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Biological Performance of *Tetranychus bastosi* (Acari: Tetranychidae) on different hosts

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Original research

ABSTRACT

Tetranychus bastosi Tuttle, Baker & Sales (Acari: Tetranychidae) has been observed in more than 36 host species and it is considered a potential pest mite for several crops, however its occurrence is still restricted to Brazil. The present study determined the biological, reproductive parameters and host preference of *T. bastosi* in three plant species: *Morus rubra* L. (Moraceae); *Ipomoea batatas* L. (Convolvulaceae); and *Psidium guajava* L. (Myrtaceae). The incubation period of *T. bastosi* eggs was longer in *M. rubra* (5.9 days), followed by *I. batatas* and *P. guajava* (4.0 days for both). The longest larval period was observed in *P. guajava* (5.7 days). The longest durations of the protonymph and deutonymph stages were recorded in *P. guajava* (3 days) and *M. rubra* (2.3 days). However, *T. bastosi* could not complete its life cycle on *P. guajava*. The longest period from egg to adult of *T. bastosi* was observed in *I. batatas* (30 days). The highest longevity of *T. bastosi* was observed in the hosts *I. batatas* and *M. rubra* (39.8 and 30.2 days, respectively). The longest average duration of a generation (T) was observed on *M. rubra* 21.3 days. Nevertheless, for the intrinsic capacity for population increase (rm) and finite rate of increase (λ) no differences were observed on *I. batatas* and *M. rubra*. In this sense, *T. bastosi* presents a high biological performance in *I. batatas* and *M. rubra*, however *P. guajava* was not considered a suitable host for the red spider mite.

Keywords red spider mite; fertility life table; populational parameters; host plant

Introduction

Tetranychidae spider mites include several ubiquitous pests of major crops around the globe, motivating a large number of studies (Bolland *et al.* 1998; Migeon and Dorkeld 2010). *Tetranychus bastosi* Tuttle, Baker & Sales, 1977 (Acari: Tetranychidae) has been reported infesting 36 host plants, among ornamental, fruit, leguminous and wild plants, however its occurrence is still restricted to Brazil (Bastos *et al.* 1979; Moraes and Flechtmann 1980, 1981; Bolland *et al.* 1998; Santos *et al.* 2010; Mendonça *et al.* 2011; Cruz *et al.* 2012; Lofego *et al.* 2013; Rosado *et al.* 2014).

The first record of *T. bastosi* dates from 1977 on *Morus rubra* L. (Moraceae) (mulberry) in the state of Ceará, Brazil (Tuttle *et al.* 1977). Recently, *T. bastosi* has been observed causing 100% of yield losses on *Ipomoea batatas* L. (Convolvulaceae) (Lima and Breda 2021). Also, new reports of the occurrence of *T. bastosi* on *Psidium guajava* L. (Myrtaceae) were observed (Furtado *et al.* 2015 unpublished data).

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The oviposition of *T. bastosi* on its hosts begins after the females have produced a significant amount of web, usually establishing colonies on the abaxial surface of the leaves, causing chlorotic spots and damaging plant growth (Santos *et al.* 2010; Lima *et al.* 2017; Barros 2013). Nevertheless, the biological performance of *T. bastosi* can be influenced by the host plant species, including intraspecific variations of different genotypes (Barros 2013; Lima *et al.* 2017). Overall, there are few studies regarding ecological aspects and the development of *T. bastosi* on different hosts of economic crops, as papaya, *Carica papaya* L. (Caricaceae) and common bean, *Phaseolus vulgaris* L. (Fabaceae) (Lima *et al.* 2017) in addition to *Jatropha curcas* L. (Euphorbiaceae) (Barros *et al.* 2013; Marçal *et al.* 2013) and cassava, *Manihot esculenta* Crantz (Euphorbiaceae) (Lima *et al.* 2017).

Thus, the objective of the present study was to evaluate the biological performance of *T. bastosi* on *M. rubra*, *I. batatas* and *P. guajava* to identify the potential for colonization and infestation of *T. bastosi* on different host species.

Material and methods

Tetranychus bastosi rearing

Stock rearing was maintained in jack bean plants *Canavalia ensiformis** L. (Fabaceae), grown in plastic pots (2 L) containing a mixture of soil and Basaplant® substrate (1:1). Healthy plants were infested through direct contact with leaves of plants infested with the mite. The stock of *T. bastosi* was maintained at the Laboratory of Agricultural and Forestry Entomology (LEAF/CECA/UFAL) with a temperature of 25±1 °C, 70±5% RH and 12h photophase.

