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# Comparative biology and growth rate of the mites *Mononychellus tanajoa* and *Euseius ho* (Acari) on cassava

Biología comparada y tasa de crecimiento de los ácaros *Mononychellus tanajoa* y *Euseius ho* (Acari) en yuca

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**Abstract:** The cassava green mite, *Mononychellus tanajoa,* is an important pest of cassava, *Manihot esculenta* (Euphorbiaceae), in the northeastern state of Maranhão, Brazil. Predatory mites of the family Phytoseiidae are key natural enemies of pest mites and are found inhabiting cassava plants. We compared some biological aspects and the growth rate of *M. tanajoa* and the generalist phytoseiid *Euseius ho* - the most abundant predatory mite inhabiting cassava plants in the study region. All experiments were conducted in the laboratory on leaf discs of cassava leaves. The predatory mite was fed in all developmental stages with *M. tanajoa*. *Euseius ho* had lower periods of egg, larva, protonymph and deutonymph developmental periods, as well as the period from egg to adult compared to *M. tanajoa*. Furthermore, the predatory mite *E. ho* had a high instantaneous rate of increase ($r_i$), yet lower than that observed for its prey, the cassava green mite *M. tanajoa*. The laboratory results suggest that the predatory mite *E. ho* may contribute to regulate populations of *M. tanajoa* in the field.

**Key words:** Biological control. Phytophagous mite. Predatory mite.

**Resumen:** El ácaro verde *Mononychellus tanajoa* es una plaga importante de la yuca *Manihot esculenta* (Euphorbiaceae) en el nordeste del estado de Maranhão, Brasil. Los ácaros depredadores de la familia Phytoseiidae, son enemigos naturales clave de los ácaros plaga y se encuentran en plantas de yuca. Se compararon algunos de los aspectos biológicos y la tasa de crecimiento de *M. tanajoa* y *Euseius ho*, el ácaro depredador, generalista fitoseideo, más abundante en las plantas de yuca en la región de estudio. Todos los experimentos se llevaron a cabo en laboratorio en discos de hojas de yuca. El ácaro depredador se alimentó en todas las etapas de desarrollo con *M. tanajoa*. *Euseius ho* tuvo menores períodos de huevo, larva, protoninfa y deutoninfa, así como de huevo a adulto comparado con *M. tanajoa*. Además, el ácaro depredador *E. ho* presentó una alta tasa instantánea de crecimiento ($r_i$) aunque inferior a la observada a su presa, el ácaro verde de la yuca *M. tanajoa*. Los resultados de laboratorio indican que el ácaro depredador *E. ho* puede contribuir a regular las poblaciones de *M. tanajoa* en el campo.

**Palabras clave:** Control biológico. Ácaro fitófago. Ácaro depredador.

## Introduction

The cassava *Manihot esculenta* Crantz, 1766 (Euphorbiaceae) is grown in several tropical and subtropical regions of the world and is considered a major staple food (Henry and Hershey 2002; Hillocks 2002; Suja *et al.* 2010). In the Northeastern state of Maranhão, Brazil, cassava is cultivated by smallholders using slash and burn agricultural practices. In this region, cassava is one of the main crops food-securing smallholders.

Cassava is attacked by a variety of pests, among them the cassava green mite *Mononychellus tanajoa* (Bondar, 1938) (Acari: Tetranychidae). This mite is considered a key pest responsible for high yield losses (Yaninek *et al.* 1989; Moraes and Flechtmann 2008). The cassava green mite attacks shoots and leaves of cassava reducing both photosynthetic rate and root dry matter (Moraes and Flechtmann 2008; Yaninek *et al.* 1989; Yaninek *et al.* 1990). Management strategies ranging from pesticides to biological control agents may help to keep populations of the cassava green mite under damaging levels (Yaninek and Hanna 2003; Delalibera Jr and Hajek 2004; Delalibera Jr *et al.* 2004; Hanna *et al.* 2005).

Regarding the biological control, predatory phytoseiid mites are key natural enemies of pest mites (McMurtry *et al.* 1970; McMurtry and Croft 1997; Sarmento *et al*. 2011). Phytoseiid mites belonging to the genus *Euseius* are considered generalist predators as they feed on pollen, nectar as well as on pest mites of the families Tetranychidae, Tarsonemidae, Tenuipalpidae and Eriophyidae (McMurtry and Croft 1997). In Brazil, phytoseiid species like *Euseius citrifolius* Denmark and Muma, 1970 (Moraes and McMurtry 1981), *E. concordis* (Chant, 1959) (Moraes and Lima 1983) and *E. alatus* De Leon, 1966 (Melo *et al.* 2009) are widely studied in regard to their potential to control pest mites. The predatory mite *Euseius ho* (De Leon, 1965) occurs throughout Brazil and in other Latin American countries such as Argentina, Colombia, Peru, Ecuador, Mexico and Puerto Rico (Moraes *et al.* 2004). In the region where our study was conducted, *E. ho* is the most abundant predatory mite inhabiting cassava plants over the year (Unpublished data). Generalist predatory mites such as *E. ho* play a major role in reducing populations of pest mites as they are able to survive in periods where the target pest is scarce or absent (Tsitsilas *et al.* 2011). Here, we studied the importance of *E. ho* as a potential natural biological control agent of the cassava green mite by comparing some biological aspects and growth rates of both mites under laboratory conditions. We predicted that although being a generalist predator, *E. ho* may contribute to the natural biological control of the cassava green mite *M. tanajoa*.

