



Biology and life-table of Typhlodromus (Anthoseius) athenas (Acari: Phytoseiidae) fed with the Old World Date Mite, Oligonychus afrasiaticus (Acari: Tetranychidae)

Samah Ben-Chaaban, Brahim Chermiti, Serge Kreiter

► **To cite this version:**

Samah Ben-Chaaban, Brahim Chermiti, Serge Kreiter. Biology and life-table of Typhlodromus (Anthoseius) athenas (Acari: Phytoseiidae) fed with the Old World Date Mite, Oligonychus afrasiaticus (Acari: Tetranychidae). *Acarologia*, 2018, 58 (1), pp.52-61. 10.24349/ACAROLOGIA/20184229 . hal-01687119

HAL Id: hal-01687119

<https://hal.science/hal-01687119>

Submitted on 18 Jan 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0 International License

Acarologia

A quarterly journal of acarology, since 1959
Publishing on all aspects of the Acari

All information:



<http://www1.montpellier.inra.fr/CBGP/acarologia/>
acarologia@supagro.inra.fr



**Acarologia is proudly non-profit,
with no page charges and free open access**

Please help us maintain this system by
encouraging your institutes to subscribe to the print version of the journal
and by sending us your high quality research on the Acari.

Subscriptions: Year 2018 (Volume 58): 380 €

<http://www1.montpellier.inra.fr/CBGP/acarologia/subscribe.php>

Previous volumes (2010-2016): 250 € / year (4 issues)

Acarologia, CBGP, CS 30016, 34988 MONTFERRIER-sur-LEZ Cedex, France

The digitalization of Acarologia papers prior to 2000 was supported by Agropolis Fondation under the reference ID 1500-024 through the « Investissements d'avenir » programme (Labex Agro: ANR-10-LABX-0001-01)



Supporting agricultural research
for sustainable development

Acarologia is under **free license** and distributed under the terms of the Creative Commons-BY-NC-ND which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are credited.

Biology and life-table of *Typhlodromus (Anthoseius) athenas* (Acari: Phytoseiidae) fed with the Old World Date Mite, *Oligonychus afrasiaticus* (Acari: Tetranychidae)

Samah Ben Chaaban^a, Brahim Chermiti^b, Serge Kreiter^c

^a Regional Research Center of Oasis Agriculture, Degache, Tunisia.

^b Département de Protection des Plantes, Institut Supérieur Agronomique de Chott-Mariem, Sousse, Tunisia.

^c Montpellier SupAgro, UMR CBGP, 755 Avenue du Campus Agropolis (Baillarguet), CS 30016, 34988 Montpellier-sur-Lez cedex, France.

ABSTRACT

The old world date mite *Oligonychus afrasiaticus* is an important spider mite pest of the date palms *Phoenix dactylifera* L. mostly in North Africa and the Middle East. A population of the predaceous mite *Typhlodromus (Anthoseius) athenas* has been recently found in Tunisia in association with a decrease of *O. afrasiaticus* densities. The objective of this paper was to assess the development and reproduction abilities of *T. (A.) athenas* on *O. afrasiaticus* under laboratory conditions at two temperatures: 27 and 32 °C. The results obtained show that females of *T. (A.) athenas* develop in 5 days at 27 °C and 4.1 days at 32 °C. The mean fecundity of *T. (A.) athenas* was 32.1 and 23.2 eggs per female at 27 and 32 °C, respectively. Life table parameters were estimated: the net reproductive rate (Ro) 27.9 and 17.9 eggs/female, the intrinsic rate of increase (r_m) 0.322 and 0.344 female/female/day and the mean generation time (T) 10.3 and 8.4 days at 27 and 32 °C, respectively.

At both temperatures tested, *T. (A.) athenas* intrinsic rate of increase was greater than that of *O. afrasiaticus* ($r_m = 0.213$ at 32 °C, against $r_m = 0.166 \text{ day}^{-1}$ at 27 °C). *Typhlodromus (A.) athenas* would be able to develop at a wide range of temperatures feeding on *O. afrasiaticus* and seems to be able to potentially control it.

Keywords Tunisia, date palm, *O. afrasiaticus*, *Typhlodromus (A.) athenas*, Phytoseiidae, life table

Zoobank <http://zoobank.org/FE6F19F1-8271-4B5C-A28F-F13774E94F89>

Received 04 April 2017
Accepted 03 August 2017
Published 18 January 2018

Corresponding author
Samah Ben Chaaban:
samah_bchaaban@yahoo.fr

Academic editor
Marie-Stéphane Tixier

DOI
10.24349/acarologia/20184229

© Copyright
Ben Chaaban S. *et al.*

Distributed under
Creative Commons CC-BY 4.0



Introduction

The tetranychid mite *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae) is one of the most important pests of date palm fruits around the world (Hussain 1969; Coudinand and Galvez 1976; Saleh and Hosny 1979; Guessoum 1986; Edongali *et al.* 1988; Dhouibi 1991; Talhouk 1991; Baankoud and Basahih 2000; Elwan 2000; Palevsky *et al.* 2003, 2004).

