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Plant Parasitic and Predatory Mites (Acari: Tetranychidae, Phytoseiidae) and Population Density Fluctuation of Two-Spotted Spider Mite (*Tetranychus urticae Koch*) on Strawberry in the Mersin Province of Turkey

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Research Article

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ABSTRACT

Determination of plant parasitic and beneficial mite diversity and population fluctuation of *Tetranychus urticae Koch* (Acari: Tetranychidae) were carried out on Strawberry (Rosaceae: Fragaria) fields between 2011 and 2013 in the Mersin province of Turkey. In outdoor strawberry fields, the mite composition has not been investigated comprehensively in this area. Fourteen plant parasitic, predatory and *saprophagous* mite species were established on strawberry leaves belongs to 5 families: *Tetranychus urticae Koch* (Acari: Tetranychidae) was the predominant harmful mite species all the sampled regions of Mersin while *Neoseiulus californicus* (McGregor), and *Phytoseiulus persimilis* (Athias-Henriot) were found common predatory species. *Amblyseius swirskii* (Athias-Henriot), *Amblyseius andersoni* (Chant), *Euseius stipulatus* (Athias-Henroit), *Euseius finlandicus* (Oudemans), *Typhlodromus intercalaris* (Livshitz-Kuznetsov) and *Phytoseius finitimus* (Ribaga sensu Denmark) which belong to the Phytoseiidae family and are identified beneficial mite species. Besides this, Proctolaelaps sp. (*Ascidae*) (Acari: Mesostigmata) was predatory mite, while *Tyrophagus putrescentiae* (Shrank) (*Acaridae*) (Acari: Astigmata) was identified as a saprophagous species. In terms of beneficial species, Phytoseiidae is the most common family. *Tetranychus urticae* Koch (Acari: Tetranychidae) have been found to be the most harmful and abundant pests species on strawberry plants causing severe damage. The aim of this study was to determination of plant parastic and beneficial mite species and observation of the population density fluctuations of *Tetranychus urticae* in three different regions of Silifke (Atayurt, Işıklı and Kurtuluş villages) in Mersin. The population density of *T. urticae* on strawberry plants began to increase in April and late-May and peaked three times in mid-April, late-May and mid-September. The data from the studies showed that biological control could be integrated to develop an effective mite management program.

INTRODUCTION

Approximately three million tons of strawberries (Rosaceae: Fragaria) are produced annually in different regions of the world [1]. The strawberries produced in all South American countries amount to about 11,884 hectares and fruit production is 318,686 metric tons. Argentina and Brazil are the most important strawberry producers in South America [2].

Turkey is the 3rd biggest strawberry producer in the world with 376.070 tons of production from 13.234 ha in 2014 [3]. Mersin, situated on the Southern Mediterranean Coast of Turkey, is the most important region with 45% of strawberry production and exportation. The strawberries are grown on a hill system in open fields under plastic tunnels. Cultivation of strawberries in plastic tunnels has increased considerably recently in Turkey [4]. New strawberry cultivars, such as Chandler, Camarosa, and Sweet Charlie, contributed much to the level of production in this area [5,6].

Mites are very important pests both in greenhouses and outdoor cultivations including strawberry farms worldwide. They feed and lay eggs on the leaves and infested plants bear sterile blooms and become stunted or may even die [7,8].

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The Two Spotted Spider Mite, feeds on strawberry (*Fargaria* spp.) leaves by piercing the mesophyll tissue [9,10]. A negative correlation between cumulative feeding mite-days and harvested yields was detected when plants became 80 mites per leaf [11]. The Two Spotted Spider Mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), is an economically harmful pest due to its high rate of fecundity and short life cycle. This species can develop easily in different environmental conditions with low relative humidity and in optimum temperature 32°C [9]. This species has 4-12 days from eggs to adult and may live for three weeks as an adult. Spider mites produce silk which protects the colonies from natural enemies and acaricides. The *T. urticae* individuals hibernate in the female stage in the litter and hidden places of the plants [9].

Due to broad morphological differences, *Tetranychus urticae* has been described with over 50 different synonyms and it is considered that it may be a species complex. *T. cinnabarinus* which has been reported in recent years as a morpho-type of *T. urticae* [12].

T. urticae and *Tetranychus turkestani* (Ugarov and Nikolski) (*Acari: Tetranychidae*) were the most important pest species on the strawberry in Turkey and in the world [8,13-16]. The Two Spotted Spider Mite (*Tetranychus urticae*), is the most common and severe plant parasitic mite that effects the production of strawberries [17-19].

Beside *T. urticae*, the phytophagous mite *Phytonemus pallidus* Banks (Acari: Tarsonemidae) is a very important pest of strawberry plantations in the United Kingdom. Among the predatory mites *Neoseiulus californicus* (McGregor) and *N. cucumeris* (Oudemans) (Acari: Phytoseiidae) were the most effective biological control agent [20].

Phytonemus pallidus and *Polyphagotarsonemus latus* (Banks) were identified from different host plants in Turkey, especially on vegetables [21-23].

Ten phytoseiid species were reported on strawberries in Latvia; *Neoseiulus agrestis* (Karg), *N. aurescens* (Athias-Henriot), *N. barkeri* (Hughes), *N. bicaudus* (Wainstein), *N. cucumeris*, *N. herbarius* (Wainstein), *N. reductus* (Wainstein), *N. zwoelferi* (Dosse), Typhlodromips rademacheri (Dosse) and Propriseiopsis okanagensis (Chant) [24].

The predatory mite *Phytoseiulus macropilis* (Banks) (Acari: Phytoseiidae) was reported as a potential biological control agent of *T. urticae* on strawberry plants [25]. It was mentioned that, Typhlodromus (Typhlodromus) pyri Scheuten, Typhlodromus (Anthoseius) rhenanus (Oudemans) (*Acari: Phytoseiidae*) and *P. macropilis* were the most abundant predatory mite species on strawberry plants in Norway and Brazil [26].

Many researchers have reported that the ecological balance was destroyed by large-scale use of acaricides and insecticides on mite and insect pests [27]. Similarly, pesticides have been used so extensively by Turkish strawberry growers for a long time to control mite and thrips populations [28].

