Population studies of arthropods on *Melia azedarach* in Seville (Spain), with special reference to *Eutetranychus orientalis* (Acari: Tetranychidae) and its natural enemies

J.E. González-Zamora*, C. López & C. Avilla

Department of Ciencias Agroforestales, University of Seville, Ctra. de Utrera, km 1, E-41013-Seville, Spain. *E-mail: zamora@us.es

Abstract

Eutetranychus orientalis has become an important pest of the ornamental tree *Melia azedarach* in the city of Seville (Spain). Trees suffer total defoliation at the end of summer. Studies were conducted in a regular plantation of this tree in the Miraflores Park in 2008 and 2009, to determine the arthropod faunal composition, with particular interest in the possible natural enemies of *E. orientalis*. *Eutetranychus orientalis* accounted for 98.3% of the arthropods found on the leaflets. Two species of phytoseiids were found, *Euseius scutalis* and *Euseius stipulatus*, but they only represented 0.2% of the arthropods. The most abundant insect was the predator thrips *Scolothrips longicornis*, which accounted for 0.9% of the arthropods found. The population of *E. orientalis* reached two peaks in 2008, with 325 individuals per leaflet in August, and 100 individuals per leaflet in November. *Scolothrips longicornis* densities closely followed *E. orientalis*, and predation was observed on various mite instars. Phytoseiids did not show such a response to the *E. orientalis* densities. *Eutetranychus orientalis* was more abundant in the exterior part of the plantation. No differences of arthropod densities were found between the various orientations in the plantation (north vs. south, east vs. west), although *E. orientalis* densities were different between rows. Distribution of *E. orientalis* population was highly aggregative, that of *S. longicornis* population was less aggregative, whereas the phytoseiid population showed a random distribution.

Keywords: *Melia azedarach*, *Eutetranychus orientalis*, *Euseius scutalis*, *Scolothrips longicornis*, population dynamics, aggregation parameters.

Published in: Exp Appl Acarol (2011) 55:389–400

DOI 10.1007/s10493-011-9476-y

Introduction

Eutetranychus orientalis (Klein), known as the oriental red mite or the citrus brown mite, has a wide distribution in the Old World, but its country of origin is not clear (EPPO 2010). It is considered as an important pest of citrus in many countries of Africa, Asia, and certain regions of Oceania, but it has also been recorded in a wide range of other plants (Migeon and Dorkeld 2009; EPPO 2010), including the chinaberry or paraiso tree, *Melia azedarach* L. The mite appeared in Europe at the beginning of 2000's in Greece and Spain, attacking citrus and other plants (Migeon and Dorkeld 2009). The first mention of *E. orientalis* in Spain occurred in Málaga (south of Spain) in 2001 on citrus, and since then it has spread throughout most of southern Spain, attacking mainly citrus, but also crops such as mango, avocado and other trees (García et al. 2003).

Eutetranychus orientalis was first detected in the city of Seville (southern Spain) in the summer of 2003, and since then it has become a serious problem in the ornamental tree *M. azedarach*, causing premature fall of leaves in mid summer. The high densities that *E. orientalis* can reach on the leaves accounts for the defoliation, futhermore before the appearance of this mite no important phytopathological problem was observed on the tree in Seville. *Melia azadarach* is planted in many parts of Spain to provide shade and adorment to parks, gardens, streets and avenues, as in the city of Seville. The loss of its leaves in summer has a negative visual impact, and causes a lack of shade, which is important in a city like Seville with high levels of solar radiation and high temperatures during this season.

Eutetranychus orientalis also attacks the Seville orange *Citrus aurantium* L., but the damage caused here is not so important. It has spread throughout citrus groves of the region, together with the closely related *Eutetranychus banksi* (McGregor), resulting in degrees of damage of variable importance (García et al. 2003).

Due to the impact of *E. orientalis* on various crops, studies have focused also on its control. There are studies of chemical control of this mite (or related species) with pesticides (Tanigoshi et al. 1990; Yadav et al. 2003; Márquez et al. 2006) and plant extracts (Refaat et al. 2002; El-Sawi 2008), but also biological control studies have been carried out, with special emphasis on phytoseiids as main predators (Fouly 1997; Momen and El-Borolossy 1999; Rasmy et al. 2003; Ibrahim et al. 2005; Romeih et al. 2005), or even fungi (El-Hahdy 2004; Paz et al. 2007).

Melia azedarach is native to the foothills of the Himalaya, but it is widely distributed in India, south-east Asia and Australia (Allaby, 2006) and many other countries in the world. This tree has several uses, but it is mainly used for its quality timber. Futhermore, components related to azadirachtin have been extracted from its seeds and investigated for pest control purposes (Charleston et al. 2006; Hammad and McAuslane 2006; Nathan et al. 2006; El-Sawi 2008). Despite its wide distribution studies of the arthropod fauna (mainly related with Acari) and pathogens of *M. azedarach* are scarce (Song et al. 2006; Arneodo et al. 2007; Song et al. 2008; Migeon and Dorkeld 2009), and as far as we know, this is the first mention of so severe a damage produced by a mite on this tree.

The objectives of this study were to determine the arthropod fauna present on *M. azedarach* in the area of study (Seville, Spain), the population dynamics of the most important arthropods present on the tree (with a special interest in the possible natural enemies of the phytophagous species), their distribution in the area of study, and other ecological parameters that could be of interest in developing future control strategies of the harmful species.