In several areas, *O. afrasiaticus* is controlled using sulphur (Coudinand and Galvez 1976; Guessoum 1986; Dhouibi 1991; Djerbi 1993; Palevsky *et al.* 2004). Similar programs have been conducted in California for many years for the control of the new world date mite *Oligonychus pratensis* (Banks) (Carpenter and Elmer 1978). Recently, the efficacy of sulphur treatments on *O. pratensis* and *O. afrasiaticus* has decreased dramatically (Gispert *et al.* 2001; Palevsky *et al.* 2004). Several other miticides were found to be effective (Al-Doghairi 2004; Palevsky *et al.* 2004). However, after application of pesticides, rates of

residues exceed the minimum level recommended. In Saudi Arabia and other neighbouring countries, natives consume many dates; such high date consumption could lead to a high risk of exposure to pesticides, especially for children and other vulnerable population (Kamel *et al.* 2007). Considerable research efforts have been undertaken for finding an environmentally friendly way to control *O. afrasiaticus*, e.g., biological control. A limited number of species of enemies were reported to prey on *O. afrasiaticus* and *O. pratensis*. In California, the biological control of *O. pratensis* on date palms has been associated with the indigenous phytoseiid mite, *Metaseiulus* (*Metaseiulus*) *flumenis* (Chant), whose presence coincides with that of the pest during the summer months (Gispert *et al.* 2001). These authors suggested that inundative releases early in the season could delay pest population increase and reduce damage. In Algerian oases, native ladybird predators *Cybocephalus palmarum* Peyerimhoff and *Exochomus flavipes* (L.) were found feeding on *O. afrasiaticus*. In Algeria, the ladybird, *Stethorus punctillum* (Weise) was evaluated to control *O. afrasiaticus* in field and lab tests; the studies showed some promising results (Guessoum 1986; Idder and Pintureau 2008). Results obtained by Negm *et al.* (2014) also showed that *Cydnoseius negevi* (Swirski and Amitai) can be an interesting predator of *O. afrasiaticus*.

In south Tunisia, Othman *et al.* (2001) released the commercially sold phytoseiid mite *Neoseiulus californicus* (McGregor) in an experimental scale to control *O. afrasiaticus*. They observed significant reductions of the pest's populations. However, little is known about the native predators associated with *O. afrasiaticus* in this region. In a previous study conducted in different Tunisian oases planted with different date palm cultivars, Ben Chaaban *et al.* (2011) mentioned that occurrence of phytoseiids on date palms was sporadic. Very few *T. (A.) athenas* were collected from pinnae of the Deglet Noor variety, but never founded in association with *O. afrasiaticus* on fruits of the same cultivar (Kreiter *et al.* 2008). Our field observations showed that in 2004 individuals of the predatory mite *T. (A.) athenas* were found to feed on *O. afrasiaticus* inhabiting fruits of Alig cultivar (Kreiter *et al.* 2008).

Considering that nothing is known on the behaviour and the relative importance of natural enemies of *O. afrasiaticus*, the objectives of the present study were: (i) to determine the population dynamics of *O. afrasiaticus* and *T. (A.) athenas* in fields and (ii) determine *T. (A.) athenas* biological traits including development, fecundity and life table parameters under laboratory conditions, as a first step in the determination of its suitability as control agents of *O. afrasiaticus*.

Materials and methods

1. Study area and sampling

Study fields. This study was carried on 2005 and 2006 in an orchard of 2 ha planted with mixed varieties of date palm trees: 'Alig', 'Kentichi', 'Bessr' and 'Deglet Noor'.

This area is located in Segdoud, in the region of Tozeur (Djerid), in southwest Tunisia. Tozeur belongs to the superior bioclimatic Saharan upstairs with a temperate winter. The annual mean temperature is about 21.6 °C, while 44 °C in August and 2.5 °C in January are the absolute maximum and minimum temperatures, respectively. The annual average rainfall is about 96 mm.

The oases in this area are continental with a mean planting space of 10 x 10 m. The principal vegetation was date palm trees with a predominance of the Deglet Noor variety and very few market-gardening or fodder practices for farmer consumption. The plot had historical outbreaks of *O. afrasiaticus* and in 2005 received two sprays of wettable sulphur on July 3rd and August 15th. In 2006, three wettable sulphur were applied on July 2nd, July 24th and August 1st. Every year, the concentration of sulphur applied was about 100 – 150 g per palm tree.

Sampling of mites on fruits. Date fruits of Alig variety were used to assess seasonal abundance of *O. afrasiaticus* and *T. (A.) athenas*.

Ten trees were selected for subsequent sampling. These trees were chosen at random to ensure coverage of the orchard, 2 trees located in the North, South, West, and East and in the middle of oases. Samples were taken at random of 10 date fruits per palm tree from bunches in the four locations (N, S, W and E). Samples were collected weekly from 30 April to 25 October in 2005 and from 15 April to 4 November in 2006. Mite populations were monitored twice a month until harvest during the rest of the two years of this study.

Date fruits were placed in plastic bags, kept in an insulated cooler with ice, brought to the laboratory and stored at a temperature of 4 °C. Motile forms of *O. afrasiaticus* and phytoseiid mites were counted under a stereomicroscope. The phytoseiid mites were mounted on slides in Hoyer medium and identified at Montpellier SupAgro (France) as *T. (A.) athenas*.

2. Life history and life table studies

Stock culture. Date palm fruits (cv. Deglet Noor) that were well-infested with spider mites (*O. afrasiaticus*) were collected from the Segdoud oases in July 2007. With several hundred of spider mites of all stages from these dates, a stock colony was started on sorghum plants (*Sorghum* sp.) (Ben Chaaban *et al.* 2008). Cultures were kept in a climatic chamber at 25 ± 1 °C, 60 ± 10 % RH, 16:8 L: D.

The initial population of *T. (A.) athenas* was collected from date fruits of Alig cultivar in 2007. The stock culture of the predatory mite was maintained on *O. afrasiaticus* on sorghum leaves in a rearing chamber (25 ± 1 °C, 60 ± 10 % RH, 16:8 L: D). The species was identified and morphologically characterized at Montpellier SupAgro, France.