Biological control methods play an important role for the control of the population level of plant parasitic mites. The best known predatory mite species for biological control of spider mites on strawberry plantations commercially were *P. persimilis*, *Galendromus occidentalis* (Nesbitt); *Neoseiulus californicus* (McGregor) and *Neoseiulus fallacis* (Garman) (*Acari: Phytoseiidae*) [5,10,29].

In outdoor strawberry fields, the mite composition has not been investigated comprehensively in Mersin-Turkey. The aim of this study was to conduct a survey to determine plant parasitic and predatory mite species strawberry field plantations in Mersin. The identification of plant parasitic and beneficial mites and establishment of their occurrence rate during the growing season of strawberry fields is the objective of this study. Beside these the determination of population density fluctuations of *T. urticae* in three different areas of Silifke (Atayurt Town, Işıklı and Kurtuluş Villages) from January 2011 to June 2013 of Mersin was the objective of this study due to the establish of mite management programme which depends on protecting ecological balance.

MATERIALS AND METHODS

The work was conducted strawberry plantations in southern Turkey (Mersin), from January 2011 to August 2013 **(Figure 1)**. This is a humid area where the humidity level was higher between January to June and represented the Mediterranean climate condition. Geographical data and a map of the surveyed areas showing where various strawberry varieties are grown are provided in **Table 1** and **Figure 1**.

Sampling area

The geographical data related surveyed areas are showed on **Table 1**.

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Table 1. Sampling areas of Mersin, location and coordinates.

Location	Coordinates
Mersin Silifke (Merkez)	36°.22',31.0836" North 33°.55',59.4696" East
Mersin Silifke (Atakent)	36°.24'1.5444" North 34°3'35.8668" East
Mersin Silifke (Atayurt)	36°.22',53.5512" North 34°,1',45.5916" East
Mersin Silifke (Taşucu)	36°.19',7.0139" North 33°.52',53.7312" East
Mersin Silifke (Yeşilovacık)	36°.11',40.902" North 33°.39',59.4972" East
Mersin Silifke (Akdere)	36°.14',25.0512" North 33°.45',1.34639" East
Mersin Silifke (Kabasakallı)	36°.23',38.8032" North 33°.59',25.188" East
Mersin Silifke (Arkum)	36°.21',6.7356" North 34°.3',15.8328" East
Mersin Yenişehir	36°.51',58.2624" North 34°.29',10.8924" East
Mersin Akdeniz	36°.48',15.1308" North 34°.38',18.8484" East
Mersin Mezitli	36°.48',15.1308" North 34°.38',18.8484" East
Mersin Toroslar	36°.48',15.1308" North 34°.38',18.8484" East
Mersin Anamur	36°.4',30.54" North 32°,50',18.7404" East

Mite sampling

The study was carried out in a strawberry plantation of Mersin, for the determination of plant parasitic and predatory mite species in fields regardless of whether sprayed or not sprayed. Regular surveys were conducted Akdeniz, Mezitli, Toroslar, Yenişehir and Silifke region of Mersin during January to July of 2011 to 2013 **(Figure 1)**.

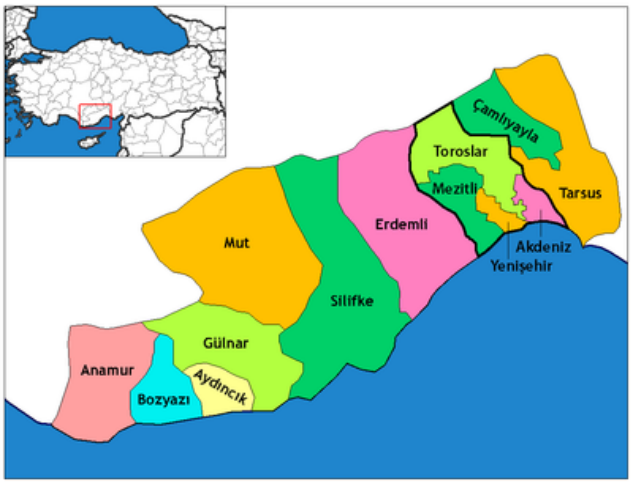

Figure 1. Surveyed areas of Mersin province.

During the surveys, the strawberry fields were applied by grower's regular procedures involving application of fungicides, insecticides and acaricides.

Fifty fully-expanded trifoliate strawberry leaves were randomly sampled at monthly intervals from each field of the surveying areas at each sampling date. The leaves were taken in different levels and height of plants. The collected leaves were put into vinyl bags and then an ice-chilled cooler. The leaves were stored in a refrigerator until examined. Mites on the leaf samples were examined both with a stereoscopic microscope and by extracting with a Berlese funnel [30]. The collected mites were preserved in alcohol (70%), then were cleaned, stained and mounted in Hoyer's medium [31]. The numbers of each mite species were counted in

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samples. Based on the slides for each species of abundance (the total number of mites). Species identification of mounted mites was carried out according to Jeppson et al. [9], Hughes [32], Papadoulis et al. [33], Faraji et al. [34], Seeman and Beard [35].

Population Densities of Mites in Strawberry Fields

Tetranychus urticae (Acari: Tetranychidae) was found to be the most harmful and common plant parasitic mite species on strawberry plants. Beside the species determination survey studies additional studies apart from that carried out at weekly interval for the determination of population fluctuations of *T. urticae* in three different areas of Mersin-Silifke (Atayurt Town, Işıklı and Kurtuluş Villages) from January 2011 to August 2013 of Mersin.

The leaves were taken for determination of population density fluctuations of *T. urticae*, from 1-5 da fields of Camarosa which is the main cultivated strawberry cultivar, at three different localities of unsprayed (since the estimation of the natural population fluctuation of *Tetranychus urticae* population) of strawberry fields in Silifke. For observing mite population, the presence of at least one mite active stage or egg considered. The leaf samples were collected at three different level of directions in each sampling site and density. From such samples data on population fluctuation of spider mites have been obtained. The average plant parasitic mite numbers (*T. urticae*) were estimated from the 50 leaves by "leaves/cm^2". The number of leaves with mites divided by the total number of leaves sampled. The average number of mites per infested leaf and calculated per unit area of cm^2. These measures can be expressed per locations, dates and seasons/years.

