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Preference of *Acarophenax lacunatus* (Cross & Krantz) (Prostigmata: Acarophenacidae) for eggs of different hosts

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Abstract

Mass rearing of natural enemies, in laboratory, can lead to the changes affecting their biological control efficacy. Therefore, this study was done to determine the preference of the mite *Acarophenax lacunatus* (Cross & Krantz) for the eggs of coleopterans *Tribolium castaneum* (Herbst), *Cryptolestes ferrugineus* (Stephens) and *Rhyzopertha dominica* (Fabricius), after its maintenance for successive generations on the population of either of these pests. The study attempted to detect the possible changes in its preferences that can indicate selection of lines with better performance over these insects. The experimental units encompassed Petri dishes divided into three areas, each containing eggs of a different host, and a physogastric female of *A. lacunatus* was released in the center of the Petri dish. The same procedure was replicated with females reared on different hosts. The eggs of the coleopterans host were placed in separate divisions, and one physogastric female of *A. lacunatus* raised on one of the host was freed in the center of the plate and the preference of the progenies was evaluated. The experiment was repeated every month for a period of nine months. There was a significant influence of time on the rate of host parasitism, with maximum parasitism occurring on *R. dominica*, in all the situations followed by *C. ferrugineus*. When *A. lacunatus* was maintained on *T. castaneum*, significantly more eggs of this host were parasitized than when raised on the other two hosts. The *A. lacunatus* showed preference for the eggs of *C. ferrugineus* and *R. dominica* compared to those of *T. castaneum*, when maintained on *C. ferrugineus*. The results indicated that maintaining biological control mites on a given host, for several generations, can improve its performance on that host.

Key words: Mite, host preference, biological control, Coleoptera.

Introduction

Several studies have shown the use of biological agents to manage stored product pests, especially due to the disadvantages of pesticides use, such as appearance of resistance to insecticides and contamination of food products by the chemical residues (Zettler and Cuperus, 1990; Brower et al., 1996). However, the success of biological control depends, on the knowledge and selection of natural enemies having the potential for use in this type of environment,

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interaction between these organisms and other species that develop there, and of their compatibility with the other control measures (Van Den Bosch et al., 1982; Debach and Rosen, 1991; Flinn, 1998).

Schöller and Flinn (2000) listed important criteria to select natural enemies for use in storage environment, which include tolerance to extreme climatic conditions, high reproductive potential, and efficiency in finding the host/prey. Besides this, the spectrum of host/prey, food preferences, dispersal capacity and viability of association with other natural enemy should also be considered. These informations are important, because in the stored products, and also in other environments, simultaneous occurrence of different pest species is very common, which essentially requires use of natural enemies with relatively broad host spectrum or a combination of specialists and generalists (Press et al., 1982; Oliveira et al., 2003a).

Stejskal et al. (2002) commented that after mass liberation, natural generalists can persists due to possibility of maintaining themselves on various host species. For example, the mite *Cheyletus eruditus* (Schrank) (Acari: Cheyletidae) is a generalist predator capable of developing in almost all the mite-pest complexes that infest stored products (Pulpan and Verner, 1965; Zdárková, 1998). However, according to Lindquist (1983), organisms that show wide host spectrum eventually show some preference when there is a chance of choice. Thus, studies about the food preference are of importance, because the data can serve as an indicator of the behavior of a natural enemy in the simultaneous presence of different species of hosts/prey. The efficacy of a natural enemy also can be affected by the storage environment, and by the method used for raising/managing them. Thus the mass rearing of a natural enemy becomes the fundamental step to implement a biocontrol program (Press et al., 1982; Brower and Press, 1992).