The rearing units of *T. (A.) athenas* were similar to those described by Overmeer (1985): a piece of black hard plastic, on a water-saturated sponge in a plastic tray with water, with the borders covered with tissue paper, to ensure a constant water supply to the phytoseiids and to prevent escape. Twice a week, *O. afrasiaticus* infested sorghum leaves were added to each rearing unit (25 ± 1 °C, 60 ± 10 % RH, 16:8 L:D). The colonies were started more than 3 months before the beginning of experiments, so that various generations had past under the rearing conditions.

Experimental unit. All experiments were carried out on non-infested sorghum leaves used in the *O. afrasiaticus* rearing. The experimental unit was a modified Huffaker cell (Overmeer 1985). Fifty *O. afrasiaticus* females were placed in each cell and they were allowed to feed, oviposit and produce web for 5 days prior to the introduction of phytoseiids. Thus, a phytoseiid placed inside the cell had different *O. afrasiaticus* stages to prey upon and some webbing as oviposition site.

Developmental time of *T. (A.) athenas*. Thirty to forty female deutonymphs were placed individually in the arenas described above, together with two young adult males. Males that died or escaped were replaced with new ones. Every 8 hours the arenas were checked under a binocular microscope to see whether females had oviposited. Eggs were placed individually in each arena. This procedure was repeated 100 times (= 100 replicates). Every 8 hours the arenas with single eggs were checked, total development from egg until adulthood and survival of immature stages were recorded.

Reproductive parameters. Once females reached the adult stage, two males were added to each arena. Mites were observed every 8 hours until first oviposition. After that, females were transferred to new arenas and every 24 hours the number of eggs laid per female/arena/day was counted. The progeny was fed with *O. afrasiaticus* until they reached the adult stage. Mean preoviposition, oviposition and postoviposition periods, fertility, and sex ratio were calculated for each female. Experiments concerning reproductive parameters were conducted with 30 replicates in a room at 27 ± 1 °C and 32 ± 1 °C, RH was 60 ± 10 % and the photoperiod was 16:8 (L: D).

Data analyses. The life table was constructed considering the female cohort studied in this experiment. The net reproductive rate (R_0 , mean number of female progeny produced by a single female during its mean lifetime, expressed in ♀/♀); gross reproductive rate (GRR, in

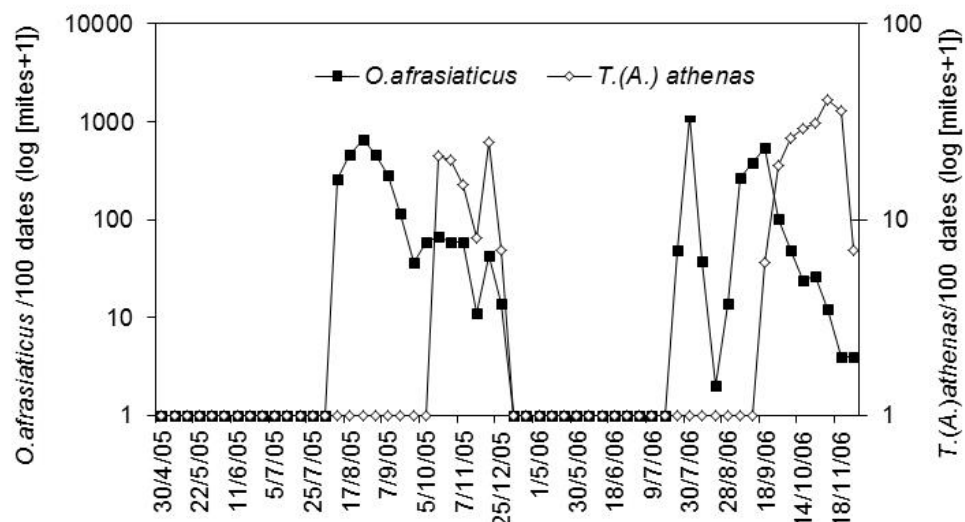


Figure 1 Population dynamics of *O. afrasiaticus* and *T. (A.) athenas* on date of 'Alig' cultivar at Segdoud, South of Tunisia in 2005 and 2006.

\varnothing/\varnothing), generation time (T , mean period between birth of the parents and that of the offspring, measured in days), intrinsic rate of increase (r_m , in $\varnothing/\varnothing/\text{day}$), finite rate of increase (λ , in $\varnothing/\varnothing/\text{day}$) and doubling time (Dt , time for population to double, measured in days) were calculated using the method recommended by Birch (1948).

Data on developmental time, duration of female reproductive periods, and fecundity were analysed using one-way ANOVA. SPSS 10 (Statistical Package for the Social Sciences, version 10) was used for statistical analyses.

Results

1. Population dynamics of *O. afrasiaticus* and *T. (A.) athenas*

In 2004 (Figure 1), *O. afrasiaticus* on Alig fruit was first observed in the second week of August. Spider mite density increased rapidly throughout August during the fruit's kimri stage, characterized by greenness. *Oligonychus afrasiaticus* density peaked at 653 /100 date on 23 August. Starting from September, the color of fruit changed to yellow, numbers of *O. afrasiaticus* on fruits decreased gradually and remained relatively low for the rest of the season. In 2005, the pests were found on Alig fruits from 23 July to the first week of December. From October onwards in 2005 and in the second decade of September during 2006, the presence of *T. (A.) athenas* coincided with decrease of *O. afrasiaticus* population (Figure 1). No *T. (A.) athenas* was found in July or August. Populations of *T. (A.) athenas* showed an increasing trend from mid October onwards in 2005 and in the second decade of September during 2006 and reached a peak between November and December. Densities of *T. (A.) athenas* had reached up to 40/100 dates at 4 November 2006.

