Persian J. Acarol., 2020, Vol. 9, No. 3, pp. 279–289.
http://dx.doi.org/10.22073/pja.v9i3.59044
Journal homepage: http://www.biotaxa.org/pja

ISSN 2251-8169
PERSIAN JOURNAL OF ACAROLOGY

Article

Almond spider mite, *Schizotetranychus smirnovi* (Acari: Tetranychidae): population parameters in laboratory and field conditions

Zarir Saeidi[1*] and Alireza Nemati[2]

1. *Department of Plant Protection, Agricultural and Natural Resources Research and Education Center, Chaharmahal va Bakhtiari, AREEO, Iran; E-mail: zarirsaeidi@yahoo.com*
2. *Department of Plant Protection, Faculty of Agriculture, University of Shahrekord, Iran; E-mail: alireza.nemat@ymail.com*

[*] Corresponding author

ABSTRACT
Schizotetranychus smirnovi Wainstein is a serious pest of almond in Iran and its population has extremely increased recently in Chaharmahal va Bakhtiari province. Biological parameters of this mite were determined on almond leaves (Mamaei variety), under laboratory conditions at 27.5 ± 1 °C, 50 ± 10 % RH, and photoperiod of 14:10 (L:D). Moreover, population fluctuation of *S. smirnovi* and its predator, *Scolothrips longicornis* Priesner, were studied on almond (Mamaei c.v.) under field conditions (from April to October) during two successive years 2008–2009. Laboratory results showed that egg incubation period is the longest (3.25 ± 0.25 and 3.05 ± 0.25 days for female and male, respectively) in the immature stage. In addition, the female total immature period (2.91 ± 0.43 days) is longer than the male (2.87 ± 0.64 days). Female and male longevity were calculated as 13.20 ± 1.10 and 9.25 ± 0.75 days, respectively. Mean fecundity of the mite was calculated as 58.13 ± 6.60 eggs/female. Field studies showed that the mite overwintered as eggs around the buds of almond shoots. Overwintering eggs hatched depending on the climate conditions from the third decade of March (in 2008) to the third decade of April (in 2009). In both years, mite population continuously increased and reached to a maximum density during June and July. According to total degree-days the mite could produce 12–14 generations per year under field conditions. In addition, *S. longicornis* showed a strong response ($F_{1,25}$ = 20.58, r = 0.69, P = 0.0001) to the *S. smirnovi* fluctuations; population of the mite and predatory thrips fluctuated simultaneously. Our findings may provide practical information about the seasonal abundance of *S. simrnovi* and be useful for agricultural experts and farmers to develop a successful integrated pest management (IPM) program.

KEY WORDS: Almond; climate condition; Iran; seasonal activity; spider mite.

PAPER INFO.: Received: 4 January 2020, Accepted: 5 March 2020, Published: 15 July 2020

INTRODUCTION

Almond is one of the most important fruit trees in Chaharmahal va Bakhtiari province which is cultivated in an area of 15636 hectares (DPEIC 2015). This crop is infested by different pest mite species including: *Acalitus phloeocoptes* (Nalepa), *Bryobia rubrioculus* (Scheuten), *Pananychus ulmi* Koch, *Tetranychus pacificus* McGregor, *Tetranychus urticae* Koch and *Schizotetranychus smirnovi* Wainstein, 1954 (Saeidi 2011; Kamali *et al.* 2016; Zalom *et al.* 2019). Among them, two species, *T. urticae* and *S. smirnovi* cause serious threats to almond particularly during summer and reduce the quality and quantity of the nuts (Saeidi 2013). Outbreak of *S. smirnovi* has occurred on almond in

How to cite: Saeidi, Z. & Nemati, A. (2020) Almond spider mite, *Schizotetranychus smirnovi* (Acari: Tetranychidae): population parameters in laboratory and field conditions. *Persian Journal of Acarology*, 9(3): 279–289.

Saman orchards, Chaharmahal va Bakhtiari province since 2006 (Saeidi 2011). The adult and immature stages injure almond foliage by sucking leaves' cell contents. Under favorable conditions, mite populations rapidly increased, plant leaves were covered with spider mite webs and the quantity and quality of the fruits were significantly reduced (Saeidi and Nemati 2017).

Temperature, humidity and host plant are the most important factors which affect distribution and seasonal activity of the spider mites under field conditions (Ullah *et al.* 2012; Bayu *et al.* 2017; Islam *et al.* 2017; Shimazaki *et al.* 2019). Moreover, population growth parameters of the spider mites such as developmental rate, survival, reproduction and longevity largely depend on these factors (El-Halawany and Abdel-wahed 2013; Riahi *et al.* 2013). High temperatures and low-humidity are the most suitable conditions for spider mites' development and outbreak in agro-ecosystems (Leite *et al.* 2003). These outbreaks are also encouraged by increased use of synthetic insecticides which form a strong selection pressure for the development of acaricide resistance in the spider mites' populations (Van Leeuwen *et al.* 2010), while destroying their natural enemies especially predatory mites and thrips (Pakyari and Enkegaard 2012).

Our literature review showed no previous study on biology and life cycle of *S. smirnovi* on almond or other host plants, therefore, here we studied the biology and population parameters of *S. smirnovi* on almond under field conditions. Results can be useful to understand seasonal activities of the mite and facilitate developing a successful integrated pest management (IPM) program under field conditions.