Statistical analysis

Population density fluctuation of phytophagous mites was obtained from all surveyed areas between 2011 and 2013. Average diversity and abundance of plant parasitic and predator mites obtained from all survey areas in the same duration mentioned above, depends on number of individuals of a species as a percentage of total individuals (all species) in a sample, and domination is number of a species as a percentage of total individuals (all species) in all samples. The climate data's were obtained from meteorological stations in Mersin during the sampling periods.

RESULTS

Mite Species on Strawberries in Mersin

Identified mites belonging to 14 species representing in 5 families were obtained from the strawberry growing areas in Mersin between 2011 and 2013. The proportional distribution of species is given in **Table 2**.

Table 2. Mite species and their proportional distribution on strawberry fields in Mersin provinces of Turkey in 2011-2013.

Order	Family	Species	Feeding Habit*	Number of Specimen	Ratio
Prostigmata	*Tetranychidae*	*Tetranychus urticae* (Koch.)	Phy.	1244	91
		Bryobia rubrioculus(Scheuten)	Phy.	28	2.1
		Eotetranychus sp.	Phy.	1	0.07
Mesostigmata	*Phytoseiidae*	*Amblyseius andersoni*(Chant)	Pre.	5	0.35
		Amblyseius swirskii Athias-Henriot	Pre.	3	0.22
		Neoseiulus californicus (McGregor)	Pre.	32	2.36
		Phytoseiulus persimilis Athias-Henrio)t	Pre.	21	1.55
		Euseius finlandicus (Oudemans)	Pre.	2	0.14
		Euseius stipulatus (Athias-Henriot)	Pre.	2	0.14
		Phytoseius finitimus Ribaga	Pre.	5	0.35
		Typhlodromus intercalaris (Livshitz – Kuznetsov)	Pre.	1	0.07
	Ascidae	*Proctoloelapus sp.*	Pre.	1	0.07
Astigmata	*Acaridae*	*Tyrophagus putrescentiae* (Schrank)	Gen.	1	0.07
Cryprostigmata	*Oribatulidae*	*Oribatula* sp.	Scav.	1	0.07

The most common distributed plant parasitic mite family belonged to Tetranychidae with 3 species, representing 93.2% of mites collected. In addition, the second most abundant families were predatory mites of Phytoseiidae (8 species). Beside this, *Proctolaelaps* sp. (Mesostigmata: Ascidae), and *Tyrophagus putrescentiae* (Shrank) (Acaridae) were identified. In our study, the phytophagous cosmopolite species *Tetranychus urticae* Koch (Tetranychidae) were abundant species in all locations. Other pest species were *Bryobia rubrioculus* (2.1%) and *Eotetranychus* (0.07%) which had very low density compared to *T. urticae*, the most common plant parasitic mite found.

N. californicus (McGregor) (Phytoseiidae) (50%) was the most common predatory mite species, among the beneficial mite species while *P. persimlis* (% 28) and *Amblyseius andersoni* (% 4) were second and third most common among the beneficial mites **(Figure 2)**.

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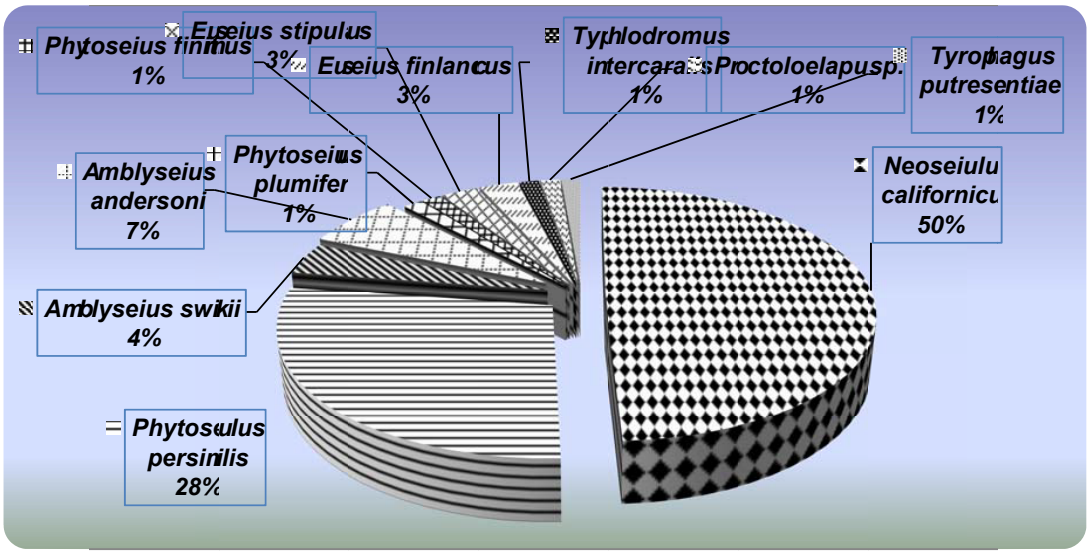

Figure 2. Proportional distribution of mite species (*Phytoseiidae* and *Ascidae*) on Strawberry plants in Mersin province in 2011-2013.

Considering predatory mite species, the highest ratio belongs to Phytoseiidae members, correlated with humidity and temperature conditions of the sampling area. Although the phytophagous mite diversities of the surveyed areas were found to be lower than those of predatory mites, their abundance ratio was higher than both those of predatory and saprophagous mites. Similar to our results, it has been reported that the abundance of plant parasitic mites exceeds predatory mites on a various of plant species [36-39].

Population fluctuation and densities of phytophagous mite *Tetranychus urticae* on strawberry plants in Mersin:

The population fluctuation and densities of phytophagous mites on strawberry plantations in Mersin provinces (in three different localities; Atayurt Town, Işıklı and Kurtuluş Villages) were investigated during 2011 to 2013.