2. Life history and life table parameters

Developmental time of immature stages. The development times of *T. (A.) athenas* are given in Table 1. Development time decreased as temperature increased from 27 to 32 °C for both females ($F_{(1, 117)} = 140.2, P < 0.000$) and males ($F_{(1, 43)} = 17.6, P < 0.0001$). The overall development time was shorter for males than for females. The immature survival rate was more

Table 1 Means (\pm SD) in days of the development duration of females and males and immature survival of *Typhlodromus (A.) athenas* fed on *Oligonychus afrasiaticus*, at 27 °C and 32 °C.

Stage	Temperature (in °C)		$P < F(df1, df2) (\alpha = 0.0001)$
	27	32	
Male	4.3 \pm 0.7 (23)	3.6 \pm 0.3 (22)	$P < F_{(1, 43)} = 17.6$
Female	5 \pm 0.3 (64)	4.1 \pm 0.5 (55)	$P < F_{(1, 117)} = 140.2$
Immature survival (%)	87%	77%	

Table 2 Mean values and standard deviation (into brackets) of durations of adult phases (days), female longevity (days), fecundity (eggs/female), oviposition rate (eggs/female/day) (mean \pm SD) and sex ratio (% female) of *Typhlodromus (A.) athenas* fed on *Oligonychus afrasiaticus*, at 27 °C and 32 °C, 60 \pm 10 % RH and 16h/8 h photophase, number of replicates (N).

	Temperature (°C)		$P < F(df1, df2) (\alpha = 0.0001)$
	27	32	
Preoviposition	0.3 \pm 0.1	0.2 \pm 0.1	$P > F_{(1, 58)} = 0.78$
Oviposition	11.4 \pm 2.7	8.5 \pm 3.5	$P < F_{(1, 58)} = 13.25$
Post-oviposition	3 \pm 2.5	0.5 \pm 0.2	$P < F_{(1, 58)} = 31.66$
Female longevity	14.7 \pm 4.2	9.2 \pm 3.4	$P < F_{(1, 58)} = 33.83$
Fecundity	23.2 \pm 10.9	32.1 \pm 8.7	$P < F_{(1, 58)} = 12.05$
Oviposition rate	2.2	2.5	$P > F_{(1, 58)} = 0.73$
Sex ratio (% female)	85.5	77.2	
N	30		

important at 27 °C (87 %) than at 32 °C (77 %) (Table1).

Adult female longevity, fecundity, oviposition rate and sex ratio.

No significant difference was observed for the duration of pre-oviposition period at the two temperatures ($F_{(1, 58)} = 0.78$, $P > 0.000$), but the duration of oviposition and post-oviposition periods were significantly shorter at 32 °C. Female longevity was lower at 32 °C (9.2 days) than at 27 °C ($F_{(1, 58)} = 33.8$, $P < 0.000$) (Table 2).

Fecundity was significantly influenced by temperature ($F_{(1, 58)} = 12.05$, $P < 0.0001$); values were 23.2 and 32.1 eggs at 27 and 32 °C, respectively. In contrast, daily fecundity of *T. (A.) athenas* did not significantly differ among the two temperatures.

The sex ratio of *T. (A.) athenas* was biased towards females and varied with temperature from 85.5 % to 77.2 % of females at 27 and 32 °C (Table 2), respectively.

Life table. Life table parameters of *T. (A.) athenas* fed on *O. afrasiaticus* at the two temperatures are presented in Table 3. The net reproductive rate (R_0) decreased from 27.9 females/female at 27 °C to 17.9 females/female at 32 °C. The intrinsic rate of natural increase (r_m) of *T. (A.) athenas* increased with temperature from 0.322 to 0.344 female/female/day. Population doubling times (D_1) was 2.15 and 2.01 days at 27 °C and 32 °C, respectively. The mean generation time (T) was 10.3 days at 27 °C and 8.4 days at 32 °C.

Discussion and conclusions

Field surveys. In this study, we have observed that fruit dates infestation of Alig cultivar was initiated between the third week of July and the first week of August, and increased rapidly during August. Densities remained relatively high until early September. It seems that excessive dry and heat conditions favour *O. afrasiaticus* populations, despite sulphur use

Table 3 Demographic parameters of *Typhlodromus (A.) athenas* fed on *Oligonychus afrasiaticus* at two temperatures: net reproductive rate (Ro), mean generation time (T), intrinsic rate of increase (r_m), doubling time (Dt), and finite rate of increase (λ).

Temperature (°C)	Ro (females/female)	T (days)	Dt (days)	λ (females/female/day)	r_m (female/female/day)
27	27.9	10.3	2.15	1.38	0.322
32	17.9	8.4	2.01	1.41	0.344

(Ben Chaaban *et al.* 2008). Our field observations showed that *T. (A.) athenas* was found to feed on *O. afrasiaticus* inhabiting fruits of Alig cultivar. This species naturally occurs in the Mediterranean area (Greece, Italy, Morocco, Spain) (Moraes *et al.* 2004; Kolokytha *et al.* 2011a, b). In Greece, this species was recorded on different plants and trees including citrus, olive, forest, rosaceous fruit trees, stone fruit trees, grapes, roses, carnations and oregano (Papadoulis *et al.* 2008).

Typhlodromus (A.) athenas was not found on Alig fruits when *O. afrasiaticus* populations peaked. However, we observed its presence from mid-September to December.

Palevsky *et al.* (2004) founded that phytoseiids were very scarce on untreated ‘Medjool’, ‘Barhi’ and ‘Deglet Noor’ date palms. *Oligonychus afrasiaticus* has been associated with the indigenous phytoseiid *Neoseiulus bicaudus* (Wainstein). The highest densities of the *N. bicaudus* were recorded in mid-June (ca. 2 mites/strand) but none was found from mid-July until the end of August, when pest populations peaked at ca. 15,000 mites/strand.