Material and methods

This study was carried out in two areas of the city of Seville (Spain). The first area was a plantation of 12,680 m^2 with 208 trees of *M. azedarach* planted in a regular alignment, located in the Miraflores Park (37º24'21.33"N, 5º57'48.98"W), called zone A (Fig. 1). The second area was about 2,700 m^2 with around 20 dispersed *M. azedarach* trees, with many weeds around the trees (zone B, adjacent to zone A). Sampling started in May 2008 and finished in September 2009, with 24 and 19 sampling dates in zones A (2008 and 2009) and B (only in 2008), respectively. Zone A was selected to study the population dynamics, distribution and appearance of the arthropods (especially mites) on the trees. The sampling period in this zone covered 2 years, 2008 (with 20 sampling dates distributed along the whole vegetative period of the tree, from May to December) and 2009 (with only four sampling dates). Zone B was considered as a control zone, where it was studied whether weeds played a role in the arthropod composition and population dynamics on the trees.

Zone A was divided in 15 plots (one of the plots was missed due to the design of the zone), containing between 4 and 28 trees, by using a grid with four rows (A-D) and four columns (1-4) (Fig. 1). This design allowed several ways of analizing the distribution of the arthropods in zone A: 1) Exterior vs. interior, with 11 plots in the exterior part and four plots in the interior part; 2) Orientation, with latitude (seven plots in the northern part, eight plots in the south) and longitude (seven plots in the eastern part, eight plots in the west); 3) Rows (A-D), with four plots in each row, and columns (1-4), with four plots in each column. In each plot, 2-3 leaves were randomly sampled from different trees on each sampling date (with the help of a pruning pole to reach the higher branches), amounting to 34 leaves per sampling date in zone A. Zone B was considered as a unique plot, and 10 leaves were randomly sampled from different trees on each sampling date. A total of 964 leaves were collected in the sampling period (2008 and 2009) in both zones. Leaves were taken to the laboratory to process them. It was observed that when mite densities were low, the mites were distributed more or less evenly over the whole leaf, sometimes with a higher incidence on the basal leaflet. Since *M. azedarach* has compound leaves, which can reach lengths of around 50 cm or more, a basal leaflet was selected from each leaf and closely observed under a stereomicroscope at 7-45× magnification. All arthropods present were recorded, and those of particular interest (especially mites and natural enemies) were collected in 70% alcohol for further identification.

Mites were digested in lactic acid at 45-50 ºC for 24 h, and mounted in Hoyer's medium until its identification at 400× magnification. *Eutetranychus* species was identified following the EPPO (2010) data sheet and the diagnostic description given by Jeppson et al (1975). Other tetranychid and phytoseiid species were identified following Ferragut and Santonja (1989) and Ferragut and Escudero (1997). Dr. Ferragut (Universidad Politécnica of Valencia, Spain), determined and/or confirmed the mite species. The only thrips species found was prepared in the same way and identificated with the help of the Mound et al. (1976) key of Thysanoptera. The rest of the insects were determined by the authors with the help of general keys.

Paired *t*-tests were performed to compare zones A vs. B in one analysis, and interior vs. exterior parts in zone A in another. In both cases data were the mean density of arthropods of each sampling date in each zone (A vs. B), or interior vs. exterior parts in zone A. Densities of arthropods in the plots were submitted to a 3-factor mixed design of repeated measures analysis of variance (ANOVA), where orientation in latitude (north vs. south) and longitude (east vs. west) (in one analysis) and situations in rows (A-D) and columns (1-4) (in other analysis) of the plots where considered as between-groups variables, and the densities of arthropods along sampling dates in each plot as the within-subjects variable. If factors studied in the analysis of variance were significant at $p < 0.05$, then the differences between the means were determined using HSD Tukey test at a 95% confidence level. All data used in each analysis were ln (x+1) transformed, to achieve normality and homoscedasticity; untransformed means are presented. All analyses were performed using the SPSS 15.0 package for Windows (SPSS 2006).

Taylor's power law ($s^2=am^b$) (Taylor 1961) was used to study the aggregation of the most significant arthropods found on *M. azedarach* leaflets, using the mean (*m*) and variance (s^2) of each sampling date of each zone, A and B. Natural logarithms were applied to Taylor's power law to calculate regression parameters *a* and *b*.

Results

Species abundance

Acari represented the main group of arthropods observed on the *M. azedarach* leaves, accounting for 98.7% of the individuals observed (Table 1). The most important acarine species was *E. orientalis*, making up 98.3% (70.9 individuals per leaflet) of the individuals observed. Life stage distribution was clearly biased towards eggs, followed by immature stages and females, with males being the least abundant.

Another phytophagous mite present was *Tetranychus urticae* Koch, with a very low incidence (0.2% of the total population, or 0.12 individuals per leaflet). *Tetranychus urticae* was always observed in leaves with no *E. orientalis*, and with a patent web. Mites of the families Tenuipalpidae (the species identified was *Brevipalpus phoenicis* (Geijskes)) and Tydeidae were also found, but again in very low numbers, representing <0.1% (0.02 individuals per leaflet) of the total arthropods observed. Phytoseiids were present on the leaves although in low numbers, representing only 0.2% (0.15 individuals per leaflet) of the arthropods. Two species were identified, *Euseius scutalis* (Athias-Henriot) and *E. stipulatus* (Athias-Henriot), and their life stage composition was very different from that of the phytophagous species, with a greater presence of mobile instars than eggs.

