LIFE CYCLE OF *METASEIULUS CAMELLIAE* AND *ZETZELLIA MALVINAE*, PREDATORS OF THE RUBBER TREE PEST MITE, *TENUIPALPUS HEVEAE* (ACARI: PHYTOSEIIDAE, STIGMAEIDAE, TENUIPALPIDAE).

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SUMMARY: The objective of this work was to study the life cycle of *Metaseiulus camelliae* Chant & Yoshida-Shaul and *Zetzellia malvinae* Matioli, Ueckermann & Oliveira when feeding on *Tenuipalpus heveae* Baker, one of the most harmful mites to rubber trees in the State of São Paulo, Brazil. The former 2 mite species are predators commonly found on leaves of rubber trees in Piracicaba, in the southwest of the State of São Paulo. The work was conducted at 25 ± 0.5°C, 82 ± 10% RH and 12 hours of photo phase a day. *M. camelliae* showed a higher reproductive potential than *Z. malvinae* (r_m = 0.101 and 0.077, respectively). Because of the slower population growth, *Z. malvinae* would seem to have an effect on the population of *T. heveae* at a later stage of the infestation than *M. camelliae*. The results suggest that both predators could be important in the control of *T. heveae*.

ACARIENS
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RÉSUMÉ : Cette étude vise à déterminer le cycle de vie de *Metaseiulus camelliae* Chant & Yoshida-Shaul et *Zetzellia malvinae* Matioli, Ueckermann & Oliveira nourris sur le ténuipalpide *Tenuipalpus heveae* Baker, qui est source de dégâts importants dans les cultures d'hévéa de l'État de São Paulo, Brésil. Ces acariens sont prédateurs et communs sur les feuilles de l'hévéa à Piracicaba, dans le sud-ouest de l'État de São Paulo. L'expérience s'est effectué à 25 ± 0.5°C, 82 ± 10% HR et 12 heures de photophase par jour. Le taux intrinsèque d'accroissement était plus élevé pour *M. camelliae* que pour *Z. malvinae* (r_m= 0.101 et 0.077, respectivement). Comme le développement de la population de cette dernière espèce est plus lent, un effet sur la population de *T. heveae* est probablement plus tardif que pour *M. camelliae*. Ces résultats suggèrent que ces deux prédateurs puissent jouer un rôle important dans le contrôle de *T. heveae*.

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Introduction

The rubber tree (*Hevea brasiliensis* Muell. Arg., Euphorbiaceae) is native to the Amazon region and is commercially cultivated on a large scale in mid-west and southeast Brazil (Gonçalves *et al.*, 2001). The introduction of the rubber tree in those areas, 20 to 30 years ago, has been followed by its systematic attack by phytophagous mites, one of which is *Tenuipalpus heveae* Baker (Tenuipalpidae). This mite was also described from the Amazon region, where it is not known to cause significant damage to rubber tree. It occurs mainly on the abaxial surface of the leaves and reaches the highest population levels in mid-west and southeast Brazil between March and April/May (Feres, 2000; Feres *et al.*, 2002; Ferla & Moraes, 2002; Bellini *et al.*, 2005; De Vis et al., 2006b). The attacked leaves turn yellowish, brownish and then fall prematurely, what seems to result in significant reduction of latex production of (Pontier *et al.*, 2001; Feres, 2000).

Phytoseiidae and Stigmaeidae are predatory mites frequently found on rubber trees in association with *T. heveae* (Feres, 2000; Ferla & Moraes, 2002; Bellini *et al.*, 2005). A study recently conducted indicated that the most frequent and abundant species of Phytoseiidae and Stigmaeidae on rubber trees in Piracicaba, State of São Paulo, are *Metaseiulus camelliae* Chant & Yoshida-Shaul and *Zetzellia malvinae* Matioli, Ueckermann & Oliveira, respectively (De Vis et al, 2006b) and that both species survived and oviposited well when fed with *T. heveae* (De Vis et al, 2006a).