Several hypotheses can explain the cause of the seasonal asynchrony between tetranychid pests and their natural enemies. First the dry conditions prevailing in the summer in the South of Tunisia prevented phytoseiids to establish themselves. Sabelis (1985) mentioned that among factors that determine the effectiveness of phytoseiids, humidity appears to be of major importance. The egg stage is especially sensitive to low humidity (Sabelis 1985; Ferrero *et al.* 2010). Differences in temperature thresholds between herbivorous pests and their natural enemies can allow pests to escape regulation early in the season and to reach damaging levels (Campbell *et al.* 1974; Hodek and Honek 1996; Obrycki and Tauber 1981). The second probable factor was the application of sulphur. Earlier findings revealed that sulphur can initially suppress pest mite populations (Croft 1990), but mite densities often increase after applications stopped, apparently because sulphur increases mortality and decreases fecundity of predators (Van de Vrie *et al.* 1972; Hanna *et al.* 1997; James *et al.* 2002; Costello 2007). Another reason for the scarcity of phytoseiids on fruits might be the presence of other food sources on the date palm. We founded *T. (A.) athenas* motile forms and eggs under the female shield of *Parlatoria blanchardi* (Targioni & Tozzetti) scales on pinnae. Generalist predators can feed on various species of Tetranychidae, Tarsonemidae, pollen, fungi, and other mites (McMurtry and Croft 1997; Luh and Croft 2001). *Typhlodromus (A.) athenas* was able to survive and reproduce on pollens of almond, apple, apricot, cherry, pear, plum, olive, and pollen (Kolokytha *et al.* 2011a). The predators’ ability to survive and develop when reared exclusively on pollen at a wide range of temperatures may also be advantageous for the increase and built up of its population before the tetranychid population development (Kolokytha *et al.* 2011b).

Biological parameters of *T. (A.) athenas*. This study was the first to evaluate the biology and predatory efficiency of the phytoseiid predator, *T. (A.) athenas* on *O. afrasiaticus*. Under laboratory conditions, this species is able to complete development when fed exclusively on *O. afrasiaticus* at 27 °C and 32 °C.

The results of this study clearly show the effects of temperature on development time, longevity and fecundity on *T. (A.) athenas* feeding on *O. afrasiaticus*. Raising the temperature from 27 °C to 32 °C causes a significant reduction of 0.9 day on the total development time from egg to adult female. Many other studies performed on several species of phytoseiid

showed that the duration of development decreases with temperature increase (Stenseth 1979; Camporese and Duso 1995; Reuveny *et al.* 1996; Lee and Ahn 2000; Ferrero *et al.* 2007; Kolokytha *et al.* 2011b). When *T. (A.) athenas* fed on all stages of *O. afrasiaticus*, the total developmental time was found shorter than for other Phytoseiid species feeding on the same prey, such as *C. negevi* (9 and 7.93 days, respectively at 25 °C and 35 °C) (Negm *et al.* 2014) and *Neoseiulus barkeri* Hughes (9.63 and 9 days, respectively at 25 °C and 35 °C).

The immature survival is higher at 27 °C (87 %) than at 32 °C. Similar results have also been reported by Kolokytha *et al.* (2011b) when *T. (A.) athenas* fed on *Tetranychus urticae* (Koch): survivorship decreased from 94.8 at 27.5 °C to 86.2 % at 30.5 °C.

The longevity of *T. (A.) athenas* females decreased from 14.7 to 9.2 days respectively at 27 °C to 32 °C. The oviposition period follows the same pattern. This trend has been observed in several species of phytoseiid (Lee and Ahn 2000; Grissa 2003; Sengonca *et al.* 2003; Gharbi 2006; Ferrero *et al.* 2007). When *Euseius scutalis* (Athias-Henriot) was evaluated against *O. afrasiaticus* at 26 °C and 70 % RH, adult female longevity was 19.4 days (Al-Shammery 2010). Negm *et al.* (2014) estimated that female longevity of *C. negevi* and *N. barkeri* reared on *O. afrasiaticus* were respectively 31.8 and 20.1 days and 35.7 and 27.4 days at 25 °C and 35 °C (35 % RH), respectively.

The sex ratio of phytoseiid mites is female biased (Amano and Chant 1977; Tanigoshi 1982). This agrees with the present findings.

Increasing temperature from 27 to 32 °C had a significant effect on the female fecundity. The number of eggs increased from 23.2 at 27 °C to 32.1 at 32 °C. Total fecundity of *T. (A.) athenas* fed on *O. afrasiaticus* at 27 °C is higher than that of *E. scutalis* (16.2 eggs at 26 °C) (Al-Shammery 2010). However, the total fecundity value of *T. (A.) athenas* fed on *O. afrasiaticus* was quite similar to that of other Phytoseiidae species feeding on *O. afrasiaticus* such as *C. negevi* (21.6 and 38 eggs respectively at 25 °C and 35 °C) and *N. barkeri* (18.8 and 34.8 eggs respectively at 25 °C and 35 °C) (Negm *et al.* 2014).

The intrinsic rate of natural increase (r_m) is an important parameter, describing the growth potential of a population under prevailing climatic and feeding conditions, as a reflection of the overall effects of temperature and food on the population's development, reproduction, and survival characteristics (Sabelis 1985; Krips *et al.* 1998; Roy *et al.* 2005).