MATERIALS AND METHODS

1. Laboratory studies

Biological parameters of *S. smirnovi* were studied on almond leaves ('Mamaei' variety), under laboratory conditions at 27.5 ± 1 °C, 50 ± 10 % RH, and 14:10 hb(L:D) based on the method described by Saeidi and Nemati (2017). Before starting the experiments, the stock colony was maintained on almond seedlings ('Mamaei' cv.) grafted on GF677 rootstock and planted in plastic pots (40 × 60 cm) under greenhouse conditions (25 ± 3 °C, 50 ± 10 % RH and a 14:10 h L: D photoperiod). One mated adult female from the stock colony was transferred on each almond leaf (40 replicates) using a fine camel hair brush (000) and after a 12 h, the adult and all eggs, except one, were removed. Observation was done twice daily to determine developmental time of mite individuals, under a stereomicroscope at 10× magnification. After emergence, newly emerged females and males (less than 24 h old) were transferred onto new leaves and adult longevity and fecundity were recorded daily until death of the last ones. The data of lower temperature threshold (m_c or T_0) and the thermal constant (K, degree-days) were obtained from Saeidi and Nemati (2017).

2. Field studies

Population fluctuations of *S. smirnovi* on almond trees (Mamaei cv.), during two successive years, 2008–2009, were studied. The field experiments were conducted in the Saman orchards (2075 m a.s.l. and at 32° 44′ N and 50° 87′ E), Chaharmahal va Bakhtiari province, Iran.

2.1. Population sampling

Two commercial orchards of almond (Mamaei cv.), spaced about 10 km were selected without any acaricides sprayed during the period of study. The orchards were almost similar in terms of almond variety, soil texture and fertilizer regime. The observations on the incidence and fluctuation of almond spider mite, *S. smirnovi*, were recorded at weekly intervals, from April and up to October. For the first sampling, 20 trees in each orchard were selected randomly and 15 random leaves from middle portion (at different sides) of each tree were collected. After being picked up, leaves were put into polyethylene bags and held in an ice-chilled cooler. Laboratory observations were conducted using a stereomicroscope at 10× magnification. Different life stages of the mite (egg, nymph and adult) were counted on the abaxial leaf surface of the almond, whereas, the number of predatory thrips was recorded on both leaf surfaces. To calculate the required leaves (sample size) in subsequent sampling intervals, the random sampling method was used with consideration of 20 trees in each sampling (Krebs 1989).

$$N = \left(\frac{Z\alpha/_2}{D}\right)^2 \left(\frac{\sigma^2}{\mu^2}\right)$$

where,
N: sample size.
D: constant error (D=0.2).
σ^2 and μ are, population variance and mean in the previous sampling, respectively.

2.2. Overwintering study

To determine overwintering stage and hatching time of the overwintered eggs, sampling was done weekly from October to April. For this purpose, 10 trees in each orchard (site) were selected randomly and five branches (15 cm in length) from different sides of each tree were collected and transferred to the laboratory. The collected branches were placed into plastic containers (5 cm^3) and incubated at 25 ± 1 °C, 50 ± 5 % RH. To keep the sample freshness, a layer of wet cotton was put in the containers' bottom. Samples were observed daily under a binocular microscope at 10× magnification and the egg status was recorded.

2.3. Host plants

The host plant range for *S. smirnovi* was determined by sampling and collecting the mite from different plant species including weeds, shrubs, fruit and ornamental trees during its population activity. The established population of different life stages, observation of feeding on host plant in laboratory using a stereomicroscope and other features like webbing and leaf feeding symptoms were used to record a plant as host for the mite.

3. Meteorology data

Daily temperature (mean, maximum, minimum) and rainfall of Saman synoptic station were collected from the Chaharmahal va Bakhtiari meteorological office.

4. Statistical analysis

The obtained data from seasonal activity of *S. smirnovi* on the almond was analyzed by Statistical Package of Social Science (SPSS), version 22 for windows. Correlation test was performed using Excel software, to determine the relation between mite population and predatory thrips densities, and environmental temperature. The calculation of environmental degree-day was done based on the following equation (Pedigo and Zeiss 1996):

$$DD = \left(\frac{m_1 + m_2}{2}\right) - m_c$$

where,
DD: degree-days for a given 24 hr period,
m_1: maximum temperature during the period,
m_2: minimum temperature during the period,
m_c: minimum cardinal temperature for the species (lower temperature threshold), which is 10.7 °C according to Saeidi and Nemati (2017).

It is worth mentioning that the assumptions and procedures of Newman (1971) were used for calculation of degree-days accumulations.

RESULTS

1. Laboratory studies

Female and male biological parameters (egg incubation period, larva, protonymph, deutonymph and total immature period) at laboratory conditions are shown in Table 1. Egg incubation period was the longest (3.25 ± 0.25 and 3.05 ± 0.25 for female and male, respectively) in immature stage. Moreover, the female total immature period (2.91 ± 0.43) was longer than male (2.87 ± 0.64 days). Female and male longevity of the mite were calculated 13.20 ± 1.10 and 9.25 ± 0.75 days, respectively. Fecundity of the mite was calculated 58.13 ± 6.60 eggs/female.

Table 1. Mean developmental time and longevity of almond spider mite, *Schizotetranychus smirnovi* Wainstein, under laboratory conditions on almond leaves (Mamaei variety).