Işıklı Village, *Tetranychus urticae* density fluctuations during 2011 to 2013 **(Figure 3).** In 2011, an increasing of the average mite density was observed very early season due to the very hot weather conditions in January, 2011 in this village.

The mite density reached 0.8 individuals/cm^2 in February and 3.5 to 4.26 individuals/cm^2 during April and May. The highest value reached was 4.46 individuals/cm^2 in June. *T. urticae* population density began to decrease until September and increased afterwards **(Figure 3)**.

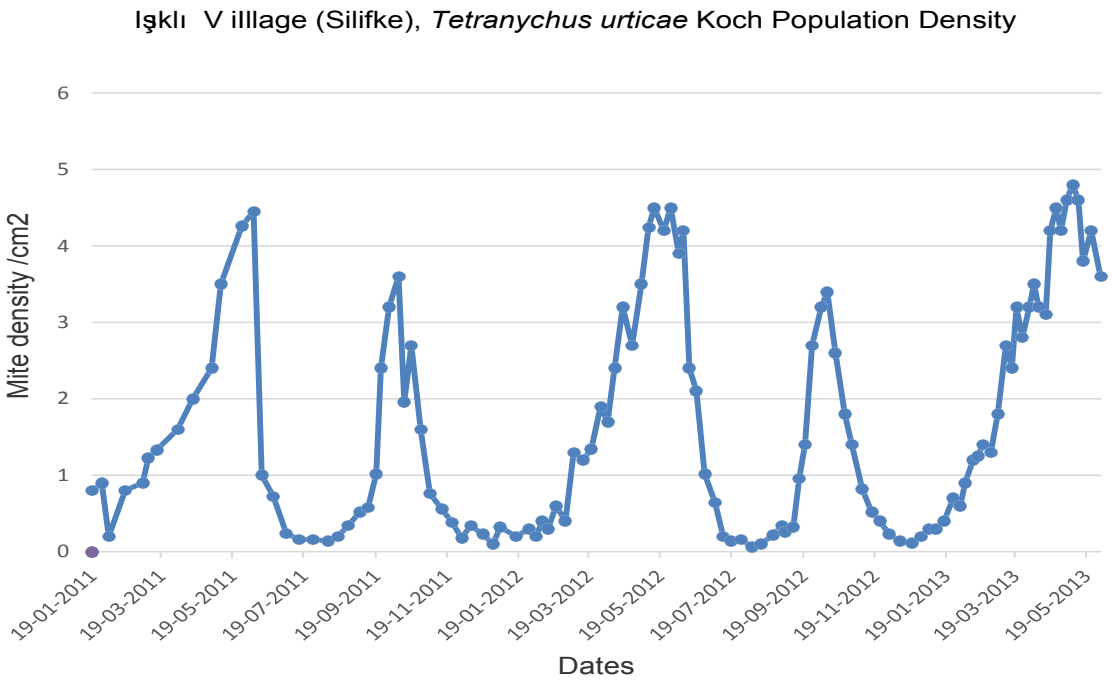

Figure 3. *Tetranychus urticae* Koch population fluctuation of in Işıklı Village (Silifke), 2011-2013 (average density of mites /cm^2).

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In 2012, the population density of mites was observed as 0.2-0.6 individuals/cm^2 from January to April due to cold weather conditions. After this, phytophagous mite density continued at a very low level until May, because of the heavy rainy season. The density reached 4.5 individuals/cm^2 at the middle of the May. The population decreased during June and July. It began to increase during August and reached its highest level in September and October and decreased afterwards **(Figure 3)**.

In 2013, the population density of *Tetranychus urticae* were started to rise in January and February slightly earlier than the same time in the previous two years. In March, the population density changed by 1.8-3.2 individuals/cm^2. The peak value was 4.8 mites/cm^2 in May (07.05.2013). The temperature and humidity increased in June, when the population value began to fall **(Figure 3)**.

Mersin-Işıklı had cooler weather conditions during November and December in 2011. The rainfall was observed to be intense and sometimes there was heavy rainfall, which affected the mite population density. The low temperature and higher precipitation caused a considerable decreasing of the mite population.

Atayurt Town; *Tetranychus urticae* density fluctuations during 2011 to 2013 **(Figure 4)**. *T. urticae* population fluctuation studies started from January 2011 and continued until June of 2013 in Atayurt. The density of harmful mite population is higher in this region than the other regions. Only in periods of heavy precipitation, and particularly during heavy rainfall periods, the mite population fallen down **(Figure 4)**.

In 2011, mite population density started to increase from January to May (1.4 mites/cm^2), and reached its maximum level in early June 2011 (5.2 mites/cm^2). Mite density was lower from June to September 2011 and began to increase afterwards. The following peak values which were observed at September (3.02 mites/cm^2 (29.09.2011), due to higher average temperature and relative humidity. Mite population density level was lowest during December **(Figure 4)**.

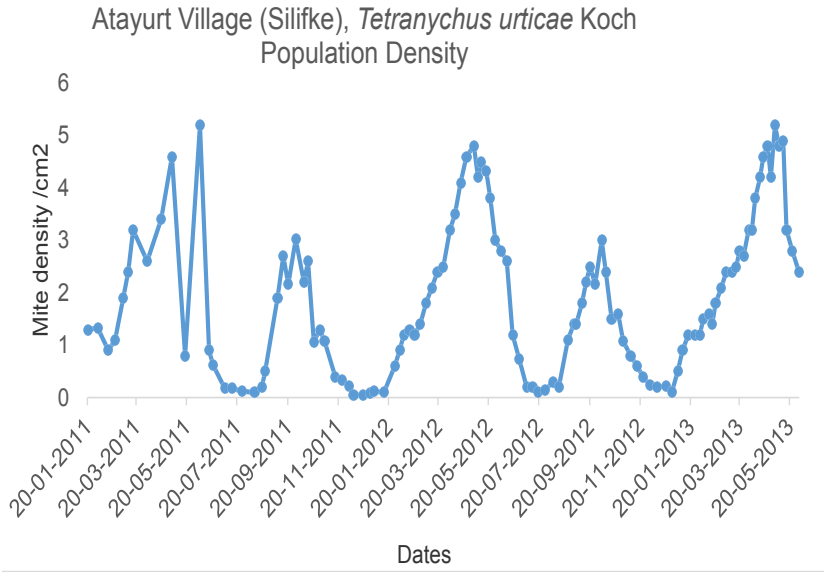

Figure 4. *Tetranychus urticae* Koch population fluctuation in Atayurt Village (Silifke), 2011-2013 (average density of mites/cm^2).