The objective of this work was to study the life cycle of *M. camelliae* and *Z. malvinae* in the laboratory when feeding on *T. heveae*.

Material and methods

The work was conducted in the beginning of 2003 in the laboratories of "Escola Superior de Agricultura Luiz de Queiroz (ESALQ), Universidade de São Paulo", Piracicaba, State of São Paulo. Experiments were conducted at 25 ± 0,5°C, 82 ± 10% RH and 12 hours of photo phase a day. The population parameters were calculated as proposed by Andrewartha & Birch (1954).

Metaseiulus camelliae: A stock colony of *M. camelliae* was initiated with specimens collected in a rubber tree plantation at ESALQ. These colonies were established on a piece of plastic sheet maintained on a piece of moist foam mat placed in a plastic tray. To prevent the predators from escaping, a strand of cotton wool was placed around the plastic plate. Three times a week, food was added to the rearing unit by placing rubber tree leaflets heavily infested with *T. heveae*. The study was initiated 6 weeks after the stock colony was set.

The life cycle was studied in experimental units consisting of disks of rubber tree leaflets of 2.2 cm in diameter infested with all stages of *T. heveae*. The disks were put with the abaxial surface up on the surface of the water contained in recipients of 2.5 cm in diameter and 1.2 cm of height. The water served as barrier to prevent predators from escaping. One *M. camelliae* female was then put in each of 60 experimental units. Each unit was observed at 7h AM, 12h and 5h PM, to determine the time of egg laying, hatching and moulting. Each female was removed from the unit when it laid the first egg. Moulting was determined by the presence of the corresponding exuvia on each rearing unit. As each female reached the adult phase, a male (from another experimental unit or, in absence of that, from the stock colony), was transferred to the unit containing the recently moulted female. Dead males were replaced until the death of the respective female. During the reproduction phase, the units were observed once a day, registering oviposition and mortality. The couples were transferred twice a week to new units, to assure abundant food and appropriate physiological condition of the leaf disks.

Zetzellia malvinae: Basically the same method used for *M. camelliae* was applied, except that parent females used initially to obtain the eggs were collected directly from rubber tree leaves taken from the plantation at ESALQ and that the experimental units were observed only twice a day, at 8h AM and 6h PM in the immature phase.

	M. camelliae			*Z. malvinae*		
Stages	Females (n=27)	Males (n=10)	Viability (%)	Females (n=23)	Males (n=10)	Viability (%)
Egg	1.9 ± 0.1	1.9 ± 0.1	100	5.9 ± 0.1	6.0 ± 0.1	84.9
Larva	0.9 ± 0.0	0.9 ± 0.0	100	3.2 ± 0.2	2.8 ± 0.3	97.8
Protochrysalis	–	–	–	1.0 ± 0.1	1.1 ± 0.1	95.5
Protonymph	2.2 ± 0.1	2.0 ± 0.1	100	4.3 ± 0.4	3.6 ± 0.5	81
Deutochrysalis	–	–	–	1.2 ± 0.1	1.2 ± 0.1	100
Deutonymph	2.2 ± 0.1	2.3 ± 0.1	98	4.2 ± 0.4	2.9 ± 0.3	97.1
Teliochrysalis	–	–	–	1.5 ± 0.0	1.4 ± 0.1	100
Egg-adult	7.2 ± 0.2	7.1 ± 0.3	98	21.3 ± 1.2	19.0 ± 1.4	62.3

TABLE 1. Development time (in days, mean ± standard error) and viability (%) of the immature stages of *Metaseiulus camelliae* and *Zetzellia malvinae* fed with *Tenuipalpus heveae* at 25.0 ± 0.5°C, 82 ± 10% RH and 12 hours of photo phase.

RESULTS

Both *M. camelliae* and *Z. malvinae* underwent the stages of egg, larva, protonymph, deutonymph and adult. The quiescent phases of immatures were very evident for *Z. malvinae* but not for *M. camelliae*. The developmental period of each immature stage was considerably shorter for *M. camelliae* (TABLE 1). The total duration of the immature phase (egg to adult) was approximately 7 days for both sexes of *M. camelliae* and approximately 21 days for females and 19 days for males of *Z. malvinae*. The survival of each immature stage of *M. camelliae* was also always higher.