Stage	Female	Male
	Duration (days)	Duration (days)
Egg	3.25 ± 0.25	3.05 ± 0.25
Larva	1.61 ± 0.25	1.29 ± 0.19
Protonymph	0.98 ± 0.17	0.69 ± 0.18
Deutonymph	1.02 ± 0.09	0.89 ± 0.37
Immature	2.91 ± 0.43	2.87 ± 0.64
Longevity	13.20 ± 1.10	9.25 ± 0.75
Life span	19.85 ± 1.98	15.50 ± 1.20
Pre-oviposition	1.31 ± 0.06	–
Oviposition	11.50 ± 1.10	–
Post-oviposition	0.19 ± 0.06	–

2. Field studies

2.1. Host plants and Damage

Our finding indicated that *S. smirnovi* not only occurred on almond trees but also on other trees especially plum, apricot, apple and walnut. Our observations showed that *S. smirnovi* caused a serious damage to almond orchards in the region especially during hot and dry conditions. Adults and immature stages of the mite settle on young leaves and start damaging almond foliage by sucking cell contents of the leaves. The damage symptoms appear as fine stippling on the upper leaf surface. Under heavy mite infestations, both leaf surfaces were covered by webbing which absorbs a large amount of dust and consequently significantly reduced photosynthesis. After a while, due to unfavorable leaf conditions, the mite migrates from the old to younger leaves. When a large population persists for a few weeks, webbing may cover the whole plant leaves which eventually turn brown, die and fall off and quality and quantity of the nut gets significantly reduced.

2.2. Over-wintering

Seasonal activities and population fluctuations of *S. smirnovi* on almond under natural conditions showed that the mite overwintered in the form of eggs at the bases of buds and spurs, on small limbs and twigs of almond (1 to 3 years old). Results showed that diapausing overwintering eggs did not hatch before March. Samples collected weekly from late November to mid-March did not hatch when incubated at optimum conditions (27.5 ± 1 °C, 50 ± 5 % RH) in laboratory, whereas those collected after second decade of March hatched 10 days later. Under natural conditions, overwintering eggs hatched depending on the climate conditions from the third decade of March (in 2008) to the third decade of April (in 2009). The average winter temperature of the first and second year of the study was 0.45 °C and 4.57 °C, respectively.

2.3. Population fluctuations of S. smirnovi *and its predator* Scolothrips longicornis *Priesner*

In 2008, overwintering eggs hatched in the fourth week of March. The mean temperature of that time was measured as 15.3 °C and with no rainfall. As temperature rose, mite population continuously increased and reached to the maximum density (99.5 mites/leaf) from 10th to 25th June and then rapidly declined to the minimum value (0.3 mites/leaf) in the fourth week of July. As the results showed, *S. longicornis* population started its increasing from 10th June and reached to the maximum (6.2 all stages of thrips/leaf) on the second week of July. Then there was an increase in the mite population and the second peak (8.1 mites/leaf) was observed in last week of July. From this time to the end of October, mite population fluctuated at almost same level. As the mite population decreased, predator population also decreased rapidly from end of July and stabilized at low level until the end of October (Fig. 1). The calculated degree-days from March 30th to November 30th was 1830.5, therefore, the mite could produce 12–14 generations per year.

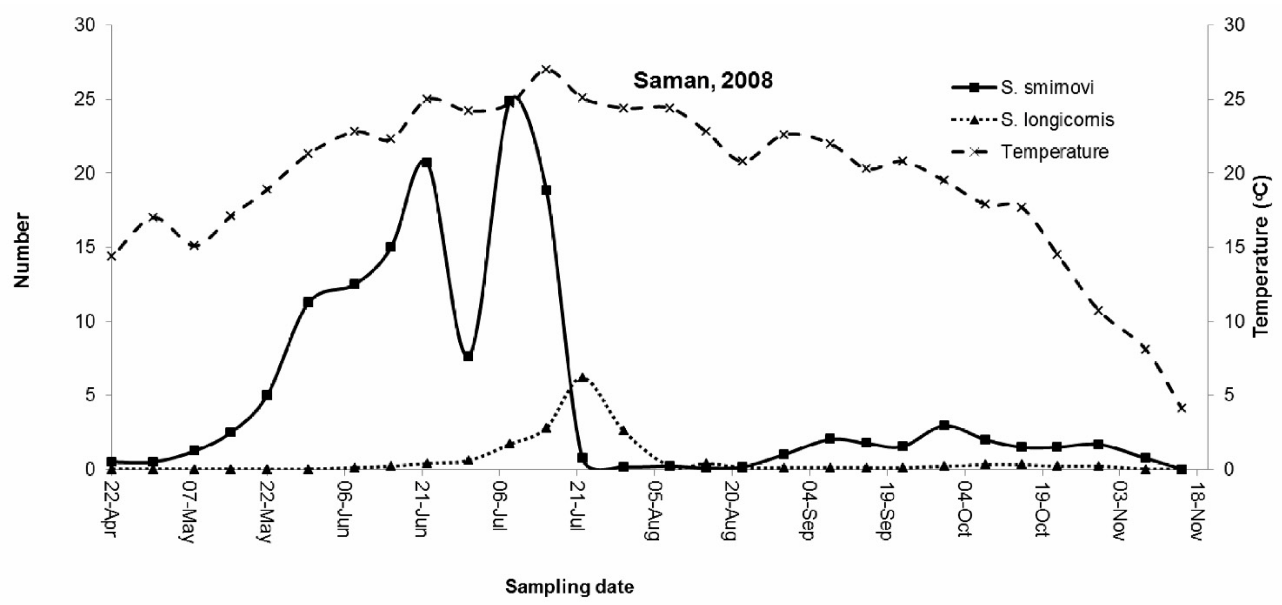

FIGURE 1. Population fluctuations of almond spider mite, *Schizotetranychus smirnovi* Wainstein, and its predator *Scolothrips longicornis* under the field conditions in Saman region, Chaharmahal va Bakhtiari province during 2008 (one fourth of the mite population was shown in the figure).