After February 2012, the population started to increase in Atayurt town. The population reached the highest value at 02 May, 2012 with a value of 4.8 mites/cm^2, the population had started to fall by June 2012 **(Figure 4)**.

Tetranychus urticae population decreased considerably due to the increase of temperatures (40°C) in July, started to increase end of August and then there was a temporary increasing in September and October. The density of mites decreased to 0.6/cm^2 in November and December 2012.

In 2013, *T. urticae* population density was higher in January than previous years. The population density of *T. urticae* varied from 0.5 to 2.1 individuals/cm^2 in January and February **(Figure 4)**. It was observed that the density of mites were 5.2, 4.8 and 4.9 individuals/cm^2 on 02.05.2013, 07.05.2013 and 12.05.2013 respectively **(Figure 4)**.

Kurtuluş Village, *Tetranychus urticae* density fluctuations during 2011 to 2013 **(Figure 5)**. Similar to the other two regions, the temperature of the Kurtuluş village was a little cooler in January and February. For this reason, the concentration of mite population was lower initially.

In March 2011, the density of mites began to increase, reaching its highest level in May (3.4 individuals/cm^2) and in June

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2011 (4.5 mites/cm^2), after which the population remained low due to high temperature and high humidity until late August of the year. The population started to increase after September 2011, which was lower than in other regions. Since Kurtuluş is at a higher altitude, the falling of the mite population started earlier than in the other regions. The highest peak value observed was 1.037 individuals/cm^2 (29.09. 2011) **(Figure 5)**.

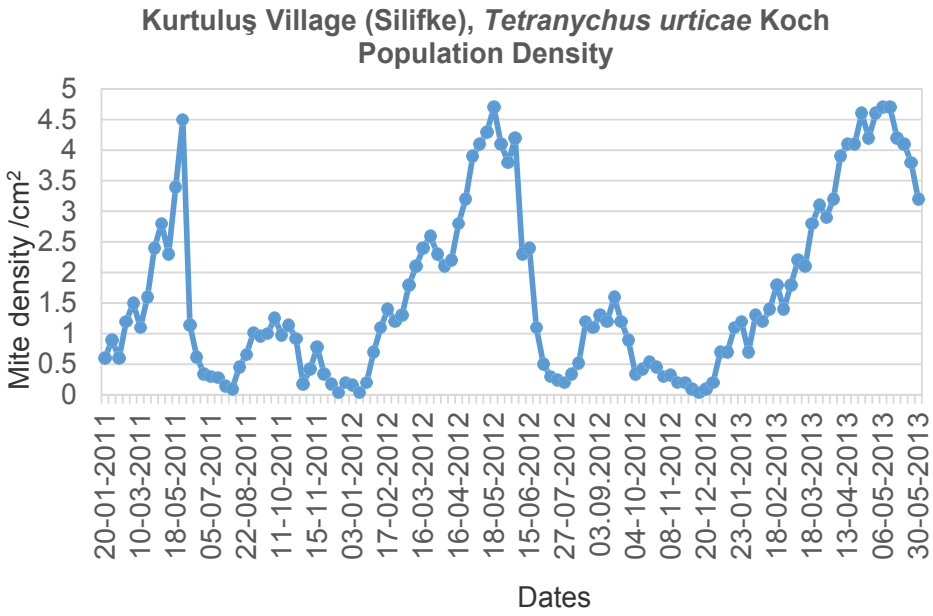

Figure 5. *Tetranychus urticae* Koch population fluctuation in Kurtuluş Village (Silifke), in 2011-2013 (average individual/cm^2).

In January 2012, the mite population density was very low; 0.2, 0.7, 2.4, 2.6, and 3.2 individuals/cm^2 in the period from January to May respectively. From the middle of May to June the mite population began to rise. The highest value reached was 4.7 individuals/cm^2 in May. The population started to fall (4.2 mites/cm^2) in June; afterwards the mite population fell considerably in July and a slight increase was observed in August. At the end of October, the population started to decline again. The mite number varied between 0.04 and 0.3 mites/ cm^2 in November and December 2012 **(Figure 5)**.

In 2013, *Tetranychus urticae* population density rose from 0.7 to 1.1 individuals/cm^2 and then fell back to 0.7 individuals/ cm^2 in January. The values were higher than the previous years and varied between 0.7-1.8 individuals/cm^2 in January and February. Population density increased to 4.7 individuals/cm^2 at the beginning of May, with high temperature and humidity during the spring months **(Figure 6a-6c)**.

The population density of *T. urticae* in all three horticultural provinces in 2011, 2012 and 2013 increased from February to March, with the exception of regional differences. The population reached its highest level in April-May and the population decreased with increasing temperature and humidity after mid-June. These periods were also the main production periods for strawberry plants in this region. During the summer months, the population was low and increased again in the autumn months.

The population density varied with temperature, humidity, precipitation, the location of the fields, pruning strawberries, and weed clearance. Looking at the 2013 annual climate data, it was observed that the temperature was higher and this explains higher population density of *Tetranychus urticae* in January and February 2013 **(Figure 6a-6c)**.