Biological features of *T. bastosi*

To obtain eggs, 50 females of *T. bastosi* were removed from the stock breeding and placed in an experimental unit for oviposition. The experimental unit consisted of a Petri dish (Ø 9cm) containing a polyethylene foam (1 cm thick), moistened with distilled water. On the set, discs of leaves (Ø 5.0 cm) of the selected host species were placed, surrounded by strips of hydrophilic cotton. Eggs were observed every 12 hours to determine the viability and duration of egg phase. After hatching, the larvae were individualized in experimental units formed inside arenas, which consists of a plastic container (26 cm long, 16 cm wide and 4 cm high) containing inside a polyethylene foam rectangle (20 cm long, 11 cm wide and 1 cm high). In each arena, eight experimental units were formed. Each experimental unit consisted of a 5.0 cm (Ø) leaf disc of the selected host species, surrounded by strips of cotton wool moistened with distilled water, to prevent mites from escaping and maintain leaf turgidity. The mites were observed every 12h, determining the viability and duration of the larva, protonymph and deutonymph stages. After the emergence of adults, males and females were observed separately every 24 hours to determine longevity. Chrysalis phases were not observed. It was not possible to calculate the duration of immature phases considering males and females.

The experiment design was completely randomized, with three treatments consisting of the plant species *M. rubra*, *I. batatas* and *P. guajava* and 100 replications per treatment, where each experimental unit represented a replication. Data were analyzed using the Two-sex life table statistical package (Chi 1988) and the TWSEX-MSChart program (Chi 2017).

Tetranychus bastosi fertility life table

Fertility life table parameters were obtained regarding the net reproduction rate (R_0), intrinsic growth rate (r_m), duration of one generation (T), finite rate of increase (λ), stage-age specific survival (s_{xj}), survival rate (l_x) and specific fecundity (m_x). Data were analyzed based on stage and age, using the Two-sex life table statistical package (Chi 1988) and the TWSEX-MSChart program (Chi 2017).

Population standard errors were estimated using the bootstrap method. A number equivalent to 100,000 bootstraps was used to obtain stable estimates of standard error. The paired bootstrap test was used to compare statistical differences (Efron and Tibshirani 1993). The computer program TWSEX-MSChart (Chi 2017) was used for the analysis and calculation of population parameters.

Results

Development of the immature stage

The viability of the immature stages of egg, larva and protonymph of *T. bastosi* was observed for the three hosts under study, however postembryonic development was completed only in *M. rubra* and *I. batatas* (Table 1). The incubation period of *T. bastosi* eggs showed a statistical difference between *M. rubra* (5.6 days) and the other plant species involved in the bioassay, *I. batatas* and *P. guajava* (4.0 days for both). The longest larval period was observed when *T. bastosi* was fed with *P. guajava* (5.7 days), differing from *M. rubra* and *I. batatas* (4.0 days). The protonymph stage lasted longer in *P. guajava* (3.0 days), differing from *M. rubra* (2.1 days) and *I. batatas* (1.6 days). The deutonymph stage was not observed on *P. guajava*, however, when compared to the other hosts, on *M. rubra* had a longer duration (2.3 days), statistically differing from *I. batatas* (1.5 days). When the development from egg to adult was evaluated, significant differences between the treatments *M. rubra* (12.8 days) and *I. batatas* (9.8 days) were observed. *T. bastosi* did not complete the cycle (egg-adult) when the host was *P. guajava* (Table 1).

Adult longevity and reproduction

The different host species significantly influenced the longevity of *T. bastosi* females (Table 2). The highest longevity of *T. bastosi* was observed in the host *I. batatas* (39.7 days), statistically differing from that of *M. rubra* (30.2 days). The pre-oviposition, oviposition and fecundity periods were not affected.

Table 1 Mean duration in days (mean ± standard error) of immature stages of *Tetranychus bastosi*, on three different host plants (*Morus rubra* L., *Ipomoea batatas* L. and *Psidium guajava* L.). (Temperature=25±1 °C, Relative Humidity=70±5%, 12h photophase).