In this study, the r_m value of *T. (A.) athenas* feeding on *O. afrasiaticus* increased from 0.322 female/female/day to 0.344 female/female/day from 27 °C to 32 °C. *Typhlodromus (A.) athenas* shows higher demographic parameter values in comparison to other phytoseiids belonging to the same genus, *i.e.*, *Typhlodromus (Typhlodromus) laurentii* Ragusa & Swirski [junior synonym of *T. (T.) setubali* Dosse] on *Panonychus citri* (McGregor) (at 25 °C, r_m = 0.158, λ = 1.171, Ro = 13.24) (Tsolakis *et al.* 2016), *Typhlodromus (Typhlodromus) pyri* Scheuten on *T. urticae* (at 25 °C, r_m = 0.110, λ = 1.12, Ro = 11.5) (Puchalska and Kozak 2015), *Typhlodromus (Anthoseius) bagdasarjani* on *T. urticae* (at 25 °C, r_m = 0.129, λ = 1.14, Ro = 13.6) (Ganjisaffar *et al.* 2011), *T. (A.) athenas* on almond pollen (r_m = 0.100, λ = 1.105, Ro = 15.71) (Kolokytha *et al.* 2011a,b). Negm *et al.* (2014) found that r_m value of *C. negevi* and *N. barkeri* feeding on mobile life stages of *O. afrasiaticus* increased for both predators from 0.14 to 0.19 female/female/day for *C. negevi* and from 0.13 to 0.16 for *N. barkeri* from 25 °C to 35 °C. Al-Shammery (2010) reported that r_m of *E. scutalis* fed on same prey at 26 °C and 70 % RH averaged 0.161. In biological control practices, r_m value can be used for selecting promising biocontrol candidates on the basis of their reproductive potential and to predict the outcome of pest-natural enemy interactions (Jervis and Copland 1996). Theoretically, a predator that has a population growth rate equal to or greater than its prey should efficiently regulate the population of its prey (Sabelis 1992). Our laboratory results indicated that *T. (A.) athenas* would be efficient in biological control of *O. afrasiaticus* as Ben Chaaban *et al.* (2008, 2011) demonstrated that feeding on 'Deglet Noor' dates, *O. afrasiaticus* presents the following demographic performances: r_m = 0.213 at 32 °C and r_m = 0.166 at 27 °C. The r_m value of *T. (A.) athenas* in the present study was higher than that of its prey on dates at 27 °C and 32 °C. Nevertheless, *T. (A.) athenas* consistently not suppressed populations of *O. afrasiaticus*

in fields. One hypothesis to explain that is that when the temperature exceeds 30 °C, *T. (A.) athenas* could avoid the adverse effects of the high temperatures by relocating themselves on shaded sites at lower temperatures where their population could increase and when the preys are scarce. Kolokytha *et al.* (2011b) showed that, the optimal developmental of *T. (A.) athenas* fed on eggs and all stages of *T. urticae* was at around 31 °C. *Typhlodromus (A.) athenas* showed seems to be a well-adapted organism to climatologic conditions of Greece and Mediterranean basin in general. When summer temperatures may rise above 35 °C, biological control of spider mites with *T. (A.) athenas* may be applicable because spider mites can develop well under such high temperatures (Sabelis 1985).

In Tunisian climatic conditions, further experiments on the predation rate of *T. (A.) athenas*, in case of mass-releases, are needed in order to get a better understanding of its efficiency for a successful biological control of *O. afrasiaticus*. The predatory mite, *Metaseiulus (Metaseiulus) flumenis*, was mass released to control the Banks grass mite, the major pest of date palms in California, early in the season when there is a higher proportion of prey eggs which are the preferred life stages of the predator (Ganjisaffar and Perring 2015). Based on the negative impact of high temperatures on *M. (M.) flumenis*, its also recommend to make the releases during the cool morning hours and in the inner canopy of the trees or inside the date bunches with minimum exposure to the sun and heat (Ganjisaffar and Perring 2017).

Moreover, even if r_m values are important, behavioural traits may be decisive in the success of a predator. For instance traits that allow predators to locate their prey fast, prey preference and alternative food occurrence may help understand the feeding behaviour of the phytoseiids traits like these remained unattended in our present study and need further investigations.