Insects were the other group of arthropods observed on *M. azedarach* leaves (Table 1), but they only represented 1.3% (0.92 individuals per leaflet) of the total population of arthropods. The thrips *Scolothrips longicornis* Priesner was the most abundant (0.9% of the total population, or 0.66 individuals per leaflet), followed by the California red scale, *Aonidiella aurantii* (Maskell) (0.2% of the total population, or 0.18 individuals per leaflet). Eggs of Chrysopidae were also observed, but at low numbers (<0.1% of the total population, 0.05 individuals per leaflet). Other insects included psocopterans, Coccinellidae larvae and various coccids (<0.1% of the total population, or 0.04 individuals per leaflet).

Population dynamics

Arthropod population dynamics was studied over 2 years (Fig. 2). Although the study covered the total vegetative period of *M. azedarach* in 2008 only (May to mid December), the partial dynamics of the arthropod populations showed a similar pattern in 2009. The densities of *E. orientalis* increased in the middle of summer, reaching a peak of around 325 individuals per leaflet in August 2008. This density quickly decreased at the end of August, but increased again in autumn, reaching densities of around 100 individuals per leaflet in November, coinciding with a late sprouting of the defoliated trees. The few data available from 2009 showed that the first observation of *E. orientalis* was at the end of July 2009 (very similar to the first observation of the mite in 2008), and the next sampling date in September showed a clearly higher densitiy (Fig. 2). But the infrequent sampling in 2009 does not allow any conclusion on the height or timing of the population peak in this second year.

Scolothrips longicornis was the principal insect which appeared on *M. azedarach* leaves during the 2-year sampling period. This insect is a known predator of tetranychids, and its density followed closely that of *E. orientalis* in summer 2008, reaching peaks of around 5 individuals per leaflet; in 2009 the highest value found was 3 individuals per leaflet (in September) (Fig. 2). Our observations confirmed that larvae (and adults) of this thrips were located on leaflets with *E. orientalis*, and they were also observed feeding on the eggs and immature stages of the mite in both years. Thrips were almost non-existent in autumn 2008.

The other arthropods of particular interest observed on *M. azedarach* leaves were phytoseiids (Fig. 2), which are generally considered important predators of tetranychid mites (McMurtry and Croft 1997). The phytoseiids population fluctuated at around 0.2 individuals per leaflet throughout the entire sampling period, both in 2008 and 2009, regardless of the supposed prey density. On no occasion was a phytoseiid observed feeding on any stage of *Eutetranychus* on leaflets with a medium to high density of *E. orientalis*, or moving around the mite colonies.

Distribution and aggregation

Densities of *E. orientalis*, phytoseiids, and *S. longicornis* were not significantly different between zones A and B, with values of $P = 0.95$ ($t = -0.06$), $P = 0.23$ ($t = 1.30$) and $P = 0.22$ ($t = -1.41$), respectively. The density of *E. orientalis* in zone A of the Miraflores park was clearly higher in the exterior part (89.2 ± 14.4 individuals per leaflet) than in the interior part (37.4 ± 4.7 individuals per leaflet), with $P = 0.0009$ ($t = 4{,}28$). There were no significant differences in phytoseiids and *S. longicornis* densities between the exterior and interior parts of zone A, with $P = 0.19$ ($t = -1.47$), and $P = 0.65$ ($t = -0.48$), respectively.

No significant differences were found between north-south and east-west orientations in the Miraflores park for *E. orientalis*, phytoseiids, and *S. longicornis* densities, with P values between 0.083 ($F_{1,12} = 3.59$ for phytoseiids in the east-west orientation) and 0.83 ($F_{1,12}$

= 0.50 for *E. orientalis* in the north-south orientation). Interactions between north-south and east-west orientations were not significant in any case, with $P > 0.58$ ($F_{1,12} = 0.33$).

There were differences in the numbers of *E. orientalis* in the rows of zone A ($P = 0.028$, $F_{3,9} = 4.88$), but not in the columns ($P = 0.92$, $F_{3,9} = 0.16$). Row B, with 47.6 ± 13.4 individuals per leaflet, was significatively different from row A, with 120.9 ± 23.7 individuals per leaflet (Tukey's HSD: $P < 0.05$). Row C (114.5 ± 29.6 individuals per leaflet) and row D (144.4 ± 31.2 individuals per leaflet) occupied an intermediate position between them. Densities of phytoseiids and *S. longicornis* were not statistically different within rows and columns of zone A, with *P* values between 0.12 ($F_{3,9} = 2.61$ for *S. longicornis* in columns) and 0.56 ($F_{3,9} = 0.72$ for phytoseiids in rows). Interactions between rows and columns were not evaluated due the lack of degrees of freedom.

The mite *E. orientalis* showed a high aggregation in all of the stages considered (Table 2), with a global value of $b = 1.62$. The *b* value of females was lower (1.53), that of the mobile stages was higher (1.69). The phytoseiids yielded a *b* value near 1 (1.03), indicating a random distribution, whereas *S. longicornis* had $b = 1.37$.