Host	Stage				
	Egg	Larva	Protonymph	Deutonymph	Egg-Adult
<i>M. rubra</i>	5.6 ± 0.05 a	2.8 ± 0.05 b	2.1 ± 0.09 b	2.3 ± 0.07 a	12.8 ± 1.18 a
<i>I. batatas</i>	4.0 ± 0.00 b	2.7 ± 0.05 b	1.6 ± 0.05 c	1.5 ± 0.35 b	9.8 ± 0.06 b
<i>P. guajava</i>	4.0 ± 0.00 b	5.7 ± 0.14 a	3.0 ± 1.04 a	-	-

Means (± standard error) followed by the same letter in the column do not differ from each other by paired Bootstrap test at 5% significance.

Table 2 Duration in days (mean±EP) of reproductive parameters and longevity of female *Tetranychus bastosi* on different host plants (*Morus rubra* L. and *Ipomoea batatas* L.). (Temperature=25±1 °C, Relative Humidity=70±5%, 12h photophase).

Host	N	Pre-oviposition (days)	Oviposition (days)	Longevity (days)	Fecundity	Sex ratio
<i>M. rubra</i>	62	1.3±0.2 a	16.3±0.5a	30.2±1.1 b	18.9±3.8 a	0.68
<i>I. batatas</i>	100	1.6±0.2 a	11.9±5.8 a	39.7±0.3 a	15.5±3.6 a	1

Means (± standard error) followed by the same letter in the column do not differ from each other by paired Bootstrap test at 5% significance.

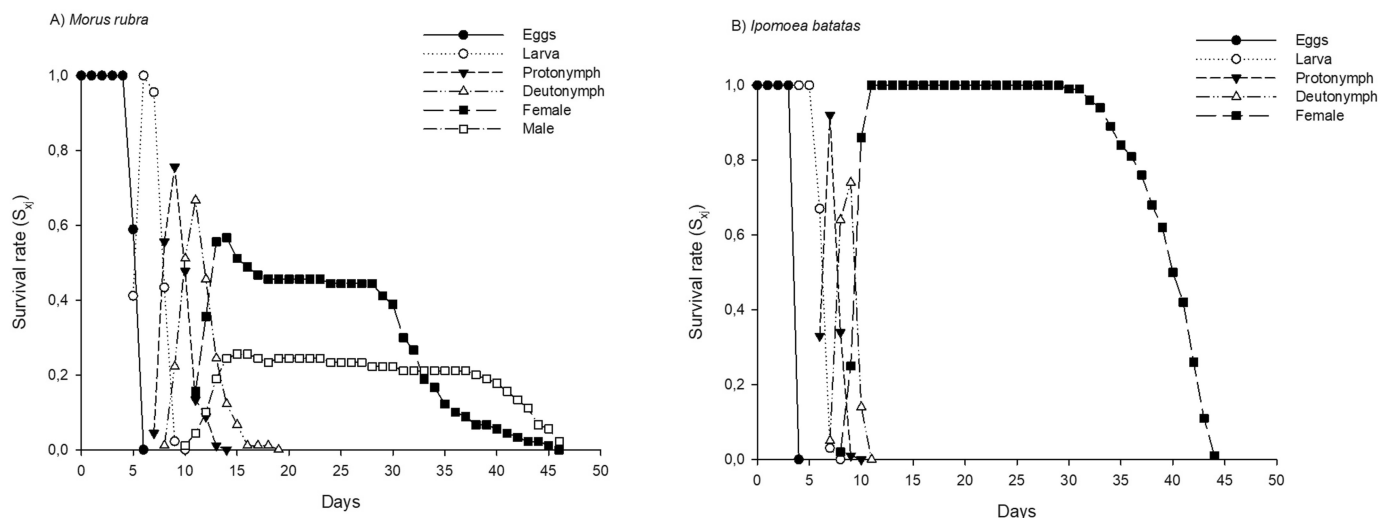


Figure 1 Age-stage-specific survival rate (S_{xj}) of *Tetranychus bastosi* in different hosts (*Morus rubra* L. and *Ipomoea batatas* L.) ($T=25\pm 1$ °C, $RH=70\pm 5\%$, 12h photophase). The age-specific survival rate (S_{xj}) represents the probability of survival of *T. bastosi* for each age x and stage j . The curves indicate differences between the stages of development and the survival of each specific age of *T. bastosi*.