References

- Al Doghairi M. 2004 — Effect of eight Acaricides against the Date dust mite, *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae) — Pak. J. Biol. Sci., 7: 1168-1171. doi:10.3923/pjbs.2004.1168.1171
- Al-Shammery K.A. 2010 — Different biological aspects of the predaceous mite *Euseius scutalis* (Acari: Gamasida: Phytoseiidae) and the effects due to feeding on three tetranychid mite species in Hail, Saudi Arabia — Asian J. Biol. Sci., 3: 77-84.
- Amano H., Chant D.A. 1977 — Life history and reproduction of two species of predacious mites, *Phytoseiulus persimilis* Athias-Henriot and *Amblyseius andersoni* (Chant) (Acarina: Phytoseiidae) — Can. J. Zool., 55: 1978-1983. doi:10.1139/z77-255
- Baankoud A.S., Basahih H.G. 2000 — A study on the effect of date palm dust mite *Oligonychus afrasiaticus* (McGregor) (Acarina: Tetranychidae) on the physiochemical characters of three different date varieties in Wadi Hadhramout, Yemen — Arab. J. Pl. Prot., 18: 82-85.
- Barreveld W.H. 1993 — Date palm products — Food and Agriculture Organization of the United Nations, Rome, Italy. Bulletin no. 101
- Ben Chaaban S., Chermiti B., Lebdi-Grissa K. 2008 — Comparison of the susceptibility of several alimentary supports to the old world mite *Oligonychus afrasiaticus* (Acari: Tetranychidae) — In: Integrative Acarology: Proceedings of the sixth Congress of the European Association of Acarologists : 425-430.
- Ben Chaaban S., Chermiti B., Kreiter S. 2011 — *Oligonychus* and phytoseiid predator seasonal occurrence on date palm *Phoenix dactylifera* (Deglet Noor cultivar) in Tunisian oases — Bull. Insect., 64(1): 15-21.
- Ben Chaaban S., Chermiti B., Kreiter S. 2011 — Comparative demography of the spider mite, *Oligonychus afrasiaticus*, on four date palm varieties in Southwestern Tunisia — J. Insect. Sci., 11: 1-12. doi:10.1673/031.011.13601
- Carpenter J.B., Elmer H.S. 1978 — Pests and Diseases of the date palm — Agric. Handbook No. 527. Science and Education Administration, Department of Agriculture, United States: 1-42.
- Dhouibi M.H. 1991 — Les principaux ravageurs des palmiers dattiers et de la date en Tunisie — Institut National Agronomique de Tunisie, Tunis, 64 pp.
- Djerbi M. 1993 — Précis de Phéniculture — FAO. 192 pp.
- Edongali E.A., Kerra H.M., Gashira B.O. 1988 — Distribution and control of date mite *Oligonychus afrasiaticus* McGregor in Libya — Arab Near East Plant Protection Newsletters, 7: 1-25.
- Elwan A.A. 2000 — Survey of the insect and mite pests associated with date palm trees in Al-Dakhliya region, Sultanate of Oman — J. Egypt. Agric. Res., 78: 653-664.
- Ferrero M., Moraes G.J., Kreiter S., Tixier M.-S., Knapp M. 2007 — Life tables of the predatory mite *Phytoseiulus longipes* feeding on *Tetranychus evansi* at four temperatures (Acari: Phytoseiidae, Tetranychidae) — Exp. Appl. Acarol., 41(1-2): 45-53. doi:10.1007/s10493-007-9053-6
- Ferrero M., Gigot C., Tixier M.-S., Van Houten Y.M., Kreiter S. 2010 — Egg hatching response to a range of air humidities for six species of predatory mites. — Exp. Appl. Acarol., 135: 237-244. doi:10.1111/j.1570-7458.2010.00992.x