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## Materials and Methods

The study was conducted in the laboratory of Arthropods of the Maranhão State University at 27±10 °C, 10h L: 14 h D photoperiod, and 60 ± 20% relative humidity.

**Mite rearing.** The cassava green mite *M. tanajoa* and the predadory mite *E. ho* were collected from unsprayed cassava fields located around the city of Miranda do Norte (3º36'44.70"S 44º34'07.51"W, 44 masl), Maranhão State, Brazil. The cassava green mite *M. tanajoa* was reared on 6-months-old potted cassava plants in a greenhouse. The predatory mite *E. ho* was reared on cassava leaf discs (5 cm diameter) floating on a Petri dish without lid (10 cm diameter x 1.5 cm height) filled with distilled water. Cotton threads underneath a glass slide (18 x 18 mm) were placed at the middle of each leaf disc to serve as shelter for predatory mites. The predatory mite *E. ho* was provided with all developmental stages of the cassava green mite (eggs, larvae, nymphs and adults).

**Biological studies.** Life cycle parameters were determined for both *M. tanajoa* and *E. ho*. The egg periods for *M. tanajoa* and *E. ho* were evaluated in cassava leaf discs of 3 and 5 cm diameter, respectively. Leaf discs were transferred to Petri dishes without lid (10 cm diameter x 1.5 cm high) filled with distilled water as described above. Gravid females of either *M. tanajoa* or *E. ho* were transferred to cassava leaf discs for a period of four hours in order to obtain newly laid eggs. Afterwards, eggs were observed twice a day (08:00 a.m. and 16:00 p.m.) to determine the duration of the egg period. All developmental stages of *M. tanajoa* were provided as prey for *E. ho*.

Recently emerged larvae of both *M. tanajoa* and *E. ho* were individually transferred to cassava leaf discs with a fine brush and the duration of each immature developmental stage was recorded twice a day (08:00 and 16:00). Mites of both species were sexed after reaching adulthood and the duration of the periods of preoviposition, oviposition, postoviposition, number of eggs/female and number of eggs/female/day for females were also daily recorded. A male of *M. tanajoa* or *E. ho* was introduced to each leaf disc containing a newly emerged female and replaced whenever it died.

**Population growth rate.** The intrinsic growth rate ($r_i$) was used to compare the population build up of both the cassava green mite *M. tanajoa* and the predatory mite *E. ho*. The $r_i$ was estimated based on reproduction and mortality data using the equation $r_i = \ln (N_f / N_0) / \Delta t$, where $N_f$ is the final number of living mites, $N_0$ is the initial number of living mites and $\Delta t$ is the interval (days) elapsed between the start and end of the bioassay (Stark *et al.* 1997; Walthall and Stark 1997a). The instantaneous rate of increase ($r_i$) is a direct measure of populaton growth in a given time and is positively related to the intrinsic growth rate ($r_m$) (Walthall and Stark 1997b). A positive $r_i$ value indicates population increase while a negative value indicates population decline (Walthall and Stark 1997b).

The intrinsic growth rates for *M. tanajoa* and *E. ho* were estimated by recording the number of eggs laid, immature and adult mites at the end of the bioassay (seven days). Four adult females of either the cassava green mite or the predator were placed separately onto cassava leaf discs (3 or 5 cm diameter, respectively). All mites tested were in the beginning of their reproductive period, i.e., ca. 10-day-old females of *M. tanajoa* or ca. 4-day-old females of *E. ho*. Males of either *M. tanajoa* or *E. ho* taken from the stock cultures were introduced in each leaf disc and replaced by new ones whenever they died.

**Statistical analyses.** Student's t tests (Sokal and Rohlf 1995) were used to compare the periods of immature development, egg to adult, preoviposition, oviposition, postoviposition and the population growth rates of *M. tanajoa* and *E. ho*. All analyses were carried out using the software Statistica 7.0 (StatSoft Inc. 2004).