Life table parameters

The larval, protonymph and deutonymph stages of *T. bastosi* overlapped in the two hosts, however the adult stage of *T. bastosi* achieved a higher survival rate when the mite was fed on *I. batatas* (Figure 1).

The specific fertility curves (m_x) fluctuated throughout the oviposition period, reaching values of 0.0 after 35 days for *M. rubra* and *I. batatas* (Figure 2). However, it is evident the expressive growth at the beginning of the oviposition period, around the 10th day, for both hosts. The maximum increase in specific fertility (m_x) of *T. bastosi* occurs approximately on the 25th day for *M. rubra*, remaining oscillating and decreasing sharply from the 30th day onwards. For *I. batatas*, the maximum values of specific fertility (m_x) were observed on the 15th day after the beginning of development, decreasing from this period onwards, as observed by the interaction between specific fertility (m_x) and survival (l_x) (Figure 2).

Regarding the parameters of the population life table of the mite *T. bastosi* the longest average duration of a generation (T) was observed on *M. rubra* (21.3 ± 0.48 days), which was different from *I. batatas* (17.9 ± 0.57 days) ($P=0.00002$) (Table 3). There were no significant differences for the net reproduction rate (R_0) for *I. batatas* (15.5 ± 3.6) and *M. rubra* (13.0 ± 2.7) ($P=0.58$). The highest intrinsic population growth capacity (r_m) did not differ among *I. batatas* (0.15 ± 0.1) and *M. rubra* (0.12 ± 0.01) ($P=0.075$), as well as the highest finite growth rate (λ) with values for *I. batatas* (1.16 ± 0.01) and *M. rubra* (1.12 ± 1.26) ($P=0.075$) (Table 3).

Discussion

Tetranychus bastosi was able to survive, reproduce and complete its development on *M. rubra* and *I. batatas*, however, it could not complete its life cycle on *P. guajava*. For that, it is suggested that the development of *T. bastosi* on *P. guajava* could be inhibited by chemical compounds of the secondary metabolism or limiting morphological factors (presence of trichomes, hairs, viscous substances, etc.) in the immature phase. In this sense, it is possible that new reports of the occurrence of *T. bastosi* on *P. guajava* may be at random, since this host was not a suitable for the red spider mite.

Mites have shown different parameters of development, fecundity and life table, according