The mite *Acarophenax lacunatus* (Cross and Krantz) (Prostigmata: Acarophenacidae) is being studied for the biological control of *Rhyzopertha dominica* and *Dinoderus minutus* (Fabricius) (Coleoptera: Bostrichidae), *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) and *Cryptolestes ferrugineus* Stephens (Coleoptera: Cucujidae) (Faroni et al., 2000, 2001; Oliveira et al., 2002, 2003a, 2003b). The information regarding its host spectrum is scanty and need more investigations. Oliveira (2001) reported the ability of *A. lacunatus* in parasitising more than one insect species and suggested that this mite can maintain itself, even in absence of *R. dominica*, in the eggs of other hosts, such as *T. castaneum, C. ferrugineus* and *Dinoderus minutus* (Fabricius) (Coleoptera: Bostrichidae). This capacity allows for its success in the deteriorating conditions and with little available food.

The following study was done to evaluate the preference of *A. lacunatus* for the eggs of the hosts *T. castaneum, C. ferrugineus* and *R. dominica*, when it was maintained on one of these hosts for successive generations, and to determine if there is selection in the lines of this mites having better performance on insects.

Material and methods

The populations *R. dominica, C. ferrugineus* and *T. castaneum*, used in this study were raised continuously on coarsely ground wheat grains, at 13 % moisture content, in glass jars of 1.7L capacity. Before use, the grains were frozen at -10 °C for 15 days. All the populations were maintained at 28 ± 2 °C, 65 ± 5 % relative humidity (rh) and 24h escotophase (Oliveira, 2001).

The populations of *A. lacunatus* were raised and maintained separately on colonies of *R. dominica, C. ferrugineus* or *T. castaneum*, in glass jars of 1.7 L capacity containing non-treated wheat grains at 13 % moisture content, 28 ± 2 °C, 65 ± 5 % (rh) and 24h escotophase (Oliveira, 2001).

The eggs of each insect host were collected by sieving the mite-free colonies through a 1 mm sieve, and placed, separately, in the center of a 10-cm culture plate. The newly emerged females

of *A. lacunatus*, from the each host population were transferred to the culture plates containing the eggs of the respective host on which they were raised. After 24h the females of *A. lacunatus* in the physogastric process and fixed to the eggs were collected.

The preference tests were done using the eggs of *R. dominica*, *C. ferrugineus* and *T. castaneum*, collected as described previously. The experiment was done in arenas represented by 5-cm culture plates, which were divided into three equidistant regions as described by Oliveira et al. (2003a), and each region received the eggs a single insect host. One physogastric female of *A. lacunatus*, close to emergence of progenies, was liberated in the center (equidistant from the host eggs) of the arena. This way, the individual of the progeny soon after emergence had free access to the eggs of any of the three hosts. Mite escape was avoided by covering the arenas with a PVC film. The arenas were maintained at 28 ± 2 °C, 65 ± 5 % (rh) and 24h escotophase. The observations were done at 12-h interval until the mite progenies fixed to some egg or till the eclosion of the insect larvae. The experiment was done in five replications for each treatment (physogastric females of *A. lacunatus* obtained from the eggs of each of the three hosts). The number of eggs of each host parasitized along the time was calculated. The trials were repeated at the 30-day interval for nine months, to evaluate the performance of various generations of *A. lacunatus* when maintained only on either of the host insect.

Data analysis

The nine month results of egg preference test were analyzed by the repeated analysis of variance, using the computer program SAS (SAS Institute 1989). Thus, for each time (hours) of evaluation the average number of parasitized eggs from month-1 to month-9 was used. According to Von Ende (1993), this type of analysis, tests the hypothesis of "parallelism", "horizontality" and "levels", allowing for the interpretations of factors between and within the plots (time x its interactions) in an experiment.

Comparing the first and the last generation allowed for better understanding of the events regarding the preference of *A. lacunatus* for the eggs of different hosts, which can be helpful in the selection of lines on the three hosts.

Results

In the analysis of variance with repeated means, the "parallelism" is tested on the bases of significance of time x host interaction, and in the absence of significance the curves are parallel. In the present study, the interaction was not significant whether *A. lacunatus* was sourced from the population of *T. castaneum* (Table 1), *C. ferrugineus* (Table 2) or of *R. dominica* (Table 3).