- Ganjisaffar F., Fathipour Y., Kamali K. 2011 — Temperature-dependent development and life table parameters of *Typhlodromus bagdasarjani* (Phytoseiidae) fed on two-spotted spider mite — Exp. Appl. Acarol., 55: 259-272. doi:10.1007/s10493-011-9467-z
- Ganjisaffar F., Perring T.M. 2015 — Prey stage preference and functional response of the predatory mite *Galendromus flumenis* to *Oligonychus pratensis* — Biol. Control., 82: 40-45.
- Guessoum M. 1986 — Approach of a bio-ecological study of the mite *Oligonychus afrasiaticus* (Boufaroua) on date palms — Annales de l'Institut National Agronomique El Harrach, Algérie, 10: 153-166.
- Hanna R., Zalom F.G., Wilson L.T., Leavitt G.M. 1997 — Sulfur can suppress mite predators in vineyards — California. Agric., 51: 19-21. doi:10.3733/ca.v051n01p19
- Hussain A.A. 1969 — Biology of *Paratetranychus afrasiaticus* McGregor infesting date palm in Iraq — Bull. Entomol. Soc. Egypt., 33: 221-225.
- Idder M.A., Pintureau B. 2008 — Efficacité de la coccinelle *Stethorus punctillum* (Weise) comme prédateur de l'acarien *Oligonychus afrasiaticus* (McGregor) dans les palmeraies de la région d'Ouargla en Algérie — Fruits, 63 (1): 85-92.
- James D.G., Price T.S., Wrightand L.C., Perez J. 2002 — Abundance and phenology of mites, leafhoppers, and thrips on pesticide-treated and untreated wine grapes in south central Washington — J. Agri. Urban. Entomol., 19: 45-54.
- Jervis M.A., Copland M.J.W. 1996 — The life cycle — In: Jervis M. & Kidd B. editors, Insect natural enemies: practical approaches to their study and evaluation — Chapman and Hall, London: 63-161.
- Kamel A.A., Al-Dosary S.B., Ibrahim S.B., Asif M. 2007 — Degradation of the acaricides abamectin, flufenoxuron and amitraz on Saudi Arabian dates — Food. Chem., 100: 1590-1593. doi:10.1016/j.foodchem.2006.01.002
- Kolokytha P.D., Fantinou A.A., Papadoulis G.T.H. 2011a — Effect of several different pollens on the bio-ecological parameters of the predatory mite *Typhlodromus athenas* Swirski and Ragusa (Acari: Phytoseiidae) — Environ. Entomol., 40(3): 597-604. doi:10.1603/EN10276
- Kolokytha P.D., Fantinou A.A., Papadoulis G.T.H. 2011b — Temperature and diet effects on immature development of predatory mite *Typhlodromus athenas* Swirski and Ragusa (Acari: Phytoseiidae) — Environ. Entomol., 40(6): 1577-1584. doi:10.1603/EN11098
- Kreiter S., Lebdi-Grissa K., Ben-Chaabane S., Chatti A., Tixier M.-S., Auger P., Chermiti B., Ksantini M., Khoulalia O. 2008 — Phytoseiid mites (Acari: Mesostigmata) from Tunisia: Catalogue, biogeography and key for identification — In: Integrative Acarology: Proceedings of the sixth Congress of the European Association of Acarologists: 197-207.
- Krips O.E., Witul A., Willems P.E.L., Dicke M. 1998 — Intrinsic rate of population increase of the spider mite *Tetranychus urticae* on the ornamental crop gerbera: intraspecific variation in host plant and Herbivore — Entomol. Exp. Appl., 89: 159-168. doi:10.1046/j.1570-7458.1998.00395.x
- Luh H., Croft B. 2001 — Quantitative classification of lifestyle types in predaceous phytoseiid mites — Exp. Appl. Acarol., 25: 403-424. doi:10.1023/A:1017988925742
- McMurtry J.A., Croft B.A. 1997 — Life-styles of phytoseiid mites and their roles in biological control — Annu. Rev. Entomol., 42: 291-321. doi:10.1146/annurev.ento.42.1.291
- Moraes G.J. de, McMurtry J.A., Denmark H.A., Campos C. B. 2004 — A revised catalog of the mite family Phytoseiidae — Zootaxa, 434, 1-494.
- Negm M.W., Fahadand J.A., Yousif N.A. 2014 — Biology, predation, and life table of *Cydnoseius negevi* and *Neoseiulus barkeri* (Acari: Phytoseiidae) on the old world date mite, *Oligonychus afrasiaticus* (Acari: Tetranychidae) — J. Insect. Sci., 14(177): 1-6.
- Othman K., Rhouma A., Belhadj R., Alimi E., Fallah H., Kreiter P., Lenfant C., Brun J. 2001 — Lutte biologique contre un acarien ravageur des dattes: essai d'utilisation de *Neoseiulus californicus* contre *Oligonychus afrasiaticus* dans les palmeraies du Djerid (Sud tunisien) — Phytoma, 540: 30-31.
- Overmeer W.P.J. 1985 — Alternative prey and other food resources — In: Helle W. & Sabelis M.W. editors. World crop pests: spider mites, their biology, natural enemies and Control. Vol. 1A, Elsevier, Amsterdam, the Netherlands: 131-139.
- Palevsky E., Ucko O., Peles S., Yablonski S., Gerson U. 2003 — Species of *Oligonychus* infesting date palm cultivars in the Southern Arava Valley of Israel — Phytoparasitica, 31: 350-355.
- Palevsky E., Ucko O., Peles S., Yablonski S., Gerson U. 2004 — Evaluation of control measures for *Oligonychus afrasiaticus* infesting date palm cultivars in the Southern Arava Valley of Israel — Crop. Prot., 23: 387-392. doi:10.1016/j.cropro.2003.09.008
- Papadoulis G.Th., Emmanouel N.G., Kapaxidi E.V. 2008 — Phytoseiidae of Greece and Cyprus (Acari: Phytoseiidae) — Indira Publishing House, Michigan, USA, 200 pp.
- Puchalska E.K., Kozak M. 2015 — *Typhlodromus pyri* and *Euseius finlandicus* (Acari: Phytoseiidae) as potential biocontrol agents against spider mites (Acari: Tetranychidae) inhabiting willows: laboratory studies on predator development and reproduction on four diets — Exp. Appl. Acarol., 68: 39-53. doi:10.1007/s10493-015-9973-5
- Reuveny H., Palevsky E., Gerson U. 1996 — Laboratory life history studies of the predaceous mite *Typhlodromus athiasae* (Acari: Phytoseiidae) — Syst. Appl. Acarol., 1: 45-53. doi:10.11158/saa.1.1.9
- Roy A.M., Brodeur J.B., Cloutier C.C. 2005 — Seasonal activity of the spider mite predators *Stethorus punctillum* (Coleoptera: Coccinellidae) and *Neoseiulus fallacis* (Acarina: Phytoseiidae) in raspberry, two predators of *Tetranychus mcdanieli* (Acarina: Tetranychidae) — Biol. Control., 34: 47-57. doi:10.1016/j.biocontrol.2005.03.012
- Sabelis M.W. 1992 — Predatory arthropods — In: Crawley M.J. Editor. Natural enemies. The population biology of predators, parasites and diseases. Blackwell, Oxford: 225-264.
- Sabelis M.W. 1985 — Reproductive Strategies — In: Helle W. & Sabelis M.W. editors. World crop pests: spider mites, their biology, natural enemies and control. Vol. 1A, Elsevier, Amsterdam, the Netherlands: 265-278.

- Saleh M.R.A., Hosny M.M. 1979 — Observations on *Oligonychus* spp. occurring on date bunches (Tetranychidae, Acari) — Research Bulletin, Faculty of Agriculture, Ain Shams University, 1114: 1-8.
- Sengonca C., Khan I.A., Blaeser P. 2003 — Prey consumption during development as well as longevity and reproduction of *Typhlodromus pyri* Scheuten (Acari, Phytoseiidae) at higher temperatures in the laboratory — J. Pest. Sci., 76(3): 57. doi:10.1046/j.1439-0280.2003.03016.x
- Stenseth C. 1979 — Effect of temperature and humidity on the development of *Phytoseiulus persimilis* and its ability to regulate populations of *Tetranychus urticae* — Bio. Control, 24(3): 311-317.
- Talhouk A.S. 1991 — On the management of the date palm and its arthropod enemies in the Arabian Peninsula — J. Appl. Entomol., 111: 514-520. doi:10.1111/j.1439-0418.1991.tb00354.x
- Tanigoshi L.K. 1982 — Advances in knowledge of the Phytoseiidae — In: Hoy M. A, editor. Recent advances in knowledge of the Phytoseiidae. Agricultural Sciences Publications, Berkeley: 1-22.
- Tsolakis H., Principato D., Jordà Palomero R. 2016 — Biological and life table parameters of *Typhlodromus laurentii* and *Iphiseius degenerans* (Acari, Phytoseiidae) fed on *Panonychus citri* and pollen of *Oxalis pes-caprae* under laboratory conditions — Exp. Appl. Acarol., 70: 205-218. doi:10.1007/s10493-016-0076-8
- Van de Vrie M., McMurtry J.A., Huffaker C.B. 1972 — Ecology of tetranychid mites and their natural enemies: A review. III. Biology, ecology, and pest status, and host-plant relations of tetranychids — Hilgardia, 41: 343-432.