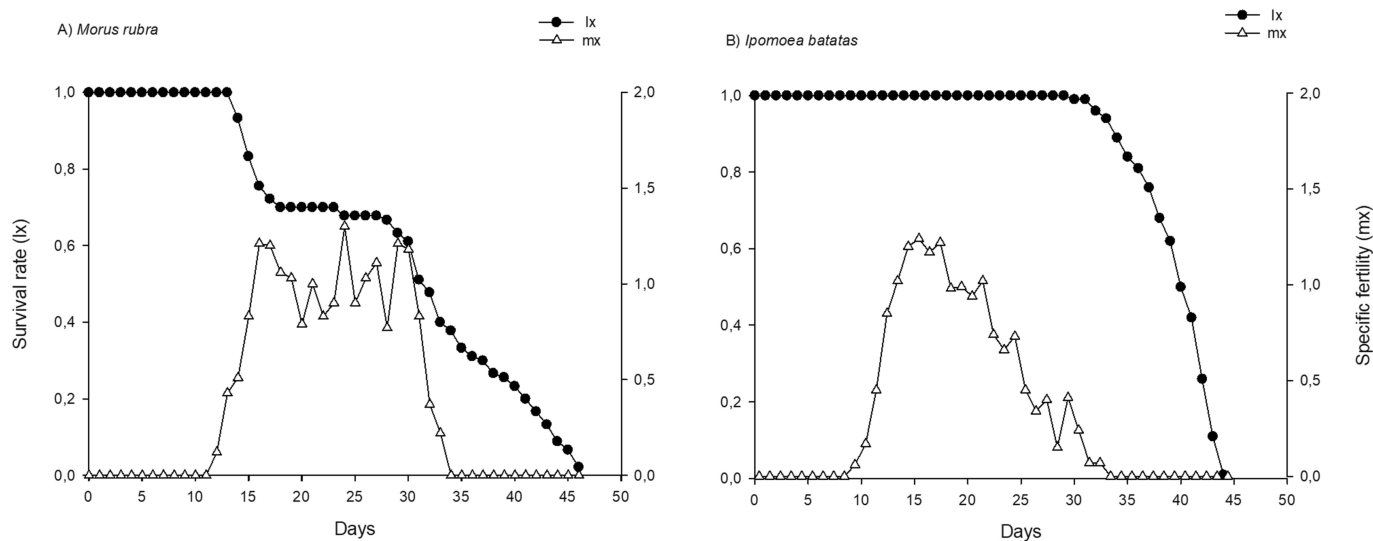


Figure 2 Specific fertility (mx) and survival rate (lx) of *Tetranychus bastosi* in different hosts (*Morus rubra* L. and *Ipomoea batatas* L.) (T=25±1 °C, RH=70±5%, 12h photophase).

to the host species, being affected not only by the species but also by the nutritional quality of the host (Helle and Sabelis 1985; Razmjou *et al.* 2009; Najafabadi 2012). The fecundity of *T. bastosi* in *I. batatas* and *M. rubra* was 15.5 and 18.9 eggs/female, respectively. These values are considered high when compared to the average fecundity of *T. bastosi* in *J. curcas* around 10.4 eggs/female (Marçal *et al.* 2013) and 7.08 to 10.88 eggs/female (Barros 2013). Our results indicate a high reproductive performance of *T. bastosi* on the hosts, with possibility to achieve major pest status on field, as observed previously for *I. batatas* (Lima and Breda 2021).

Lower longevity results than those of the present study were reported for females of *T. bastosi* on *J. curcas*, ranging from 9.16 to 13.88 days according to Barros (2013) and 16.0 days (Marçal *et al.* 2013). Females of *T. bastosi* on *P. vulgaris* and *M. esculenta* showed average longevity of 16.9 and 13.0 days, respectively (Lima *et al.* 2017). Information about the longevity period under controlled conditions may suggest a pre-availability and adaptation between *T. bastosi* and the host species.

For *I. batatas*, *T. bastosi* presented a sex ratio of 1, indicating that all eggs produced by females feeding on this host, origin only females. According to Young *et al.* (1986) female mites are able to control sex ratio according to several factors, including the oviposition environment and resource quality, however, further investigation is needed to fully understand

Table 3 Fertility life table parameters of *Tetranychus bastosi* in different hosts (*Morus rubra* L. and *Ipomoea batatas* L.). (Temperature=25±1 °C, Relative Humidity=70±5%, 12h photophase).

Host	Ro	T(days)	rm	λ
<i>M. rubra</i>	13.0 ± 2.7 a	21.3 ± 0.48 a	0.12 ± 0.01 a	1.12 ± 1.26 a
<i>I. batatas</i>	15.5 ± 3.6 a	17.9 ± 0.57 b	0.15 ± 0.1 a	1.16 ± 0.01 a

Ro = net reproduction rate. T = average duration of one generation. rm = intrinsic growth rate. λ = finite rate of increase. Means (± standard error) followed by the same letter in the column do not differ from each other by paired Bootstrap test at 5% significance.

this parameter.

The intrinsic rate of increase adequately summarizes the physiological qualities of a species and can also be assimilated to mites evaluating the ability to increase population (Golizadeh *et al.* 2017; Southwood and Henderson 2000). In the present study, high net development rates were observed for *I. batatas* and *M. rubra*, likewise, the innate capacity for population increase and the finite rate of population increase. Similar results of r_m for *T. bastosi* were observed in *J. curcas*, *P. vulgaris* and *M. esculenta* (0.05, 0.18 and 0.12, respectively) and λ (1.02, 1.20 and 1.13 respectively) (Marçal *et al.* 2013; Pedro Neto *et al.* 2013; Lima *et al.* 2017). Thus, *T. bastosi* presents a significant biological performance on the hosts *I. batatas* and *M. rubra*.

Conclusion

The biological performance of *T. bastosi* varied among the hosts, revealing that *I. batatas* and *M. rubra* are adequate hosts to *T. bastosi* while *P. guajava* was not suitable for *T. bastosi* development. Studies towards differences of biological traits in *T. bastosi* are scarce but may indicate its potential to achieve major pest status in the field. However, further studies are needed to fully understand the interactions among *T. bastosi* and its host plants.

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