In 2009, overwintering eggs hatched at the fourth week of April but because of the rainy days, they could not lay on the leaf until May 15th. During this year, population of the phytophagous mite and predatory thrips fluctuated simultaneously. The first population peak of *S. smirnovi* (1 mite/leaf) and *S. longicornis* (0.90 thrips/leaf) was observed on May 25th and June 15th, respectively. From fourth week of May to fourth week of June, mite population decreased gradually and reached near zero but then increased rapidly to its second peak (13.2 mites/leaf) at the first week of August. Predator population also increased to a maximum (1.4 thrips/leaf) at the second week of August. The third (27.6 mites/leaf) and fourth (30.4 mites/leaf) peaks of the mite population were observed in fourth week of August and October's second week, respectively. A similar trend was observed in the population fluctuation of predatory thrips. From mid-October to mid-November, population of *S. smirnovi* decreased on the leaves and females migrated to the shoots to lay overwintering eggs (Fig.

2). Calculated degree-days from March 30th to November 30th was 1658.3, therefore, the mite could produce 11–13 generations. In both years of study, a significant positive correlation ($F_{1,25}$ = 20.58, r = 0.69, P = 0.0001) was found between populations of *S. smirnovi*, and predatory thrips, *S. longicornis*.

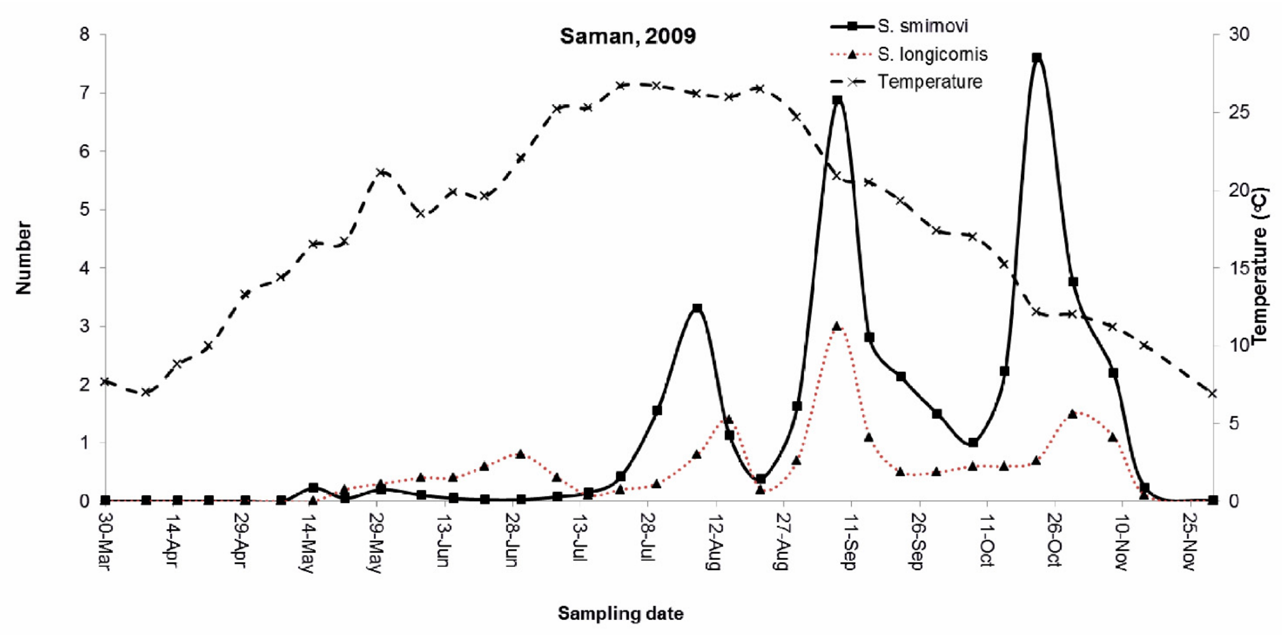

FIGURE 2. Population fluctuations of almond spider mite, *Schizotetranychus smirnovi* Wainstein, and its predator *Scolothrips longicornis* under the field conditions in Saman region, Chaharmahal va Bakhtiari province during 2009 (one fourth of the mite population was shown in the figure).

Observations showed that temperature plays an important role in population fluctuations of *S. smirnovi.* In early spring not only eggs hatched depending on the temperature, but also the pest population slowly increased, due to rainfall and low temperature during April and May, whereas by gradual increase of the temperature, the mite populations rapidly increased during June and July (Figs. 1, 2). Moreover, as temperature dropped in October to less than 15 °C, mite population growth declined, and females gradually moved to 2–3 years old shoots laying overwintering eggs around the buds until the end of October. Results showed significant positive correlations of mean temperature with population density of the mite, *S. smirnovi*, ($F_{1,25}$ = 5.98, r = 0.45, F = 0.022) and predatory thrips, *S. longicornis*, ($F_{1,25}$ = 5.57, r = 0.44, F = 0.027) during both studied years.