Parameter	*M. camelliae*	Z. malvinae
Longevity of the females (days)	47.9 ± 2.5	37.6 ± 4.4
Pre–oviposition period (days)	3.3 ± 0.1	2.3 ± 0.2
Oviposition period (days)	40.4 ± 2.3	25.3 ± 3.1
Post–oviposition period (days)	4.2 ± 1.4	10.1 ± 2.4
Generation time (T, days)	36.6	44.1
Fecundity (eggs/female)	49.3	46.0
Oviposition rate (eggs/female/day)	1.0	1.2
Sex ratio (% females)	57.1	69.7
Net reproduction rate (Ro)	40.2	29.6
Intrinsic rate of increase (r_m)	0.101	0.077
Finite rate of increase (λ)	1.106	1.08

TABLE 2. Life history parameters (mean ± standard error) of *Metaseiulus camelliae* and *Zetzellia malvinae* fed with *Tenuipalpus heveae* at 25.0 ± 0.5 °C, 82 ± 10 % RH and 12 hours photo phase.

M. camelliae had a shorter developmental time but a larger oviposition period, resulting in longer longevity but shorter generation time (T) than *Z. malvinae*. Fecundity and mean daily oviposition rate of the 2 species were similar, but proportion of females was smaller for *M. camelliae* than for *Z. malvinae*. Net reproduction rate (Ro), intrinsic rate of increase (r_m) and finite rate of population growth (λ) were considerable larger for *M. camelliae* (TABLE 2).

DISCUSSION

Both *M. camelliae* and *Z. malvinae* developed and reproduced on *T. heveae*. Developmental time from egg to adult was considerably shorter for *M. camelliae* resulting in a concurrently shorter mean generation time (T), in spite of the slightly longer pre-oviposition period for this species. These parameters, together with the higher viability of the immature stages and the longer oviposition period for *M. camelliae*, resulted in larger potential of population growth for this species *i.e.* larger net reproduction rate (R_o), intrinsic rate increase (r_m) and finite rate of population increase (λ). Those results could suggest *T. heveae* to be more suitable as prey to *M. camelliae* than to *Z. malvinae*. However, it should be considered that these predators belong to different families, with quite different intrinsic biological characteristics.

Among the Phytoseiidae, few information on the life history of species of *Metaseiulus* is available as compared to that of other genera. Nevertheless, there is a considerable volume of information about the biology of *Metaseiulus* (= *Typhlodromus*) *occidentalis* (Nesbitt). CROFT & MCMURTRY (1972) determined the r_m of this species to be 0.213, when feeding on eggs of *Tetranychus urticae* Koch, at 25°C. PRUSZYNSKI & CONE (1973) observed developmental period of 6.1 days and oviposition rate of

2.5 eggs/female/day for *M. occidentalis* fed the same prey, at the same temperature. TANIGOSHI *et al.* (1975) reported a developmental period of 10.4 days and an oviposition rate of 2.1 eggs/female/day when the predator was fed *Tetranychus mcdanieli* McGregor, at 24°C. The population parameters (r_m, Ro and oviposition rate) observed in this study for *M. camelliae* are lower than those determined for *M. occidentalis* (fed *T. urticae*). The preference of *M. occidentalis* for tetranychid species as prey has been demonstrated in the literature (TANIGOSHI *et al.*, 1975; ROSEN & HUFFAKER, 1982; MCMURTRY & CROFT, 1997). In a previous study, we observed that *M. camelliae* could be a specialized predator in Tenuipalpidae; repeated efforts to rear that predator on pollen and/or tetranychids were always unsuccessful (DE VIS et al., 2006a). The high fecundity and longevity as well as the short developmental period of *M. camelliae* indicate that *T. hevae* is a good food source for the reproduction of that predator. The difference between the r_m value found for *M. camelliae* and *M. occidentalis* could in fact reflect the evolutionary restrictions imposed by the characteristics of their favoured prey, corresponding to the reproductive capacity and local density of the latter (SABELIS, 1996). Tenuipalpids are generally smaller and have lower reproductive capacity, resulting in lower local 'biomass' density than the larger and more prolific tetranychids.