Discussion

One of the main interests of this work was to know the arthropod fauna present on *M. azedarach*. After the monitoring program developed in 2008 and 2009, the predominance of the mite *E. orientalis* over the rest of the arthropods found in this tree was clear. This tree has been planted throughout Seville largely because of its lack of significant pest problems, at least until 2003. The rest of the Acari fauna observed on *M. azedarach* presented very little numerical importance. The other mites found were *T. urticae* and few individuals of the Tenuipalpidae and Tydeidae, which appeared in very low numbers and never on the same leaflets together with *E. orientalis*. Predator mites were represented by two phytoseiid species – *E. scutalis* and *E. stipulatus* – also in very low numbers. *Euseius scutalis* seemed to be more abundant, accounting for 73.3% of the adult phytoseiid females identified. Both species have been previously described in Spain, although it is not very common to see them together due to their different ecological preferences (Ferragut and Escudero 1997).

The life stage distribution of *E. orientalis* was very similar to that of other tetranychids, such as *T. urticae* and *Panonychus ulmi* (García-Marí et al. 1991), with a predominance of eggs, followed by immature stages, females and males. This was also the case for *T. urticae* found on *M. azedarach*.

The group of insects found on *M. azedarach* was very limited, and the most important species was the thrips *S. longicornis*. This species is known as a specific predator of tetranychids, capable of their control (Gerlach and Sengonça 1985; Oatman et al. 1985). Chrysopidae eggs were found (in some of them only the chorion), although no larvae were seen in the samples. The most common phytophagous insect species found on the leaflets of *M. azedarach* was the California red scale, *A. aurantii*. This species is common in other trees, like the Seville orange, and other ornamental plants, and this is the first time that it is cited on *M. azedarach*, but at so low densities that no damage was observed on the leaves.

The population dynamics of *E. orientalis* on *M. azedarach* trees in Seville was similar to those found in other countries on different plants, where one or two density peaks were found throughout 1 year (Tanigoshi et al. 1990; KapurGhai and Mandeep 2003; Rabindra et al. 2006; Zhou et al. 2006), although the timing of these peaks varied among the references. No differences were observed between zones A and B concerning the dynamics of arthropod densities or species composition, and therefore no effect of weeds could be determined. Weeds were sampled on different moments (data not shown), but very few mites were observed on them (phytoseiids, *Tetranychus* sp. and tydeids, but no *E. orientalis*).

The optimal development temperature for *E. orientalis* is between 25 and 30 ºC on *Albizia lebbek* (L.) Benth (Imani and Shishehbor 2009) and between 21 and 27 ºC on citrus trees (Bodenheimer 1951, quoted in EPPO 2010), and the summer temperatures in Seville (mean temperature around 27-28 ºC in July-August both in 2008 and 2009) did not seem to be a problem, its density peaking at 325 individuals per leaflet in August 2008 (Fig. 2).

Phytoseiids are considered as the main predators of tetranychids, and one of the most promising species is *E. scutalis*, which can adequately develop feeding on *E. orientalis* nymphs, with high r_m values (0.175-0.257) (Momen and AbdelKhalek 2008; Al-Shammery 2010) that are similar or superior to the few r_m values (0.094-0.144) obtained for *E. orientalis* at different temperatures (Imani and Shishehbor 2009). *Euseius scutalis* was reported to control *E. orientalis* numbers at non-damaging densities in lemmon in the Jordan valley (Tanigoshi et al. 1990). However, the *E. scutalis* density found on *M. azedarach* leaves in Seville did not respond to *E. orientalis* at all. Furthermore, it seemed to keep a regular level throughout the period of sampling, independently of the supposed prey. This result agrees quite well with the classification of life styles of phytoseiids made by McMurtry and Croft (1997), who include *Eusieus* species in Type IV phytoseiids: generalists that cannot normally regulate mite densities (especially when they reach high numbers), and generally feed on pollen and other substances obtained from leaves. Densities of *E. orientalis* on citrus were as much as 15 mobile stages per leaf, with a good biological control when they were around 4-

10 mobile stages per leaf (Tanigoshi et al. 1990), whereas mite densities on *M. azedarach* reached around 150 mobile stages per leaflet. Using an aproximate equivalence of 2-3 lemmon leaves for one chinaberry leaflet, it is easy to understand that mite density on *M. azedarach* was much higher and a deterrent for the phytoseiid's activity. Moreover, the leaf of *M. azedarach* is different from the citrus leaf, more hairy and with many nectaries, which can be the source of food for the phytoseiids, instead of feeding on other arthropods.

Research into phytoseiids able to control *E. orientalis* densities is very extensive (Fouly 1997; Momen and El-Borolossy 1999; Rasmy et al. 2003; Ibrahim et al. 2005; Romeih et al. 2005) but there have been no clear practical results. A promising phytoseiid species is *Amblyseius swirskii* (Athias-Henriot), which can also adequately develop feeding on *E. orientalis* (Ali and Zaher 2007; Zaher et al. 2007), and it is commercially produced and extensively used in greenhouses of southern Spain to control a variety of pests (Calvo et al. 2009).

The most important predator observed during the sampling period was the thrips *S. longicornis*, with high densities in both years which followed closely the *E. orientalis* population (in 2008; no data available for 2009), although it was unable to limit mite numbers and the subsequent damage observed on trees. Other species of *Scolothrips* have been reported to feed on *E. orientalis*, such as *S. indicus* Priesner in India (Walter et al. 1995), and various *Scolothrips* species are generally considered to be important predators of tetranychids (Gerlach and Sengonça 1985; Oatman et al. 1985; García-Marí and González-Zamora 1999).