## Results

Eggs of the predatory mite *E. ho* hatched within 1.5 ± 0.03 days (means ± SE, n = 82) whereas those of the cassava green mite *M. tanajoa* had a longer incubation period (4.7 ± 0.01 days) (means ± SE, n = 104) (df = 487, t = 85.79, P < 0.05, Fig. 1). Viability of eggs, measured as percentage of hatching, were similar for *M. tanajoa* (95.93%, n = 442) and *E. ho* (95.34%, n = 86). The duration of the larval period of *E. ho* (0.6 ± 0.03 days, n = 75) was shorter than that of *M. tanajoa* (1.0 ± 0.02 days, n = 101) (df = 174, t = 9.15, P < 0.05, Fig. 1). Similarly, the stage of protonymph of *E. ho* (0.7 ± 0.03 days, n = 57) developed faster than that of *M. tanajoa* (0.9 ± 0.02 days, n = 77) (df = 132, t = 5.59, P < 0.05, Fig. 1). The duration of the stage of deutonymph was faster for *E. ho* (0.7 ± 0.02 days, n = 40) in comparison to *M. tanajoa* (1.0 ± 0.02 days, n = 70) (df = 108, t = 5.95, P < 0.05, Fig. 1). As a result of short development, *E. ho* had a shorter egg-to-adult period (4.4 ± 0.08 days, n = 40) in comparison to *M. tanajoa* (10.3 ±

**Table 1.** Durations of preoviposition, oviposition, postovipositon, number of eggs/ female and number of eggs/ female/ day of the cassava green mite *M. tanajoa* and the predatory mite *E. ho*. n = Number of replicates. Means followed by the same letter within rows are not significantly different (Student's t test, P > 0.05).

| Reproductive parameters | *Mononychellus tanajoa* | | *Euseius ho* | |
|---|---|---|---|---|
| | **Duration (days) ± SE** | **n** | **Duration (days) ± SE** | **n** |
| Preoviposition period | 1.2 ± 0.05**a** | 56 | 1.2 ± 0.06**a** | 32 |
| Oviposition period | 16.3 ± 0.28**a** | 22 | 21.7 ± 0.22**b** | 22 |
| Postoviposition period | 2.5 ± 0.16**a** | 22 | 2.6 ± 0.10**a** | 22 |
| Number eggs/ female | 84.4 ± 4.22**a** | 22 | 47.3 ± 0.85**b** | 22 |
| Number eggs/ female/ day | 5.3 ± 0.19**a** | 22 | 2.1 ± 0.03**b** | 22 |

0.02 days, n = 67) (df = 105, t = 42.84, P < 0.05, Fig. 1). The periods of protochrysalid, deutochrysalid and teliochrysalid for *M. tanajoa* were 0.8 ± 0.02, 0.7 ± 0.01, 0.9 ± 0.02, respectively (Fig. 1).

*Euseius ho* and *M. tanajoa* had similar preoviposition (df = 76, t = 0.48, P > 0.05, Table 1) and postoviposition periods (df = 42, t = 0.48, P > 0.05, Table 1). The periods of preoviposition and postoviposition for *E. ho* were 1.2 ± 0.06 and 2.6 ± 0.10 days, respectively, and the same periods for *M. tanajoa* were 1.2 ± 0.05 and 2.5 ± 0.16 days, respectively (Table 1). The predatory mite *E. ho* had, however, a longer oviposition period (21.7 ± 0.22 days) than *M. tanajoa* (16.3 ± 0.28 days) (df = 42, t = 15.11, P < 0.05) (Table 1). Conversely, the number of eggs/ female and the number of eggs/ female/ day were higher for *M. tanajoa* than for *E. ho* (Table 1). Daily oviposition was higher for *M. tanajoa* (5.3 ± 0.19) in comparison to *E. ho* (2.1 ± 0.03) (df = 42, t = 16.30, P < 0.05). Consequently, *M. tanajoa* laid more eggs (84.4 ± 4.22) than *E. ho* (47.3 ± 0.85) during their ovipositional periods (df = 42, t = 8.61, P < 0.05) (Table 1). *Mononychellus tanajoa* also presented higher values of population growth (0.42 ± 0.01) than *E. ho* (0.35 ± 0.005) (df = 49, t = 3.96, P < 0.05, n = 22 for both species).