The results of the study with *Z. malvinae*, especially the fecundity and longevity, could have been negatively influenced by the method used in this study. Under natural circumstances this predator hides in domatia of rubber tree leaflets, which correspond to the bent areas at the base of leaflets, near the petiole (DE VIS et al., 2006b). The rearing units used in the present study had no such domatia, and the mites usually hided in the region between the main vein and the margin of the leaf disk, sometimes getting trapped in the water. In several instances, mites trapped but still alive were taken back from the water onto the leaf disk. Although during the study it was found that *T. heveae* resists water-immersion for more than one day, foraging and thereby fecundity and longevity of trapped females, even if for a few hours, could be affected.

Among the stigmaeids, *Zetzellia mali* (Ewing) is one of the best-studied species as predator of pest mites in apple and pear orchards in the northern hemisphere. WHITE & LAING (1977) determined the r_m of *Z. mali* to be 0.109 when fed the Eriophyidae *Aculus schlechtendali* (Nalepa), at 19°C. Despite the higher temperature of the present study, r_m was comparatively lower for *Z. malvinae*. The developmental period of *Z. mali* was approximately 13, 16 and 21 days, when feeding on *A. schlechtendali*, *Panonychus ulmi* (Koch) and *T. urticae*, at 24 ± 1, 24 and 21 ± 1°C, respectively (ELLINGSEN, 1971; WHITE & LAING, 1977; JAMALI *et al.*, 2001). The first 2 values are lower than obtained in this study, but the latter is comparable to the values obtained for *Z. malvinae*. The results of those studies could indicate that *T. heveae* is not a very appropriate prey for the development of *Z. malvinae*. On the other hand, *Z. malvinae* had higher fecundity, longevity and Ro than reported by FERLA & MORAES (2003a) for the stigmaeid *Agistemus floridanus* Gonzalez, also fed *T. heveae*. The much higher r_m found for *A. floridanus* (0.16) seems to be related to the much shorter generation time of *A. floridanus* (19.2 days) than of *Z. malvinae* (44.1 days).

Considering the results obtained in this study, it is conceivable that *M. camelliae* and *Z. malvinae* affect the population of *T. heveae* in rubber tree plantations in a similar way as *M. occidentalis* and *Z. mali* affect the population of *P. ulmi* in apple and pear orchards. According to WHITE & LAING (1977), because of the slow development, *Z. mali* only reaches high population levels in the summer and fall but nevertheless contributes to the control of the pests in those seasons while in spring and early summer control is primarily effected by *M. occidentalis*. Mites of the genus *Zetzellia* are frequently found in rubber trees in mid-west and southeast Brazil (FERES, 2000; FERLA & MORAES, 2002; BELLINI *et al.*, 2005; DE VIS et al., 2006b). *Zetzellia* aff. *yusti* was the most abundant predator in two rubber tree plantations in Olímpia, in the northeast of the State of São Paulo (BELLINI *et al.*, 2005), but nothing is known about the potential of that stigmaeid as a biological control agent of *T. heveae*.

In principle, inundative releases of *M. camelliae* and *Z. malvinae* would seem a promising strategy for the control of *T. heveae*. This pest has been difficult to control, even with the use of acaricides (FERLA & MORAES, 2003b). However, rubber trees are usually very high (over 10 m high), with large crowns and high leaf area index, which would turn inundative releases expensive. An alternative would be the association of rubber trees with other plants on which the predators could survive during the leafless period. Considering the large extension of rubber tree plantations in Brazil, it would seem that further studies on the possibility to develop conservation techniques of *M. camelliae* and *Z. malvinae* in rubber tree plantations are extremely needed.

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