The effect of time was tested through the significance of "horizontality" of the curves, e.g. if the time is not significant, the graphic representation is a line parallel to time axis. The test of "levels" corresponds to the effect of host species. The tests of "horizontality" and "levels" become irrelevant, if time x treatment interaction is significant. In this study, the mite *A. lacunatus* showed significant differences in the parasitism of eggs when exposed to *T. castaneum*, *C. ferrugineus* or *R. dominica* for 84 hours, independent of host on which they were maintained (Tables 1, 2 and 3).

When maintained on *C. ferrugineus*, the parasitism of the mite was influenced as much by the time as by the months (Table 2), increasing linearly in both cases (Figure 2). However, when raised on *T. castaneum* or *R. dominica*, the parasitism was not affected by the months (Tables 1 and 3), which increased linearly (Figures 1 and 3). Significantly more eggs of *R. dominica* were parasitized when *A. lacunatus* was raised on it or on *T. castaneum* (Figure 1 and 3), especially in the first month of the evaluation. However, when *A. lacunatus* was sourced from *C. ferrugineus* (Figure 2), the parasitism of eggs of *C. ferrugineus* and *R. dominica* was similar, indicating a clear preference for eggs of these hosts against *T. castaneum*.

Table 1. Multivariate analysis with repeated means, of the number of eggs of the hosts *T. castaneum, C. ferrugineus* and *R. dominica* parasitized by the individuals of *A. lacunatus* maintained for successive generations on *T. castaneum,* in a test for selection of choice. The effects are computed among plots (a) and within plots (b).

(a) Among plots					
Source of Variation		F	Degrees of	Freedom	*p*
Months		2,72	1		0,11
Hosts		20,92	2		< 0,0001 *
(b) Within Plots					
Source of Variation	Wilks' Lambda	F	Degrees of	Freedom	*p*
				Numerator	Denominator
Time	0,1202	23,18	6	19	< 0,0001 *
Time X Months	0,7816	0,88	6	19	0,52
Time X Hosts	0,7131	0,58	12	38	0,84
Time X Months X Hosts	0,5814	0,98	12	38	0,48

* Significant at 5% by F-test.

Table 2. Multivariate analysis with repeated means, of the number of eggs of the hosts *T. castaneum, C. ferrugineus* and *R. dominica* parasitized by the individuals of *A. lacunatus* maintained for successive generations on *C. ferrugineus,* in a test for selection of choice. The effects are computed among plots (a) and within plots (b).

(a) Among plots					
Source of Variation		F	Degrees of	Freedom	*p*
Months		23,08	1		< 0,0001 *
Hosts		35,43	2		< 0,0001 *
(b) Within Plots					
Source of Variation	Wilks' Lambda	F	Degrees of	Freedom	*p*
			Numerator	Denominator	
Time	0,2331	10,42	6	19	< 0,0001 *
Time X Months	0,7912	0,84	6	19	0,56
Time X Hosts	0,6684	0,71	12	38	0,74
Time X Months X Hosts	0,7707	0,44	12	38	0,93

* Significant at 5% by F-test.

Table 3. Multivariate analysis with repeated means, of the number of eggs of the hosts *T. castaneum*, *C. ferrugineus* and *R. dominica* parasitized by the individuals of *A. lacunatus* maintained for successive generations on *R. dominica*, in a test for selection of choice. The effects are computed among plots (a) and within plots (b).

(a) Among Plots					
Source of Variation		F	Degrees of	Freedom	*p*
Months		2,26	1		0,15
Hosts		64,09	2		< 0,0001 *
(b) Within Plots					
Source of Variation	Wilks' Lambda	F	Degrees of	Freedom	*p*
			Numerator	Denominator	
Time	0,1413	19,24	6	19	< 0,0001 *
Time X Months	0,4750	3,50	6	19	0,01*
Time X Hosts	0,4260	1,68	12	38	0,11
Time X Months X Hosts	0,5499	0,68	12	38	0,98

* Significant at 5% by F-test.