Spring and summer rains also have an effective role in reducing pest populations. Total precipitation during the first, second, third and fourth weeks of April and first week of May, 2009, was measured as 9.9, 58.8, 0.5, 30.2 and 7.8 mm, respectively, which probably prevent mite from successfully establishing on almond leaves. Again, when a rainfall (totally 11.4 mm) occurred on June (19th to 22th, 2009), the population of almond spider mites was reduced significantlyto the extent that it was difficult to find different stages of the mite on almond leaves. Same trend was detected in the studied orchards after the rainfall of 9thto 10th of September 2008 (11.4 mm).

DISCUSSION

Schizotetranychus smirnovi has been a major pest of almond since 2005 in Chaharmahal va Bakhtiari province, Iran. The relative importance of this pest is mainly due to use of extensive sprayings against other important pests such as aphids and almond wasp (Saeidi and Nemati 2017). Moreover, the increasing temperature and drought stress during the growth season has increased the mite's population (Saeidi 2011).

Our laboratory studies indicated that immature stages of *S. smirnovi* were completed within a few days (2.87 ± 0.64 and 2.91 ± 0.43 for male and female, respectively) at 27.5 °C. This is in agreement with Saeidi and Nemati (2017), who found that among the 11 constant temperatures (10–36 °C), the optimum temperature range for population development of *S. smirnovi* was 27.5 to 30 °C. Immature development period of *T. urticae* female at the same temperature was reported as 4.48 days on almond (Saeidi 2013) and 9.4 days on peach (Riahi *et al.* 2013). This is 3.5 days for *T. mcdanieli* on red raspberry (Roy *et al.* 2002).

We calculated longevity of the male and female as 9.25 ± 0.75 and 13.20 ± 1.10 days, respect-tively. This was reported 20.5 ± 2.02 days for *T. urticae* females on peach (Riahi *et al.* 2013). In the present study, the longevity of *S. smirnovi* females (9.25 ± 0.75 days) and males (13.20 ± 1.10) was higher than *T. urticae* females and males (3.75 ± 0.62 and 5.92 ± 0.55 days, respectively) on peach (Riahi *et al.* 2013) as well as longevity of *T. urticae* females (10.45 days) on almond (Saeidi 2013). Other researchers reported different results at similar or close constant temperatures. Carey and Bradley (1982) found the mean longevity of *T. urticae* females 14.71 and 9.71 days at 23.8 and 29.4 °C, respectively. Kasap (2004) reported the longevity of two-spotted spider mite females 29.9, 25.9, 16.8 and 4.7 days at 20, 25, 30 and 35 °C, respectively.

Mean daily fecundity (5.05 ± 0.16) and total fecundity (58.13 ± 6.60) of *S. smirnovi* at 27.5 °C were higher than *T. urticae* (3.1 ± 0.55 and 18.74 ± 2.61) on peach susceptible variety 'J.H Hale' (Riahi *et al.* 2011). Other researchers reported different results at the same temperature for *T. urticae*. Saeidi (2011) reported 15.1–57.6 eggs/female on different varieties of almond, whereas Ju *et al.* (2008) reported 141 eggs/female on eggplant. The difference observed could be due to species, host plant, the geographical origin and adaptation of different species.

Field findings indicated that *S. smirnovi* not only caused a serious problem on almond orchards in the region but also was observed on other horticultural crops especially plum, apricot, apple and walnut trees. Incidence of *S. smirnovi* was reported for the first time by Wainstein (1960) on plum and apricot in Kazakhstan. Later, it was collected by Mitrofanov (1978) from Tajikistan. Outbreak of the mite on almond trees was reported by Saeidi *et al.* (2011) in Iran. Migeon and Dorkeld (2008) collected the mite on walnut (*Juglans regia*), white berry (*Morus alba*), apple (*Malus domestica*) and apricot (*Prunus armeniaca*). The knowledge on different factors and mechanisms influencing host plant acceptance and feeding may be important in determining strategies on management and estimating the risk posed by pest species to new areas. Testing host acceptance is very important in respect to invasive species which may be able to extend their host range and become a problem in agro-ecosystems.

Based on results presented here, *S. smirnovi* overwinters in the form of eggs at the bases of buds and spurs, on small limbs and twigs of almond, diapausing until the following March. Other almond injurious spider mites such as *T. urticae*, and *T. pacificus* overwinter in the form of adult females under rough almond bark, in ground litter, and on winter weeds (Zalom *et al.* 2016), whereas *Panonychus ulmi* overwinters in the form of eggs on rough bark at the bases of buds and spurs, on small limbs and twigs, and in limb crevices and forks (Garcia-Marl *et al.* 1991). Our observations showed that, in 2008, overwintered eggs hatched in the 4th week of March whereas in 2009, they hatched in the 4th week of April. Saeidi and Nemati (2017) estimated the lower thermal threshold of *S. smirnovi* as 10.7 °C. Based on the meteorological data (Figs. 1, 2), mean temperature of the first (2008) and second (2009) year of study increased above this level from the fourth week of March and fourth week of April, respectively. Observations of Garcia-Marl *et al.* (1991) showed that overwintered eggs of *P. ulmi* hatched after their cold requirements had been fulfilled. Moreover, chilling requirements to break diapause differ in eggs collected from two different locations in Spain. In Valencia, the warmer region, only 70 days at 1 °C were needed to break diapause whereas in Lerida it took 90–100 days (Garcia-Marl *et al.* 1991).

