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Life table of the red spider mite *Tetranychus bastosi* (Acari: Tetranychidae) on different host plants.

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ABSTRACT — *Tetranychus bastosi* Tuttle, Baker & Sales was described from Ceará state, northeastern Brazil. It has so far been reported from 25 plant species, among which cassava (*Manihot esculenta* Crants), common bean (*Phaseolus vulgaris* L.) and papaya (*Carica papaya* L). Although there is no information about its impact on crop yield, high population levels have been observed on some crops, leading to suppose that damage might occur in some occasions. In this study, fertility life table parameters were calculated for *T. bastosi* on cassava, common bean and papaya at 25 ± 2 °C, 70 ± 5% RH and photoperiod of 12/12 h. The best performance of *T. bastosi* occurred on *C. papaya* and *P. vulgaris*, on which the intrinsic rate of population increase reached 0.184 and 0.183 female/female/day, respectively. These results agree with the most common occurrence of this mite on papaya and on common bean than on cassava.

KEYWORDS — biology; phytophagous mite; performance; *Carica papaya*; *Phaseolus vulgaris*; *Manihot esculenta*

INTRODUCTION

Tetranychus bastosi Tuttle, Baker & Sales was originally described from specimens collected on red mulberry, *Morus rubra* L. (Moraceae), in Crato, Ceará state, Brazil (Tuttle *et al* 1977). It now seems to be widespread in that country, where it has been reported from the northern, northeastern and southeastern regions; it still has not been reported from other countries (Migeon & Dorkeld 2006). *Tetranychus bastosi* has been found on 25 plant species (Bastos *et al* 1979, Moraes & Flechtmann 1980, 1981, Bolland *et al* 1998, Santos *et al* 2010, Mendonça *et al* 2011, Sarmento *et al* 2011, Cruz *et al* 2012, Lofego *et al* 2013, Rosado *et al* 2014). It has been mentioned as a potential pest of some crops (Moraes & Flechtmann 2008, Santos *et al* 2010). Among the plants cultivated in northeastern Brazil, *T. bastosi* seems to reach particularly higher levels on bean (*Phaseolus vulgaris* L.) plants. The biology of this mite was studied on *Jatropha curcas* L. (Euphorbiaceae) (Pedro Neto *et al* 2013), which has been considered for cultivation in several tropical countries for biodiesel production (Openshaw, 2000).

Thus, the objective of this paper was to compare the biotic potential of *T. bastosi* on bean plants and two other plant species onto which it has been found, namely cassava (*Manihot esculenta* Crantz) and papaya (*Carica papaya* L.), all important crops in Brazil. Our hypothesis was that *T. bastosi* has a better biological performance on bean than on

those other plant species. Although there is no official information on the economic importance of this mite species, it has become increasingly common in northeastern Brazil and information about their biology are necessary for their management.

MATERIALS AND METHODS

Approximately 300 specimens of *T. bastosi* were collected from *Turnera subulata* Sm. (Turneraceae), in Crato (7°05'S – 39°40'W and 461 m altitude), Ceará state. These were used to establish stock colonies on cassava, common bean and papaya plantlets. The colonies were maintained separately for at least three months before the beginning of the evaluations, in a greenhouse, at ambient conditions. Tests were conducted at 25 ± 2 °C, 70 ± 5% RH and photoperiod of 12/12 h.

To obtain the eggs to start the evaluations, a group of 50 females was transferred from each stock colony to separate experimental units consisting of a piece (4 x 4 cm) of a leaf of the respective plant species onto which they had been held, placed with the abaxial surface up onto a disk of polyethylene foam mat in a Petri dish. The edges of the leaf piece were covered by a strip of cotton wool that contacted the polyurethane mat, which was maintained wet by daily addition of distilled water.

Eight hours later, the females were removed and the eggs laid were observed every 8 h to determine survivorship and duration of embryonic development. After hatching, each larva was isolated in an experimental unit similar to that described in the previous paragraph. Post-embryonic immatures were also observed every 8 h to determine survivorship and duration of each stage. After adult emergence, males were kept in isolation, whereas one male from the stock colony was transferred to each unit containing a recently molted female. When dead, males were replaced by new males from the same source. Oviposition level was determined by daily examination of each unit. The experimental units were replaced periodically (every third to fourth day) to ensure adequate physiological conditions of leaf piece. The progeny of each female was reared separately to adulthood to determine sex ratio.

Data analysis was done within a completely randomized design, with three treatments, each corresponding to a plant species, and each replicate corresponding to one mite. The test was initiated with 142 eggs when the substrate was *P. vulgaris* and 125 eggs on each of the other substrates. Data were tested for normality and homogeneity of variance and subsequently subjected to variance analysis and compared by Tukey's HSD test (5% significance level), using the software GraphPad Prism 5 version.