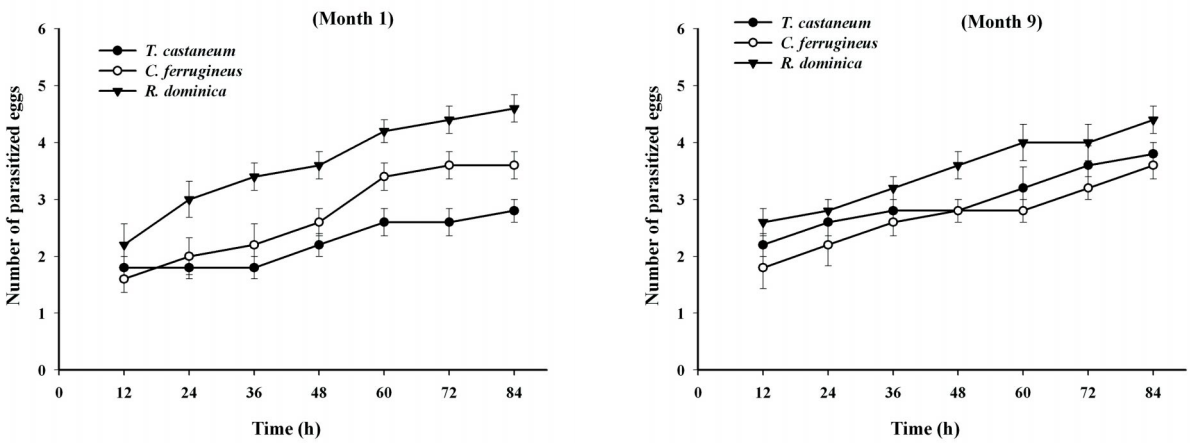

Figure 1. Variation in the parasitism of eggs different hosts by the female of the mite *A. lacunatus* maintained on *T. castaneum*, for one or nine months.

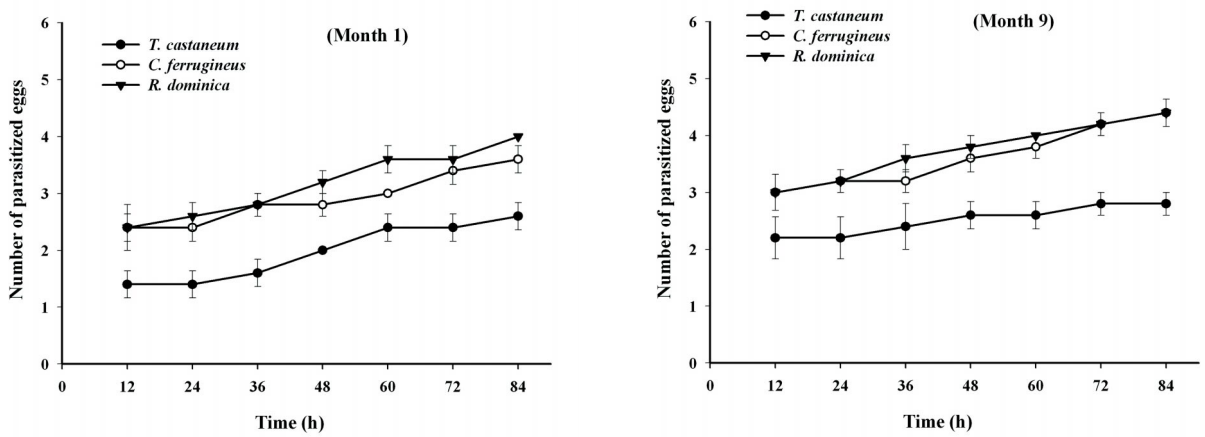

Figure 2. Variation in the parasitism of eggs of different hosts by the female of the mite *A. lacunatus* maintained on *C. ferrugineus*, for one or nine months.