The mite *E. orientalis* was most abundant in the exterior part of the *M. azedarach* plantation of zone A. There were also differences between densities depending on the row considered, with higher densities in the exterior rows, but no differences were observed regarding columns or orientation. Phytoseiids and *S. longicornis* densities did not show clear differences between the different parts of zone A. This pattern suggests that *E. orientalis* colonized the area of study from the exterior, perhaps depending on the row situation, whereas the other two groups of arthropods (phytoseiids and especially thrips) are not conditioned by this aspect, showing greater mobility.

Eutetranychus orientalis populations were highly aggregative on the leaflets of *M. azedarach*, as occurs with many other tetranychids in different crops, with *b* values around 1.49 ± 0.10 for mobile stages (Jones 1990a; García-Marí et al. 1991). On the contrary, the phytoseiids found on *M. azedarach* had a random distribution, which in some way reflects a weak association of the phytoseiids with the mite. This behaviour differs among phytoseiid species which normally feed on tetranychids, with *b* values ranging between 1.23 and 1.59

(Cross 1984; Wilson et al. 1984; Jones 1990b; García-Marí et al. 1991). Instead, the thrips *S. longicornis* showed a relatively high aggregation, conditioned by the presence of its prey.

The problem of *E. orientalis* in Seville city mainly arises from the visual effect of defoliated trees at the end of summer. An integrated management of this problem should take into account the main predators of the pests observed in this study, with improved knowledge of the biology of the arthropods of interest. It would be interesting to advance in the biology and ecology of the thrips *S. longicornis* in urban areas, but predators have not been able to limit mite populations until now, and the use of pesticides and substances able to limit mite densities should be considered, whilst at the same time respecting the natural enemies of pests and the environment where they are to be used. Another strategy to consider, if natural presence of predators is not enough to regulate numbers of *E. orientalis*, is augmentation of predators via inoculative releases, which can be of interest and deserves further study, especially regarding some phytoseiids such as *A. swirskii*.

Acknowledgements

The authors wish to thank Carmen Lora, director of the Miraflores Park of Seville city, for her support and for allowing us the use of the facilities in the park to carry out this work. We also thank Pedro Torrent, from the Servicio de Parques y Jardines of Seville town council, for his help in finding the sampling zones and throughout the period of study. Species of mites were determined and/or confirmed by Francisco Ferragut, from the Universidad Politécnica de Valencia (Spain).

References

Ali FS, Zaher MA (2007) Effect of food and temperature on the biology of *Typhlodrompis swirskii* (Athias-Henriot) (Acari: Phytoseiidae). Acarines 1:17-21

Allaby, M (ed.) (2006) Dictionary of Plant Sciences. Oxford University Press, Oxford, UK

Al-Shammery KA (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

Arneodo JD, Marini DC, Galdeano E, Meneguzzi N, Bacci M, Domecq C, Nome SF, Conci LR (2007) Diversity and geographical distribution of phytoplasmas infecting China-tree in Argentina. J Phytopathol 155:70-75

Calvo FJ, Bolckmans K, Belda JE (2009) Development of a biological control-based Integrated Pest Management method for *Bemisia tabaci* for protected sweet pepper crops. Entomol Exp Appl 133:9-18

Charleston DS, Kfir R, Dicke M, Vet LEM (2006) Impact of botanical extracts derived from *Melia azedarach* and *Azadirachta indica* on populations of *Plutella xylostella* and its natural enemies: A field test of laboratory findings. Biol Control 39:105-114

Cross JV (1984) Biological control of two-spotted spider mite (*Tetranychus urticae*) by *Phytoseiulus persimilis* on strawberries grown in 'walk in' plastic tunnels, and a simplified method of spider mite population assesment. Plant Pathol 33:417-423

El-Hady MM (2004) Susceptibility of the citrus brown mite, *Eutetranychus orientalis* (Klein) to the entomopathogenic fungi *Verticillium lecanii* and *Metahrrizium anisopliae*. Egypt J Biol Pest Control 14:409-410

El-Sawi SA (2008) Toxicity and bioactivity of *Melia azedarach* L. on the two spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae), and its predacious mite, *Euseius scutalis* (Athais - Henriot) (Acari: Phytoseiidae). Egypt J Biol Pest Control 18:289-295

EPPO (2010) Data Sheets on Quarantine Pests: *Eutetranychus orientalis*. http://www.eppo.org/QUARANTINE/insects/Eutetranychus_orientalis/EUTEOR_ds.pdf . Accesion date 02/08 2010

Ferragut F, Santonja MC (1989) Taxonomía y distribución de los ácaros del género Tetranychus Dufour 1832 (Acari: Tetranychidae), en España. Bol San Veg -Plagas 15:271-281

Ferragut F, Escudero A (1997) Taxonomía y distribución de los ácaros depredadores del género Euseius Wainstein 1962, en España (Acari: Phytoseiidae). Bol San Veg -Plagas 23:227-235

Fouly AH (1997) Effects of prey mites and pollen on the biology and life tables of *Proprioseiopsis asetus* (Chant) (Acari, Phytoseiidae). J Appl Entomol 121:435-439

García E, Márquez AL, Orta S, Alvarado P (2003) Caracterización de la presencia de *Eutetranychus banksi* (McGregor) y *Eutetranychus orientalis* (Klein) en el Sur de España. Phytoma España 153:90-96