## Discussion

Although considered a generalist predator, *E. ho* fed and completed its life cycle on the cassava green mite *M. tanajoa*. Prey preference often matches reproductive success in phytoseiid mites (Dicke *et al.* 1990; Gnanvossou *et al.* 2003). The predatory mite *E. ho* had a lower egg-to-adult period in comparison to the cassava green mite *M. tanajoa* (Fig. 1). Indeed, all immature stages of *E. ho* (egg, larva, protonymph and deutonymph) developed faster than those of *M. tanajoa* (Fig. 1). Even though being a generalist predator, *E. ho* proved to be a potential natural enemy of *M. tanajoa* and could be used in conservation biological control programmes. Bruce-Oliver *et al.* (1996), evaluated the effects of several food resources on the development, fecundity and longevity of *Euseius fustis* (Pritchard and Baker, 1962), which is a generalist predatory mite associated to cassava in Africa. *Euseius fustis* sucessfully completed its life cycle when fed on *M. tanajoa*, *Oligonychus gossypii* (Zacher, 1921), maize (*Zea mays* L., 1753) pollen, castor bean (*Ricinus communis* L., 1753) pollen and cassava pollen. *Euseius fustis* fed on castor bean pollen or maize pollen had higher fecundity and longevity compared to *M. tanajoa* as prey indicating that the *Euseius* species may also benefit from alternative.

A suitable natural biological control agent of pest mites should have a fast development time and a high oviposition rate when feeding on its prey. Our results show that *E. ho* had a high reproductive potential when fed on the cassava green mite alone indicating that this predatory mite species is adapted to this type of prey and a potential biological control agent of *M. tanajoa*. The longer oviposition period (21.7 ± 0.22 days) combined with the shorter developmental time (4.4 ± 0.08 days) of *E. ho* in comparison to its prey are important parameters for a biological control agent.

The predatory mite *E. ho* had a high instantaneous rate of increase ($r_i$), yet lower than that observed for its prey, the cassava green mite *M. tanajoa*. *Euseius ho* and *M. tanajoa* were confined in small leaf discs during experiments, which may have favoured prey location and predation resulting in high growth rate of the predatory mite. Predatory mite species are also favoured by tetranychid species which spin low amounts of web (McMurtry and Croft 1997; Vantornhout *et al.* 2004). It may also help to explain the high growth rate of *E. ho* feeding on *M. tanajoa* as the latter does not produce much web. The biological control of tetranychid mites under field conditions depend on several factors which may influence the survival and persistence of predatory mites such as the host plant, climate-related variables and the interaction with other (Kennedy and Storer 2000; Pratt *et al.* 2002; Zundel *et al.* 2009). Pest populations may be managed through preservation and enhancement of resident natural enemies using conservation biological control (Letourneau and Altieri 1999; Landis *et al.* 2000). However, it is essencial to know the biology of the pest and its natural enemies in order to have success in this type of biological control (Landis *et al*. 2000). As a generalist predatory mite, *E. ho* may be favoured by cassava intercropped with pollen-producing plants such as maize, pumpkin (*Cucurbita moschata* Duchesne) and weeds. Indeed, in the region where the study took place, smallholders usually intercrop cassava with maize, pumpkin besides allowing weeds to grown freely. The ability of generalist predatory mites to use pollen or alternative prey as food source to develop, reproduce and survive is key for their establishment and persistence in cassava plantations.

In conclusion, our laboratory results show that the predatory mite *E. ho* is a potential biological control agent of the cassava green mite *M. tanajoa*. However, complementary field studies are necessary to assess the real potential of *E. ho* in regulating populations of the cassava green mite *M. tanajoa*.

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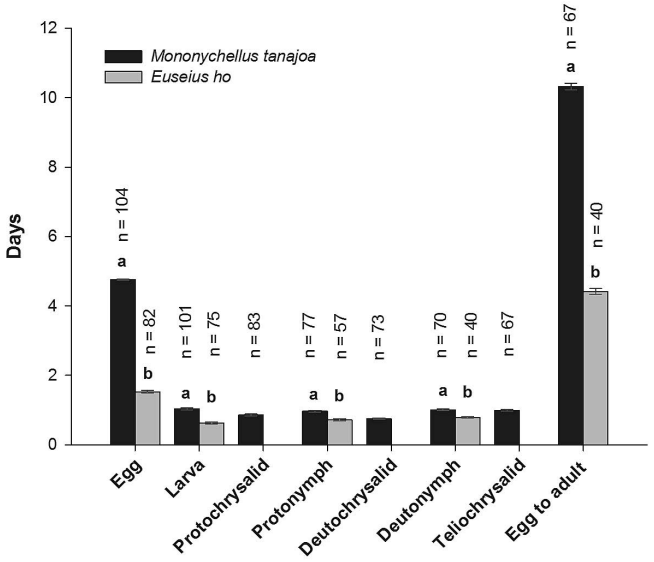


**Figure 1.** Durations of immature stages and egg-to-adult periods for the cassava green mite *Mononychellus tanajoa* and the predatory mite *Euseius ho*. Means ± SE are given (Student's t test; P < 0.05). The number of replicates is presented above each bar.

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