Fertility life tables were prepared according to Birch (1948). Biological parameters and estimates for their variances were calculated by "LifeTable SAS" (SAS Institute 1999-2001), adapted by Maia *et al* (2000). Biotic parameters were compared by Student´s t tests.

TABLE 1: Mean duration (± Standard Error) in days of the immature stages of *Tetranychus bastosi* on three different host plants, at 25 ± 2 °C, 70 ± 5% RH and 12h/12h photophase. Number in parenthesis below each host plant indicates respectively the number of females and males reaching adulthood.

Stage	Host Plants		
	P. vulgaris (122; 14)	*C. papaya* (93; 18)	*M. esculenta* (86; 20)
Females			
Egg	4.5 ± 0.02 **a**	4.5 ± 0.05 **a**	4.9 ± 0.02 **b**
Larva	2.4 ± 0.05 **a**	2.5 ± 0.05 **a**	2.8 ± 0.12 **b**
Protonymph	2.1 ± 0.07 **ab**	1.8 ± 0.10 **a**	2.3 ± 0.14 **b**
Deutonymph	1.8 ± 0.07 **a**	1.8 ± 0.11 **a**	1.8 ± 0.15 **a**
Egg – adult	10.5 ± 0.29 **a**	11.2 ± 0.18 **a**	12.3 ± 0.24 **b**
Males			
Egg	4.5 ± 0.08 **a**	4.8 ± 0.20 **a**	4.9 ± 0.05 **a**
Larva	2.4 ± 0.11 **a**	2.3 ± 0.09 **a**	3.1 ± 0.23 **b**
Protonymph	1.6 ± 0.11 **a**	2.0 ± 0.09 **a**	2.3 ± 0.15 **b**
Deutonymph	1.8 ± 0.23 **a**	2.2 ± 0.15 **a**	2.5 ± 0.23 **a**
Egg – adult	10.3 ± 0.81 **a**	11.7 ± 0.25 **a**	13.4 ± 0.32 **b**
Females and Males			
Egg	4.5 ± 0.02 **a**	4.6 ± 0.05 **a**	4.9 ± 0.01 **b**
Larva	2.4 ± 0.04 **a**	2.5 ± 0.04 **a**	2.8 ± 0.10 **b**
Protonymph	2.0 ± 0.07 **ab**	1.9 ± 0.08 **a**	2.3 ± 0.12 **b**
Deutonymph	1.8 ± 0.06 **a**	1.9 ± 0.10 **a**	2.0 ± 0.13 **a**
Egg – adult	10.5 ± 0.28 **a**	11.3 ± 0.16 **a**	12.5 ± 0.21 **b**

Means followed by the same letters in each line do not differ by Tukey´s test ($P < 0.05$).

TABLE 2: Mean duration (± Standard Error) in days of the different periods of *Tetranychus bastosi* adult female reared on three different host plants at 25 ± 2 ° C, 70 ± 5% RH and 12h/12h photophase.

Host	Periods				
	Nº	Pre-oviposition	Oviposition	Post-oviposition	Longevity
P. vulgaris	41	1.6 ± 0.1 **a**	8.2 ± 0.4 **a**	0.0 ± 0.0 **a**	16.9 ± 0.6 **a**
C. papaya	40	1.8 ± 0.1 **a**	9.5 ± 0.5 **a**	0.3 ± 0.2 **b**	18.5 ± 0.6 **b**
M. esculenta	40	2.0 ± 0.2 **a**	8.2 ± 0.5 **a**	0.7 ± 0.2 **b**	13.0 ± 0.6 **a**

Means followed by the same letters in each column do not differ by Tukey´s test (P< 0.05).

RESULTS

For females and males, durations of each stage and of the whole immature phase were generally similar on the different host plants, although significant differences were observed for some developmental stages and in those cases the longest durations were observed on *M. esculenta* ($F_{(0.823)}$ = 772, P < 0.0001) (Table 1).

Development from egg to adult female ranged from 10.5 days on *P. vulgaris* to 12.3 days on *M. esculenta*, whereas development from egg to adult male ranged from 10.3 days on *P. vulgaris* to 13.4 days on *M. esculenta*. Consequently, a similar pattern was observed when females and males were considered together, with durations from egg to adult ranging from 10.5 days on *P. vulgaris* to 12.5 days on *M. esculenta*.

No significant differences were observed for the durations of pre-oviposition and oviposition periods on the different host plants, but the duration of the post-oviposition period was significantly shorter on *P. vulgaris* ($F_{(2,118)}$ = 5.37, P < 0.0059) and longevity was longer on *C. papaya* ($F_{(2,98)}$ = 1.54, P < 0.219) (Table 2).