García-Marí F, González-Zamora JE, Orenga Royo S, Saques Fernandez J, Laborda Cenjor R, Soto Sanchez A, Ribes Koninckx A (1991) Distribución espacial y asociación entre especies de ácaros fitófagos (Tetranychidae) y depredadores (Phytoseiidae) en hojas de fresón. Bol San Veg -Plagas 17:401-415

García-Marí F, González-Zamora JE (1999) Biological control of *Tetranychus urticae* (Acari: Tetranychidae) with naturally occurring predators in strawberry plantings in Valencia, Spain. Exp Appl Acarol 23:487-495

Gerlach S, Sengonça C (1985) Comparative studies on the efectiveness of the predatory mite, *Phytoseiulus persimilis* Athias-Henriot, and the predatory thrips, *Scolothrips longicornis* Priesner. J Plant Dis Prot 92:138-146

Hammad EAF, McAuslane HJ (2006) Effect of *Melia azedarach* L. extract on *Bemisia argentifolii* (Hemiptera : Aleyrodidae) and its biocontrol agent *Eretmocerus rui* (Hymenoptera : Aphelinidae). Environ Entomol 35:740-745

Ibrahim GA, El-Sayed El-Ghobashy KM, Shoeib AA (2005) Biological control of citrus brown mite *Eutetranychus orientals* using predatory mite, *Neoseiulus californicus* (McGregor) (Acari: Tetranychidae & Phytoseiidae) on citrus trees. Egypt J Agric Res 83:131-139

Imani Z, Shishehbor P (2009) Effect of temperature on life history and life tables of *Eutetranychus orientalis* (Klein) (Acari: Tetranychidae). Systematic and Applied Acarology 14:11-18

Jeppson LR, Keifer HH, Baker EL (1975) Mites injurious to economic plants. University of California Press, Berkeley, USA

Jones VP (1990a) Developing sampling plans for spider mites (Acari:Tetranychidae): those who don't remenber the past may have to repeat it. J Econ Entomol 83:1656-1664

Jones VP (1990b) Sampling and dispersion of the twospotted spider mite (Acari: Tetranychidae) and the western orchard predatory mite (Acari: Phytoseiidae) on tart cherry. J Econ Entomol 83:1376-1380

KapurGhai J, Mandeep K (2003) Differential susceptibility of various cultivars to infestation with the citrus brown mite, *Eutetranychus orientalis*. Annals of Agri Bio Research 8:247-253

Márquez AL, Wong E, Garcia E, Olivero J (2006) Efficacy assay of different phytosanitary chemicals for the control of *Eutetranychus orientalis* (Klein) (Oriental Spider Mite) on Fine lemon and Valencia-Late orange crops. Bulletin OILB/SROP 29:305-310

McMurtry JA, Croft BA (1997) Life-styles of phytoseiid mites and their roles in biological control. Annu Rev Entomol 42:291-321

Migeon A, Dorkeld F (2009) Spider Mites Web: A Comprehensive Database for the Tetranychidae. http://www.ensam.inra.fr/CBGP/spmweb/notespecies.php?id=321. Accesion date 06/22 2010

Momen F, El-Borolossy M (1999) Suitability of the citrus brown mite, *Eutetranychus orientalis* as prey for nine species of phytoseiid mites (Acari : Tetranychidae, Phytoseiidae). Acarologia 40:19-23

Momen F, AbdelKhalek A (2008) Influence of diet on biology and life-table parameters of the predacious mite *Euseius scutalis* (A.H.) (Acari: Phytoseiidae). Archives of Phytopathology and Plant Protection 41:418-430

Mound LA, Morison GD, Pitkin BR, Palmer JM (1976) Thysanoptera. Royal Entomological Society of Lodon, London, UK

Nathan SS, Savitha G, George DK, Narmadha A, Suganya L, Chung PG (2006) Efficacy of *Melia azedarach* L. extract on the malarial vector *Anopheles stephensi* Liston (Diptera : Culicidae). Bioresour Technol 97:1316-1323

Oatman ER, Badgley ME, Platner GR (1985) Predators of the two-spotted spider mite on strawberry. Cal Agricul January-February:9-12

Paz Z, Gerson U, Sztejnberg A (2007) Assaying three new fungi against citrus mites in the laboratory, and a field trial. Biocontrol 52:855-862

Rabindra P, Sanjay K, Devendra P (2006) An account of mite pest fauna associated with common vegetables grown in Ranchi. J Pl Prot Envir 3:149-151

Rasmy AH, Momen FM, Zaher AbouElella GM (2003) Influence of diet on life history and predatory capacity of *Amblyseius zaheri* Yousef & El-Brolossy (Acari: Phytoseiidae). Insect Sci Appl 23:31-34

Refaat AM, Momen FM, Amer SAA (2002) Acaricidal activity of sweet basil and French lavender essential oils against two species of mites of the family Tetranychidae (Acari: Tetranychidae). Acta Phytopathologica Et Entomologica Hungarica 37:287-298

Romeih AHM, Hassan MF, Rizk AboShnaf RIA (2005) Description and life history of *Typhlodromus citri* Hassan & Romeih sp. n. (Acari: Phytoseiidae). Egypt J Biol Pest Control 15:49-56

Song ZW, Xue XF, Hong XY (2006) Three new species of *Aculops* Keifer (Acari : Eriophyidae : Phyllocoptinae) from Gansu Province, China. Orient Insects 40:381-390

Song ZW, Xue XF, Hong XY (2008) Eriophyoid mite fauna (Acari : Eriophyoidea) of Gansu Province, northwestern China with descriptions of twelve new species. Zootaxa1-48

SPSS Inc. 2006. SPSS 15.0 for windows. Version 15.0.1.