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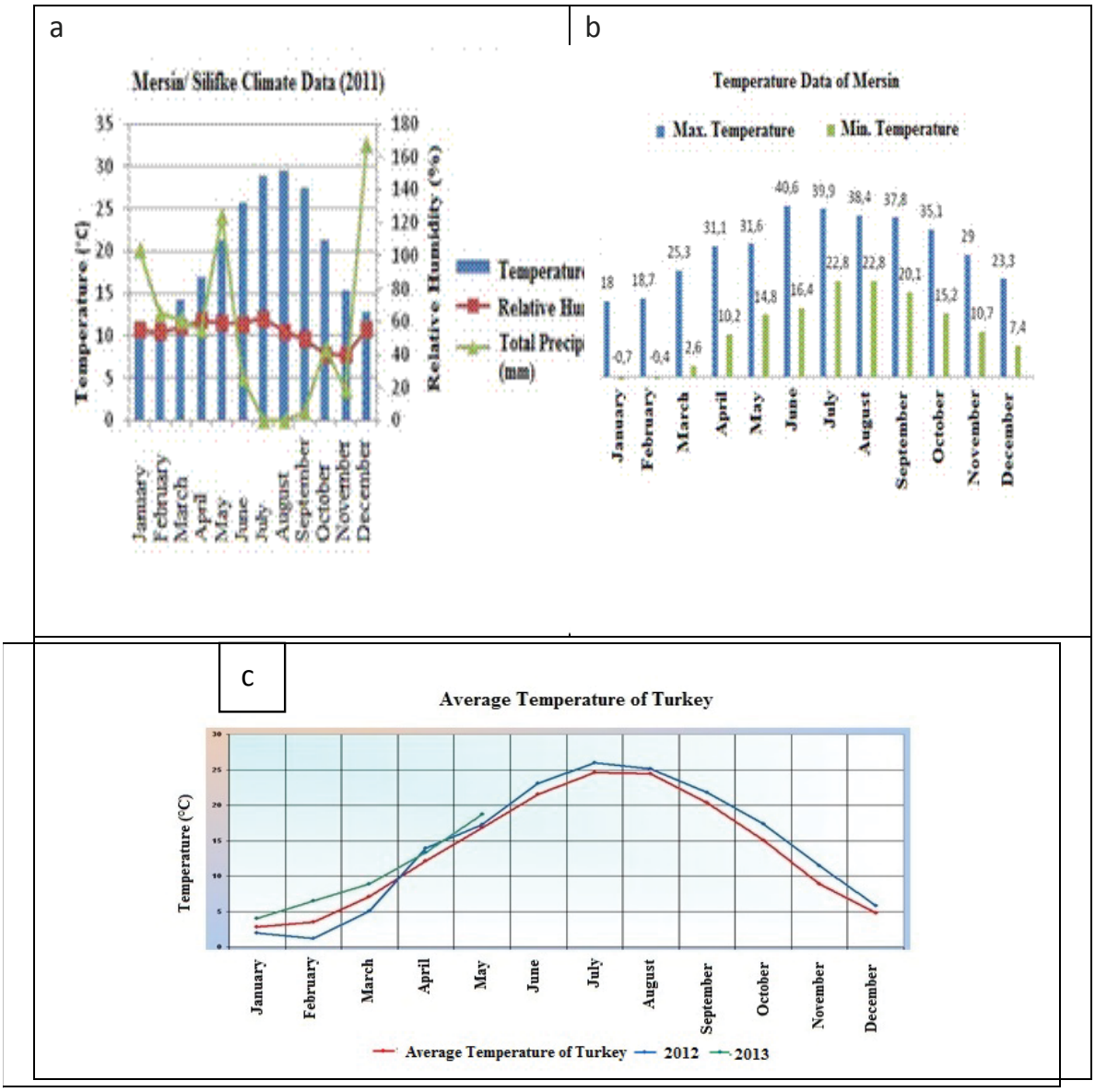

Figure 6. Temperature records of Silifke-Mersin Region (a) in 2011; (b) in 2012 and (c) in 2013.

DISCUSSION

This is the first detailed studies concentrates on phytophagous and beneficial mites on strawberry fields in Silifke-Mersin of Turkey. The phytophagous and predatory mite fauna were relatively rich in Mersin. The phytoseiids were abundant in all growing seasons, which is mostly in tunnels and open fields in Mersin-Turkey.

We identified *B. rubrioculus* and *Eotetranychus* sp. as phytophagous in lower proportion. Beside this, eight phytoseiid and one *Proctolaelaps* species (*A. andersoni*; *A. swirskii*, *N. californicus*, *P. persimilis*, *E. finlandicus*; *E. stipulatus*; *P. finitimus* and *T. intercalaris*) beneficial mites, one saprophagous (*Tyrophagus putrescentiae*) and one *Cryptostimgata* sp. were identified on strawberries in Mersin. *Tetranychus urticae* is a major pest and *Neoseiulus californicus* is its most important and common established predatory mite in strawberry fields in this region while *P. persimilis* and *A. andersoni* followed this species.

The phytoseiid species *Phytoseiulus persimilis* (Athias-Henriot), *Neoseiulus californicus* (McGregor), (Oudemans) and *Amblyseius swirskii* Athias-Henriot, are used commercially in strawberry fields in Turkey and the world [8,29]. *N. californicus* was determined previously as an effective predatory mite for strawberry plants in Turkey [29]. As an addition to our survey in Mersin, we identified *Propriseiopsis okanagensis* Chant (Acari: Phytoseiidae) and *Tarsonemus pallidus* Banks (Acari: Tarsonemidae) in the samples on strawberries from Adapazarı.

Tetranychus urticae populations were controlled by *Neoseiulus fallacis* (Garman) (Acari: Phytoseiidae), over 12 weeks in 2.5 ha following minimal inoculations into a strawberry field [40]. The effect of different release rates of *Neoseiulus californicus* (McGregor), significantly reduced the phtophagous mite population on strawberry plants [41]. *N. californicus* attacked most often

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Phytonemus pallidus (Banks) (Acari: Tarsonemidae) on strawberry plants and *Amblyseius andersoni* Chant (Acari: Phytoseiidae) fed on the cyclamen mite successfully (Croft et al.). In the greenhouse production of strawberries in Argentina, predatory and plant parasitic mite population fluctuations and spatial distribution followed each other [42]. Ten Phytoseiidae species were reported on strawberries from Latvia. It was established that Phytoseiidae are important biological control agents of phytophagous arthropods, especially of mites [20,43].