Our results clearly showed that the mite population increased rapidly during June and July 2008 and 2009. The relation between *S. smirnovi* and mean temperature was significantly positive. Various researchers recorded the highest number of spider mites on different host plants during the summer season. According to Singh and Singh (1993), increase in population of *T. urticae* was associated with periods of high temperature and low humidity on okra. Kumar *et al.* (2015) reported *T. urticae* as a serious problem on okra plant during the summer months in Varanasi, India. Kumral and Kovanci (2005) reported that *T. urticae* population was positively correlated with mean temperature, while negatively to mean humidity. They also recorded the highest population of the mite on eggplant from late June to late August in Bursa province, Turkey.

Calculation of total degree-days indicated that *S. smirnovi* could produce12–14 generations/year under field conditions. According to Saeidi and Nemati (2017), females and males of *S. smirnovi* required an average of 136.67 and 125.31 DD to complete their development on almond at laboratory conditions, respectively. Other researchers reported different results for *T. urticae.* Riahi *et al.* (2013) reported an average of 136.43 DD, whereas, Kasap (2004) reported the mean number of 160.21 DD for *T. urticae* on peach and apple, respectively.

As the results indicated, *S. longicornis* showed a strong response to the *S. smirnovi* fluctuation (Figs. 1, 2). Kirk (1997) demonstrated that predatory thrips were sometimes able to suppress the mite population below the damage threshold, depending on the timing of introduction. According to Pakyari and Enkegaard (2012) daily consumption of *T. urticae* eggs by female *S. longicornis* (24 eggs per day at 26 °C) was higher than those reported for female phytoseiid mites. The predation capacity of *S. longicornis* suggested using this predatory thrips for control of *T. urticae* and other Tetranychidae mites in greenhouses (Kiliç and Yoldas 2004; Pakyari and Enkegaard 2012) and open farmlands (Masarovic 2013). Our observations showed that in addition to *S. longicornis*, several natural enemies, including predatory mites of Phytoseiidae, Trombidiidae, Erythraeidae, Anystidae and Tydeidae and predatory Coccinellids fed on almond spider mites. The efficiency of these should be studied further.

This is the first study of the annual life cycle, population fluctuations of *S. smirnovi* on almond trees under natural conditions and provides fundamental information for other researchers who are interested to work on different biological aspects of this mite. Moreover, it provides practical information on the seasonal abundance of *S. smirnovi* and its associated predator, which may prove useful for the agricultural experts and farmers to develop a successful integrated pest management (IPM) program.

ACKNOWLEDEMENT

Financial support provided by the Agricultural and Natural Resources Research & Education center, Chaharmahal va Bakhtiari, province, Iran is gratefully acknowledged.

REFERENCES

Bayu, M.S.Y.I., Ullah, M.S., Takano, Y. & Gotoh, T. (2017) Impact of constant versus fluctuating temperatures on the development and life history parameters of *Tetranychus urticae* (Acari: Tetranychidae). *Experimental and Applied Acarology*, 72: 205–227. DOI: 10.1007/s10493-017-0151-9

Carey, J.R. & Bradley, J.W. (1982) Developmetal rates, vital schedules, sex ratios, and life tables for *Teranychus urticae*, *Tetranychus turkestani* and *Tetranychus pacificus* (Acarina: Tetranychidae) on cotton. *Acarologia*, 23(4): 333–345.

Department of Planing and Economy, Information and Communication (DPEIC) (2015) *Iranian Annual Statistics, No. 2, garden products*. Ministry of Agriculture, Tehran , Iran, 170 pp.

El-Halawany, A.S.H & Abdel-wahed, N.M. (2013) Effect of temperature and host plant on developmental times and life table prarmeters of *Tetranychus urticae* Koch on persimmon trees (Acari: Tetranychidae). *Egyptian Journal of Agricultural Research*, 91 (2): 595–607.

Garcia-Marl, F., Costa-Comelles, J., San Jose, S. & Ferragut, F. (1991) Some observations on diapause in winter eggs of *Panonychus ulmi* (Koch) (Tetranychidae). *In*: Schuster, R. & Murphy, P.W. (Eds.), *The Acari. Reproduction, Development and life-history strategies.* Chapman and Hall, 554 pp.

Islam, M.T., Jahan, M., Gotoh, T. & Ullah, M.S. (2017) Host-dependent life history and life table parameters of *Tetranychus truncatus* (Acari: Tetranychidae). *Systematic and Applied Acarology*, 22: 2068–2082.
DOI: 10.11158/saa.22.12.4

Kamali, H., Sirjani, M. & Bazoobandi, M. (2016) Biological characteristics of almond bud mite, *Acalitus phloeocoptes* (Nalepa) (Acari: Eriophyoidea) in Khorasan-e- Razavi Province. *Plant Pest Research*, 6(2): 63–74 (In Persian with English abstract).

