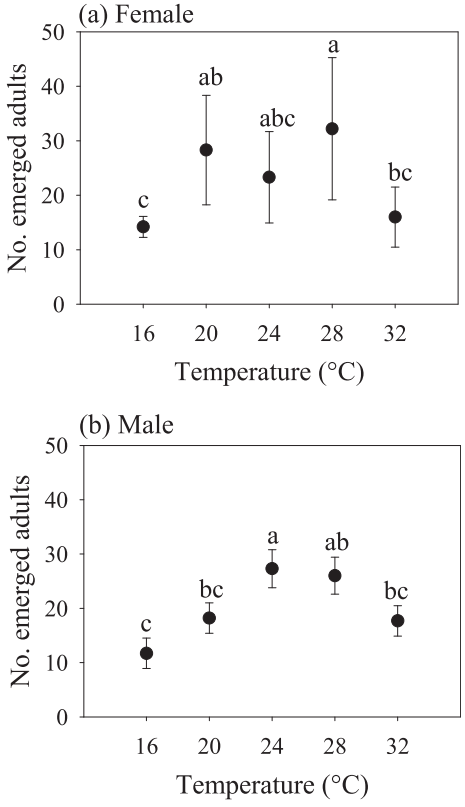

Fig. 3. Number (mean ± 95% CI) of emerged *Acanthoscelides obtectus* females (a) and males (b) at constant temperatures. Significant differences between means are designated by different letters (LSD test, $P < 0.05$).