Tanigoshi LK, Bahdousheh M, Babcock JM, Sawaqued R (1990) *Euseius scutalis* (Athias-Henriot) a predator of *Eutetranychus orientalis* (Klein) (Acari: Phytoseiidae, Tetranychidae) in Jordan: toxicity of some acaricides to *E. orientalis*. Arab J Pl Prot 8:120-114

Taylor LR (1961) Aggregation, variance and the mean. Nature 189:732-735

Walter DE, Halliday RB, Smith D (1995) The oriental red mite, *Eutetranychus orientalis*

(Klein) (Acarina, Tetranychidae), in Australia. J Aust Entomol Soc 34:307-308

Wilson LT, Hoy MA, Zalom FG, Smilanick JM (1984) Sampling mites in almonds: I. Within-tree distribution and cumping pattern of mites with comments on predatory-prey interactions. Hilgardia 5:1-13

Yadav SK, Ashok S, Veer S (2003) Relative efficacy of some insecticides/acaricides for the management of mite, *Eutetranychus orientalis* (Klein), on ber under field conditions. Annals of Biology 19:221-223

Zaher MA, El-Bishlawy SAO, Ali FS (2007) Some ecological and biological studies on *Typhlodrompis swirskii* (Athias-Henriot) (Acari: Phytoseiidae). Acarines 1:23-27

Zhou C, Zhang W, Qiao L, Sun X, Wang Z (2006) The biological characteristics, effective accumulate temperature and occurrence regulation of *Eutetranychus orientalis*. Scientia Silvae Sinicae 42:89-93

Figure captions

Fig. 1 Drawing of zone A of the Miraflores Park of Seville (Spain), showing the different plots with the distribution of trees. Latitude (north and south) and longitude (east and west), and rows (A-D) and columns (1-4) are represented in the drawing.

Fig. 2 Population development of *Eutetranychus orientalis*, *Scolothrips longicornis*, and phytoseiid mites on *Melia azedarach* leaflets during 2008 and 2009 in the city of Seville (Spain). Vertical bars represent the standard error.

Table 1 Arthropods found on *Melia azedarach* leaflets (n = 964) in 2008 and 2009 in Seville (Spain).

	Number	% of total arthropods	% within species/group
TOTAL ARTHROPODS	69,516		
Acari	**68,627**	**98.7**	
Tetranychidae			
Eutetranychus orientalis	68,347	98.3	
Eggs			63.5
Immatures			28.4
Males			3.2
Females			4.9
Tetranychus urticae	114	0.2	
Eggs			63.5
Mobile instars			36.5
Phytoseiidae	143	0.2	
Eggs			19.4
Mobile instars			80.6
Euseius scutalis			73.3[1]
Euseius stipulatus			26.7[1]
Others	23	<0.1	
Tenuipalpidae (*Brevipalpus phoenicis*)			30.4
Tydeidae			52.2
Others			17.4
Insects	**889**	**1.3**	
Scolothrips longicornis (Thysanoptera,Thripidae)	633	0.9	
Neuroptera, Chrysopidae (eggs)	48	<0.1	
Aonidiella aurantii (Hemiptera, Diaspididae)	170	0.2	
Others	38	<0.1	

[1] Percentage obtained from 15 females.

Table 2 Agreggation parameters of various arthropods found on *Melia azedarach* leaflets during 2008 and 2009 in the city of Seville (Spain).

Species and life stage	No. of observations	Intercept (ln a ± SE)	Slope (b)	95% confidence interval of b	R^2
Eutetranychus orientalis					
Eggs	30	2.23±0.25	1.63	1.49-1.76	0.955
Inmatures+males	29	2.25±0.17	1.67	1.56-1.79	0.970
Females	30	1.55±0.13	1.53	1.40-1.67	0.948
Mobile stages	30	2.09±0.17	1.69	1.57-1.80	0.969
All stages	30	2.40±0.24	1.62	1.50-1.74	0.962
Phytoseiids					
All stages	30	0.15±0.16	1.03	0.88-1.18	0.868
Scolothrips longicornis					
All stages	20	1.17±0.15	1.37	1.21-1.52	0.949

The parameters obtained come from the regression line $\ln s^2 = \ln a + b \ln m$, where s^2 is the variance and m is the mean of the population.