T. urticae, *T. cinnabarinus*, *Panonychus ulmi* (Koch), *Petrobia lupini* (McGregor) (Prostigmata: Tetranychidae), *Steneotarsonemus fragaria* (Zimmerman), *S. pallidus* (Banks) (Prostigmata: Tarsonemidae), *Phytoseiulus persimilis*, *Euseius finlandicus* (Oudemans), *Neoseiulus picketti* (Specht) and *Kampimodromus aberrans* (Oudemans) (Mesostigmata: Phytoseiidae) were identified as common plant parasitic and predatory mite species on strawberries from Greece [15].

T. cinnabarinus and *T. urticae* were determined as the most abundant and common phytophagous species. These species were also observed on strawberry plants from different countries [13,15,44]. *Neoseiulus californicus* and *N. cucumeris* (Oudemans) (Acari: Phytoseiidae) were more effective predators than *Typhlodromus pyri* Scheuten (Acari: Phytoseiidae) on the phytophagous mites *Tetranychus urticae* and *Phytonemus pallidus* (Banks) (Arachnida: Acari: Tarsonemidae) on strawberries in England [20]. The peak densities of *T. urticae* were lower than economic thresholds in open strawberry fields both in Norway and Brazil. The plant parasitic mite population has been restrained mainly by rainfall in the open field and by predatory mites in the tunnels [26].

Sabelis [45] revealed that moist and warm weather conditions are virtual requirements for the reproduction and development of mites. The mite populations reached their highest level during April and May in the strawberry fields in Aydın, which is similar to our results [8]. Population Density fluctuation of Two Spotted Spider Mite (*Tetranychus urticae* Koch) reached economic threshold level two times in a year on strawberry in Mersin. The mite population density is accepted as 3-5 individuals as spray thresholds per leaf unit, it is necessary to take into account peak values as spraying times of strawberry. Seasonal accumulations of different levels of mite infestation levels on strawberry plants significantly reduced yield [46-48].

CONCLUSION

As a conclusion, it is very important to identify the plant parasitic and predatory mite species as species level and their population density for the assessment of effective control methods. We found that predatory mite fauna is rich and also occurred predatory mite species naturally. These results suggest that the phytoseiid species are a potential biological agent for the suppression of *T. urticae* populations in outdoor strawberry plantations in Mersin.

We found that *Neoseiulus californicus* (McGregor) is a better choice for the population development studies and biological control agent because they are the most common and abundant predatory mites in this region.

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REFERENCES

1. Jackson DI and Looney NE. Temperate and subtropical fruit production. 2nd edn. CABI, London, UK 1999.
2. Antunes LEC and Peres NA. Strawberry production in Brazil and South America. International Journal of Fruit Science 2013;13:156-161.
3. TUIK. Türkiye İstatistik Kurumu. 2015 Web Site: http://www.tuik.gov.tr/PreTablo.do?alt_id=1001
4. Özdemir E. Early production of strawberry cultivars grown under plastic houses on sand dunes. Small Fruits Review 2003;2:81-86.
5. Kazak C, et al. The potential of the Hatay population of *Phytoseiulus persimilis* to control the carmine spider mite *Tetranychus cinnabarinus* in strawberry in Silifke-Içel, Turkey. Phytoparasitica 2002;30:451-458.
6. Kazak C and Kibritçi C. Population Parameters of *Tetranychus cinnabarinus* Boisduval (Prostigmata: Tetranychidae) on Eight Strawberry Cultivars Turkish. Journal of Agriculture and Forestry 2008;32:19-27.
7. Strand LL. *Integrated pest management for strawberries.* University of California Statewide Integrated Pest Management Project Publication 3351, Berkeley, USA 1994; p: 142.
8. Çakmak İ, et al. The population densities of spider mites and their natural enemies on protected strawberries in Aydın province. Turkish Journal of Entomology 2003;27:191-205.
9. Jeppson LR, et al. Mites injurious to Economic Plants. University California Press, 1975; pp: 253-283.
10. Easterbrook MA, et al. Biological control of strawberry tarsonemid mite *Phytonemus pallidus* and two-spotted spider mite *Tetranychus urticae* on strawberry in the UK using species of *Neoseiulus* (Amblyseius) (Acari: Phytoseiidae). Experimental and Applied Acarology 2001;25:25-36.