Kasap, I. (2004) Effect of apple cultivar and of temperature on the biology and life table parameters of the two-spotted spider mite *Tetranychus urticae*. *Phytoparasitica*, 32(1), 73–82.
DOI: 10.1007/bf02980863

Kiliç, T. &Yoldas, Z. (2004) Thysanoptera in greenhouse grown cucumbers: distribution and frequency of the species in Izmir province. *Turkish Journal of Entomology,* 28(2): 151-160.

Kim, J., Lee,S.-K., Kim, J.-M., Kwon, Y.-R., Kim, T.-H. & Kim, J.-S. (2008) Effect of temperature on development and life table parameters of *Tetranychus urticae* Koch (Acari: Tetranychidae) reared on eggplants. *Korean Journal of Applied Entomology*, 47(2): 163–168.

Kirk, W.D.J. (1997) Feeding. In: Lewis, T. (Ed.), *Thrips as crop pests*. CAB International, Wallingford, UK, pp. 119–174.

Krebs, C.J. (1989) *Ecological methodology*. Harper and Row publishers, New York, 652 pp.

Kumar, D., Raghuraman, M. & Singh, J. (2015) Population dynamics of spider mite, *Tetranychus urticae* Koch on okra in relation to abiotic factors of Varanasi region. *Journal of Agrometeorology*, 17(1): 102–106.

Kumral, N.A. & Kovanci, B. (2005) Seasonal population dynamics of the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) under acaricide constraint on eggplant in Bursa province (Turkey). *Acarologia*, 46(4): 295–301.

Leite, G.L.D., Picanco, M., Zanuncio, J.C. & Marquini, F. (2003) Factors affecting mite herbivory on eggplants in Brazil. *Experimental and Applied Acarology*, 31: 243–252.
DOI: 10.1023/B:APPA.0000010379.05878.2c

Masarovic, R., Doricova, M. & Fedor, P. (2013) The first record of predaceous *Scolothrips longicornis* Priesner, 1926 (Thysanoptera: Thripidae) in Slovakia. *Journal of Central European Agriculture*, 14(2): 243–250.
DOI: 10.5513/JCEA01/14.2.1253

Migeon, A. & Dorkeld, F. (2008) Spider mites web: a database dedicated to the knowledge of an acarine pest family, the Tetranychidae. *Six European Congress of Acarology, July 2008, Montpellier, France*, Hal-01137132.

Mitrofanov, V.I., Strunkova, Z.I. & Livshits, I.Z. (1987) *Keys to the tetranychid mites (Tetranychidae, Bryobiidae) fauna of the USSR and adjacent countries*. SSR, I.o.Z.a.P.E.N.P.T., Dushanbe, Donish, 224 pp.

Newman, J.E. (1971) Measuring corn maturity with heat units. *Crop and Soils*, 23: 11–14.

Pakyari, H. & Enkegaard, A. (2012) Effect of different temperatures on reproductive performance of *Scolothrips longicornis* reared on *Tetranychus urticae* eggs. *International Journal of Acarology*, 38(7): 571–575.
DOI: 10.1080/01647954.2012.714401

Pedigo, L.P. & Zeiss, M.R. (1996) *Analyses in insect ecology and management*. Iowa State University Press, 168 pp.

Riahi, E., Nemati, A., Shishehbor, P. & Saeidi, Z. (2011) Population growth parameters of the two-spotted spider mite, *Tetranychus urticae*, on three peach varieties in Iran. *Acarologia*, 51(4): 473–480.
DOI: 10.1051/acarologia/20112029

Riahi, E., Shishehbor, P., Nemati, A. & Saeidi, Z. (2013) Temperature effects on development and life table parameters of *Tetranychus urticae* (Acari: Tetanychidae). *Journal of Agricultural Science and Technology,* 15: 661–672.

Roy, M., Brodeur, J. & Cloutier, C. (2002) Relationship between temperature and developmental rate of *Stethorus punctillum* (Coleoptera: Coccinellidae) and its prey *Tetranychus mcdanieli* (Acarina: Tetranychidae). *Environmental Entomology*, 31: 177–187.
DOI: 10.1603/0046-225X-31.1.177

Saeidi, Z. (2011) Reaction of some almond cultivars to almond spider mite, *Schizotetranychus smirnovi*, in Saman region, Chaharmahal va Bakhtiari province. *Plant Protection Journal*, 3(2): 111–123.

Saeidi, Z. (2013) Investigation on resistance of different almond cultivars/genotypes to two-spotted spider mite, *Tetranychus urticae* Koch in laboratory and greenhouse condition. *Journal of Entomological Research*, 5(4): 353–364.

Saeidi, Z. & Nemati, A. (2017) Relationship between temperature and developmental rate of *Schizotetranychus smirnovi* (Acari: Tetranychidae) on almond. *International Journal of Acarology*, 43(2): 142–146.
DOI: 10.1080/01647954.2016.1234507

Saeidi, Z., Nourbakhsh, S.H., Nemati, A. & Ueckerman, E.A. (2011) First Report of *Schizotetranychus smirnovi* Wain. in Iran. *19th Iranian Plant Protection Congress*, *31 July–3 August 2010, Tehran, Iran*, p. 373.

Singh, R.N. & Singh, J. (1993) Incidence of *Tetranychus cinnabarinus* (Boisd.) (Acari: Tetranychidae) in relation to weather factors in Varanasi. *Pestology*, 13: 18–23.