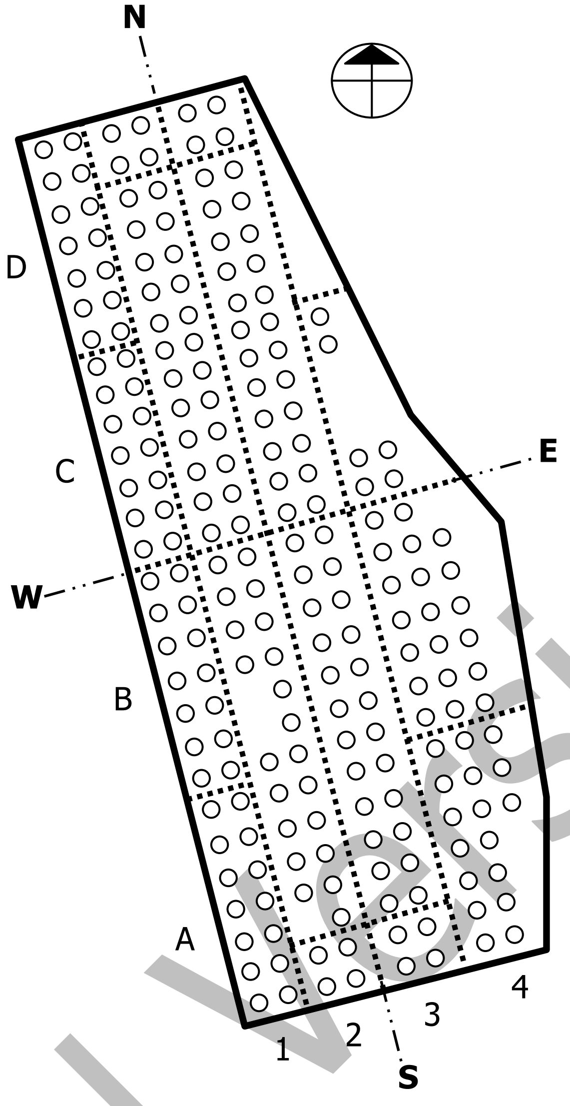

Figure 1

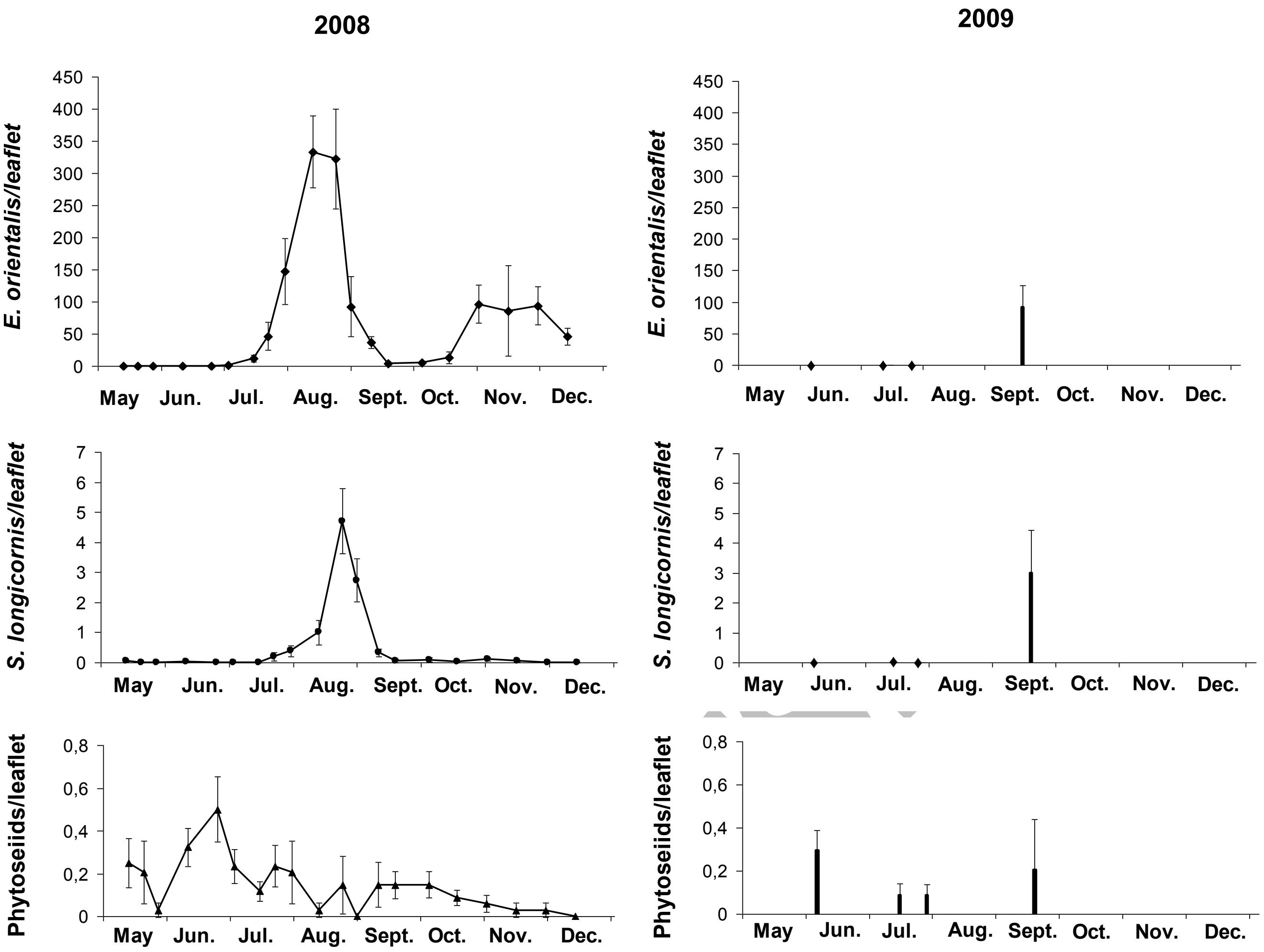
2008
2009
E. orientalis/leaflet
0
50
100
150
200
250
300
350
400
450
S. longicornis/leaflet
0
1
2
3
4
5
6
7
Phytoseiids/leaflet
0
0,2
0,4
0,6
0,8
May
Jun.
Jul.
Aug.
Sept.
Oct.
Nov.
Dec.

Figure 2