e-ISSN:2321-6190
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11. Nyoike WT and Liburd OE. Effect of *Tetranychus urticae* (Acari: Tetranychidae), on Marketable Yields of Field-Grown Strawberries in North-Central Florida. Journal of Economic Entomology 2012;106:1757-1766.
12. Auger PA, et al. Evidence for synonymy between *Tetranychus urticae* and *Tetranychus cinnabarinus* (Acari, Prostigmata, Tetranychidae): Review and new data. Acarologia 2013;53:383-415.
13. Port CM and Scopes NEA. Biological control by predatory mites (*Phytoseiulus persimilis* Athias-Hentriot) of red spider mite (*Tetranychus urticae* Koch) infesting strawberries grown in plastic tunnels. Plant Pathology 1981;30:95-99.
14. Yiğit A and Erkılıç L. Studies on the chemical control of *Tetranychus cinnabarinus* Boisd. (Acarina, Tetranychidae), a pest of strawberry in the East Mediterranean Region of Turkey. Crop Protection 1992;11:433-438.
15. Pagona PS, et al. Phytophagous mites and their predators observed on cultivated plants in Greece during 1975-1990. Annals Institue Phytopathology Benaki 1994;17:35-87.
16. Migeon A and Dorkeld F. Spider Mites Web: A Comprehensive Database for the Tetranychidae; 2015.
17. Poe SL. Influence of host plant physiology on populations of *Tetranychus urticae* (Acarina: Tetranychidae) infesting strawberry plants in Peninsular Florida. Florida Entomologist 1971;54:183-186.
18. Greco N, et al. Spatial distribution and coincidence of *Neoseiulus californicus* and *Tetranychus urticae* (Acari: Phytoseiidae, Tetranychidae) on strawberry. Experimental and Applied Acarology 1999;23:567-579.
19. Sato ME, et al. Management of *Tetranychus urticae* (Acari: Tetranychidae) in strawberry fields with Neoseuilus californicus (Acari: Phytoseiidae) and acaricides. Experimental and Applied Acarology 2007;42:107-120.
20. Fitzgerald J, et al. Interactions among phytophagous mites, and introduced and naturally occurring predatory mites, on strawberry in the UK. Experimental and Applied Acarology 2007;43:33-47.
21. Uygun N, et al. A citrus pest in the East Mediterranean region of Turkey, *Polyphagotarsonemus latus* (Banks) (Acarina: Tarsonemidae). Turkish Journal Entomology 1994;19:1-4.
22. Tunç İ and Göçmen H. New greenhouse pests, *Polyphagotarsonemus latus* and *Frankliniella occidentalis* in Turkey. FAO Plant Protection Bulletin 1994;42:218-220.
23. Uysal C, et al. Ankara parklarında zarar yapan Tetranychoidea (Acarina: Prostigmata) türleri ve konukçularının saptanması üzerinde araştırmalar. Turkish Journal Entomology 2001;25:147-160.
24. Petrova V, et al. Seasonal dynamics of predatory mites (Acari: Phytoseiidae) on strawberries in Latvia. Ekológia (Bratislava) 2000;19:207-210.
25. Oliveira H, et al. Evaluation of the predatory mite *Phytoseiulus macropilis* (Acari: Phytoseiidae) as a biological control agent of the two-spotted spider mite on strawberry plants under greenhouse conditions. Experimental and Applied Acarology 2009;47:275-283.
26. Castilho RC, et al. Two-spotted spider mite and its natural enemies on strawberry grown as protected and unprotected crops in Norway and Brazil. Experimental and Applied Acarology 2015;66:509-528.
27. Yu SJ. The toxicology and biochemistry of insecticides. CRC Press, London, UK 2008; p: 276.
28. Dura O, et al. Determination of the effective dose of *Metarhizium anisopliae* str. F 52 for biological control of western flower thrips on pepper plant. Bahce 2012;41:1-7.
29. Çakmak I and Çobanoğlu S. *Amblyseius californicus* (McGregor, 1954) (Acari: Phytoseiidae), a new record for the Turkish fauna. Turkish Journal of Zoology 2006;30:55-58.
30. Boller EF. Eine einfache Ausschwemm-methode zur schellen Erfassung von Raumilben, Trips und anderen K1 einarthopoden im Weinbau. Zeitschrift fur Obst und Weinbau 1984;120:249-255.
31. Hoy MA. Agricultural Acarology. Introduction to Integreted Mite Management. CRC Press Taylor and Francis Group, New York, USA 2011; p: 410.
32. Hughes AM. *The mites of stored food and houses.* Ministry of Agriculture, Fisheries and Food Technical Bulletin No. 9. Her Majesty's Stationery Office, London, UK 1976; p: 400.
33. Papadoulis GT, et al. Phytoseiidae of Greece and Cyprus (Acari: Mesostigmata). West Bloomfield, MI, Indira Publishing House, USA 2009; p: 200.
34. Faraji F, et al. A checklist and a key for the Phytoseiidae species of Turkey with two new species records (Acari: Mesostigmata). International Journal of Acarology 2011;37:221-243.
35. Seemann OD and Beard JJ. Identification of exotic pest and Australian native and naturalised species of *Tetranychus* (Acari: Tetranychidae). Zootaxa 2011;2961:1-72.
36. Bhullar MB and Ghai JK. Seasonal abundance of phytophagous and predatory mites infesting brinjal in Punjab. Annals of Biology 2003; 19: pp: 231-234.

e-ISSN:2321-6190
p-ISSN:2347-2294

37. Can M and Çobanoğlu S. Studies on the determination of mite (Acari) species and their hosts of greenhouse vegetables in Kumluca, Antalya. Ziraat Fakültesi Dergisi 2010;23:87-92.

38. Çobanoğlu S and Kumral NA. The biodiversity and population fluctuation of plant parasitic and beneficial mite species (Acari) in tomato fields of Ankara, Bursa and Yalova provinces. Turkish Journal of Entomology 2014;38:197-214.

39. Kumral NA and Çobanoğlu S. The Mite (Acari) biodiversity and population fluctuation of predominant species in eggplant. Journal of Agricultural Sciences 2016;22:261-274.

40. Coop LB and Croft BA. *Neoseiulus fallacis*: dispersal and biological control of *Tetranychus urticae* following minimal inoculations into a strawberry field. Experimental and Applied Acarology 1995;19:31-43.

41. Oatman ER, et al. Effect of releases of *Amblyseius californicus* on the two-spotted spider mite on strawberry in southern California. Journal of Economic Entomology 1977;70:638-640.

42. Greco N, et al. *Neoseiulus californicus* (Acari: Phytoseiidae) as potential control agent of *Tetranychus urticae* (Acari: Tetranychidae): effect of pest/predator ratio on pest abundance on strawberry. Experimental and Applied Acarology 2005;37:57-66.

43. Steeghs N, et al. Predatory mites of the family Phytoseiidae (Acari, Mesostigmata) from South Sweden. Entomologisk Tidskrift 1993;114:19-27.

44. Pena JE. Potential invasive pests of agricultural crops. CABI Invasive Species Series, University of Florida, USA 2013; p: 440.

45. Sabelis MW. Development. In: Helle W, Sabelis MW (eds.), Spider Mites, Their Biology, Natural Enemies and Control. World Crop Pests. Vol 1B. Elsevier, Amsterdam, pp: 43-53.

46. Wyman JA, et al. Effects of varying two spotted spider mite infestation levels on strawberry yield. Journal of Economic Entomology 1979;72:747-753.

47. Croft BA, et al. Predation, reproduction, and impact of phytoseiid mites (Acari: Phytoseiidae) on cyclamen mite (Acari: Tarsonemidae) on strawberry. Journal of Economic Entomology 1998;91:1307-1314.

48. Mass JL. Compendium of Strawberry Diseases. 2nd edn. Minenesota, USA: APS Press, The American Phytopathology Society 1987; p: 138.