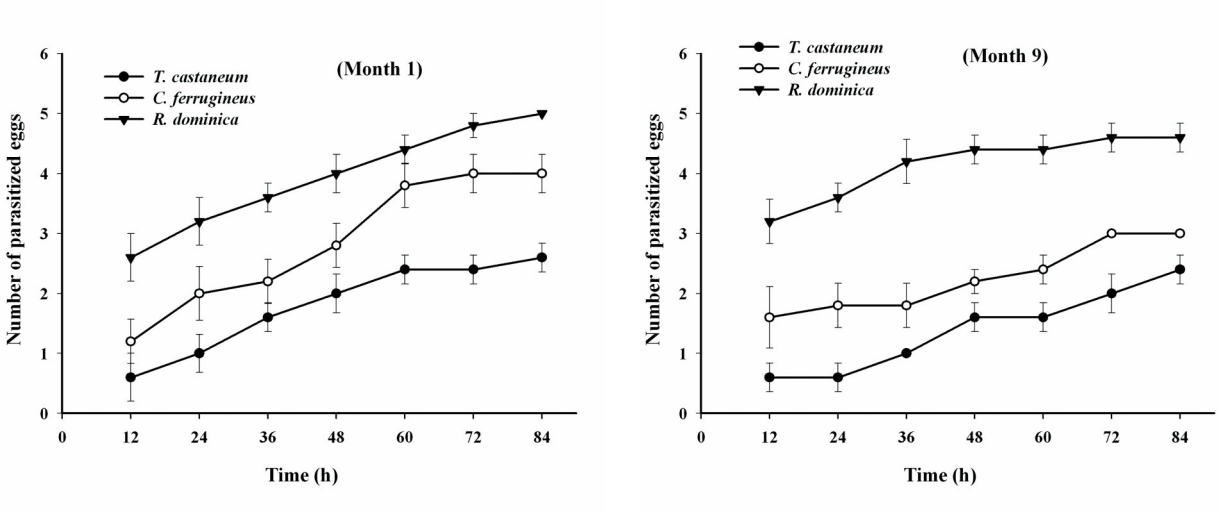

Figure 3. Variation in the parasitism of the eggs of different hosts by the female of the mite *A. lacunatus* maintained on *R. dominica*, for one or nine months.

Discussion

The data from this study show that the parasitism of *A. lacunatus* is influenced by the host species on which it is raised and maintained. In the Laboratório de Grãos Armazenados do Departamento de Engenharia Agrícola, Universidade Federal de Viçosa (UFV), this mite is raised and maintained continuously for years on *R. dominica*. When *A. lacunatus* was maintained on *T. castaneum*, significantly more eggs of this host were parasitized than when raised on the other two hosts, in which case *R. dominica* and *C. ferrugineus* were the preferred hosts. This indicates that maintaining biological control mites on a given host, for several generations, can improve its performance on that host. The difference of preference is equalized in months, which suggests that it is possible to select mites with increased parasitism in an artificial manner if raised on *T. castaneum* population.

The *A. lacunatus* showed preference for the eggs of *C. ferrugineus* and *R. dominica* compared to those of *T. castaneum*, when maintained on *C. ferrugineus*, suggesting conditioning of successive generations of the mite on *C. ferrugineus* also favored the selection of the eggs of this coleopteron by the individuals of the future generations. The mites sourced from *R. dominica* showed preference for eggs of this host, however, it should be emphasized that in Brazil, *A. lacunatus* is being maintained on *R. dominica*, since its introduction in 1992, indicating that this habit preference for *R. dominica* can be fixed genetically.

Oliveira et al. (2003a) found similar results in studies with the coleopterons *R. dominica*, *D. minutus* and *T. castaneum*. On offering eggs of these coleopterons in test of choice, the mite *A. lacunatus* showed a clear preference for the eggs of *R. dominica* and *D. minutus*, in relation to *T. castaneum*, probably because that former two coleopterons are correlated species and belonged to the same family. Presumably the eggs of *R. dominica* and *D. minutus* have morphological and nutritional similarity, which consequently, influenced the choice.

It is important to note that the eggs of *C. ferrugineus* are smaller than those of *T. castaneum* and *R. dominica*, thus may constitute an inferior resource. On the other hand, the lines of this mite can be selected for better efficiency in a research program of greater time span, because genotypes capable of attacking new hosts are selected, or the preference for *R. dominica* is

really fixed genetically.

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