Shimazaki, S., Ullah, M.S. & Gotoh, T. (2019) Seasonal occurrence and development of three closely related *Oligonychus* species (Acari: Tetranychidae) and their associated natural enemies on fagaceous trees. *Experimental and Applied Acarology*, 79(1): 47–68.
DOI: 10.1007/s10493-019-00410-3

Ullah, M.S., Haque, M.A., Nachman, G. & Gotoh, T. (2012) Temperature-dependent development and reproductive traits of *Tetranychus macfarlanei* (Acari: Tetranychidae). *Experimental and Applied Acarology*, 56: 327–344.
DOI: 10.1007/s10493-012-9523-3

Van Leeuwen, T., Vontas, J., Tsagkarakou, A., Dermauw, W. & Tirry, L. (2010) Acaricide resistance mechanisms in the two-spotted spider mite *Tetranychus urticae* and other important Acari: a review. *Insect Biochemistry and Molecular Biology*, 40: 563–572.
DOI: 10.1016/j.ibmb.2010.05.008

Wainstein, B.A. (1960) Tetranychoid mites of Kazakhstan (with revision of the family). *Nauch-issled. Instituta Zashchity Rastenii*, 5: 172–174.

Zalom, F.G., Haviland, D.R., Symmes, E.J. & Tollerup, K.E. (2019) *Almond web spinning spider mites*. Available from: https://www2.ipm.ucanr.edu/agriculture/almond/webspinning-spider-mites/ (Accessed on 6 June 2019).

کنهٔ تارتن بادام، *Schizotetranychus smirnovi* (Acari: Tetranychidae): پارامترهای جمعیت در شرایط آزمایشگاه و کشتزار

زریر سعیدی[۱*] و علیرضا نعمتی[۲]

۱- بخش گیاهپزشکی، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی چهارمحال و بختیاری، سازمان تحقیقات، آموزش و ترویج کشاورزی، ایران؛ رایانامه: zarirsaeidi@yahoo.com

۲- گروه گیاهپزشکی، دانشکدهٔ کشاورزی، دانشگاه شهرکرد، ایران؛ رایانامه : alireza.nemat@ymail.com

* نویسندهٔ مسئول

چکیده

کنهٔ تارتن بادام (*Schizotetranychus smirnovi* Wainstein) یکی از آفات مهم بادام در ایران بوده که در سال‌های اخیر در استان چهارمحال و بختیاری طغیان کرده است. ویژگی‌های زیستی کنه روی برگ‌های بادام (رقم مامایی)، در شرایط آزمایشگاه (دما ۱ ± ۲۷/۵ درجهٔ سلسیوس، رطوبت نسبی ۱۰ ± ۵۰ درصد و دوره نوری ۱۴:۱۰ ساعت) تعیین شد. همچنین تغییرات جمعیت آفت و شکارگر آن *Scolothrips longicornis* Priesner، روی بادام (رقم مامایی) در شرایط کشتزار (از فروردین تا آبان) در مدت دو سال (۱۳۸۷ تا ۱۳۸۸) مطالعه شد. نتایج آزمایشگاهی نشان داد که طول دورهٔ جنینی (۰/۲۵ ± ۳/۲۵ و ۰/۲۵ ± ۳/۰۵ روز به ترتیب برای ماده و نر)، طولانی‌ترین مرحلهٔ نابالغ است. همچنین طول دورهٔ پورگی ماده (۰/۴۳ ± ۲/۹۱ روز) طولانی‌تر از نر (۰/٦٤ ± ۲/۸۷ روز) است. طول عمر افراد نر و ماده به ترتیب ۱/۱۰ ± ۱۳/۲۰ و ۹/۲۵ ± ۰/۷۵ روز محاسبه شد. میانگین زادآوری کنه ٦/٦۰ ± ۵۸/۱۳ تخم/ماده محاسبه شد. بررسی‌های صحرایی نشان داد که کنه به صورت تخم در پیرامون جوانه‌های بادام زمستانگذرانی می‌کند. تخم‌های زمستانگذران بسته به شرایط آب و هوایی از دههٔ نخست فروردین (در سال ۱۳۸۷) تا دههٔ نخست اردیبهشت (در سال ۱۳۸۸) تفریخ شدند. در هر دو سال، جمعیت کنه به تدریج افزایش یافت و در ماه‌های تیر و مرداد به اوج رسید. بر اساس مجموع روز-درجه، کنهٔ تارتن بادام می‌تواند ۱۲ تا ۱٤ نسل در سال در شرایط کشتزار تولید کند. همچنین رابطه بین تغییرات جمعیت تریپس شکارگر *S. longicornis* و جمعیت کنه *S. smirnovi* مثبت و معنی‌دار بود ($F_{1,25} = 20.58$, $r = 0.69$, $P = 0.0001$). نتایج این بررسی اطلاعات عملی و مفیدی در مورد تغییرات فصلی کنهٔ *S. smirnovi* در اختیار کارشناسان و کشاورزان قرار می‌دهد تا بر این اساس برنامهٔ موفقی برای مدیریت کنترل آفت اجرا کنند.

واژگان کلیدی: بادام؛ شرایط آب و هوایی؛ ایران؛ تغییرات فصلی؛ کنه تارتن.

اطلاعات مقاله: تاریخ دریافت: ۱۳۹۸/۱۰/۱٤، تاریخ پذیرش: ۱۳۹۹/۱/۱۷، تاریخ چاپ: ۱۳۹۹/٤/۲۵