Total fecundity and daily oviposition rate were significantly higher on *C. papaya* (respectively $F_{(2,118)}$ = 14.16, P < 0.0001 and $F_{(2,118)}$ = 56.60, P < 0.0001) (Table 3).

These parameters were almost twice as high on *C. papaya* as on *M. esculenta*, and intermediate in *P. vulgaris*. Sex ratio (proportion of females) was high on the three host plants in both parental and F1 generations, ranging between 0.80 and 0.89.

TABLE 3: Oviposition (± SE) and sex ratio (% females) of *Tetranychus bastosi* on three different host plants at 25 ± 2 °C, 70 ± 5% RH and 12h/12h photophase.

Host plants	Eggs/female	Eggs/female/day	Sex ratio	
			Parental	F_1
P. vulgaris	36.1 ± 2.5 **a**	1.5 ± 0,1 **b**	0.89	0.88
C. papaya	50.6 ± 4.4 **b**	2.1 ± 0.2 **c**	0.80	0.88
M. esculenta	26.5 ± 2.2 **a**	1.1 ± 0.1 **a**	0.81	0.86

Means followed by the same letters in each column do not differ by Tukey´s test (P< 0.05).

Calculated life table parameters (Table 4) showed best performance of *T. bastosi* on *C. papaya* and *P. vulgaris*, which was compatible with the significant slower immature development and lower reproduction rates on *M. esculenta*.

TABLE 4: Biological parameters of *Tetranychus bastosi* reared on three different host plants, 25 ± 2 °C, 70 ± 5% RH and 12h/12h photophase.

Biological Parameters	Host Plants		
	C. papaya	*P. vulgaris*	*M. esculenta*
R_0	32.0 **b** (29.2 - 34.8)	25.4 **b** (23.6 - 27.2)	16.8 **a** (15.4 - 18.2)
T	18.9 **a** (18.4 - 19.1)	17.7 **a** (17.3 - 17.9)	22.1 **a** (21.5 - 22.3)
r_m	0.184 **b** (0.181 - 0.188)	0.183 **b** (0.180 - 0.186)	0.128 **a** (0.125 - 0.132)
l	1.20 **b** (1.19 - 1.21)	1.20 **b** (1.19 - 1.20)	1.13 **a** (1.13 - 1.14)
Dt	3.8 **a** (3.7 - 3.8)	3.8 **a** (3.7 - 3.8)	5.4 **b** (5.2 - 5.5)

Means (Confidence Interval- 95%) followed by the same letter in the same line, do not differ by comparisons of treatments two by two with confidence interval at 95% probability after estimating errors by the Jackknife method.

In summary, *T. bastosi* had higher net reproductive rates (R_0 respectively 32.0 and 25.4), intrinsec

rate of population increase (r_m 0.184 and 0.183) and finite rate of population increase (λ both 1.20), and shorter doubling time (Dt both 3.8) on *C. papaya* and *P. vulgaris*, respectively.

Discussion

The results indicated that papaya and common bean were the best hosts for *T. bastosi*, allowing quicker development of the immature stages and higher oviposition rates. These partially confirmed our hypothesis. Biotic parameters determined on those hosts were lower than determined by Pedro Neto *et al* (2013) for the same mite species on *J. curcas*, but their study was conducted at slightly higher temperature (26 °C). Yet, the population growth was higher than determined for another world important tetranychid pest, the two spotted spider mite, *Tetranychus urticae* Koch, on several plant species (Modarres Najafabadi *et al* 2014; Riahi *et al* 2013; Silva *et al* 2009; Fazlul Hoque *et al* 2008). *Tetranychus urticae* is an important pest of papaya and common bean in Brazil. However, in the drier areas of northeastern Brazil, *T. bastosi* occurs more frequently on irrigated *C. papaya* than *T. urticae* and may cause significant damage to this crop (Moraes & Flechtmann 1980; Moraes & Flechtmann 2008).

In the urban area of Piracicaba, São Paulo state, in southeastern Brazil, *T. bastosi* has been found in large populations on *Amaranthus* sp. and *Turnera* sp. during the dry season, leaving other neighboring plant species untouched. Quite often, the phytoseiid mite *Neoseiulus idaeus* Denmark & Muma is found on those plants preying upon the different stages of *T. bastosi*, as reported by Moraes & McMurtry (1983) in northeastern Brazil. Preliminary trials conducted in greenhouses have shown that when infested leaves are transfered from those plants onto common bean plants, the mite attain high population levels. *Tetranychus bastosi* may actually be more widespread than presently known, given its great morphological similarity with other red species of tetranychid mites, from which they can be separated by the shape of the male aedeagus (Tuttle *et al* 1977).

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