Journal of the Saudi Society of Agricultural Sciences 19 (2020) 146–150

Contents lists available at ScienceDirect

Journal of the Saudi Society of Agricultural Sciences

journal homepage: www.sciencedirect.com

Full length article

Field studies on occurrence, alternate hosts and mortality factors of Date Palm Mite, *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae)

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ARTICLE INFO

Article history:
Received 23 March 2018
Revised 29 May 2018
Accepted 26 August 2018
Available online 27 August 2018

Keywords:
Off-fruit season
Punicae
IPM
Pathogens

ABSTRACT

The occurrence of date palm mite (DPM), *Oligonychus afrasiaticus*, its association with other mite species and alternate host plants were studied in nine provinces of Saudi Arabia during eight consecutive years (2011–2018). In addition, different mortality factors of DPM during the fruiting season were assessed in Riyadh city. The results showed that all DPM developmental stages were recorded on date palm young-aged fronds as well as grasses growing underneath the trees during off-fruit periods, even in severe winters. Interestingly, DPM was found only on narrow leaf alternate host plant species belonging to the families Arecaceae and Poaceae. Moreover, *Hyphaene thebaica*, *Phoenix canariensis*, *Cenchrus ciliaris*, *Dichanthium annulatum*, *Hilaria* sp., *Hyparrhenia hirta*, *Pennisetum ciliarae*, *P. divisum*, *Pennisetum* sp. and *Aeluropus littoralis* were reported for the first time as alternate host plants of the DPM. Two phytophagous mites, *Eutetranychus orientalis* and *E. palmatus* (Tetranychidae), and the predatory mite *Spinibdella cronini* (Bdellidae) were found associated with DPM on date fruits. However, the phytoseiid mite *Cydnoseius negevi* was found on the grasses growing under the trees. Amongst mortality factors, pathogens followed by predators were responsible of deaths in different DPM stages. However, the unknown environmental factors caused maximum mortality of all DPM stages than any other factor. Based on the obtained data, it is suggested that young-aged fronds should be sampled prior to fruit setting for early detection of DPM and consequently should be chemically treated during the off-season. In addition, the alternate host plants as well as date palm trees growing along the roadside should be chemically treated as they may be a source of DPM. Also, more attention should be given to search and conserve indigenous predators which can be used efficiently against DPM. It is anticipated that such data can provide valuable information to improve IPM program for controlling DPM in other regions of Saudi Arabia.

1. Introduction

The date palm mite (DPM), *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae), is a severe pest of date palm, *Phoenix dactylifera* L., in Saudi Arabia (SA) and most of the arid part of the North Africa and the Middle East (Aldosari, 2009; Chaaban et al., 2011, 2012; Palevsky et al., 2003, 2004; Negm et al., 2014). It causes heavy losses by feeding and making webs on date fruits, thus impairing their quality and quantity (Palevsky et al., 2003; Chaaban et al., 2011).

Seasonal occurrence of DPM either during the fruiting season or after harvesting, has been studied at different orchards in many date palm-cultivating countries. At the end of the fruit season, i.e. during August-September, DPM migrates to different parts of date palm trees as well as to alternate hosts, to overwinter, and survive there until the new fruits appearance in the next season (Ba-Angood and Basshaih, 2000; Chaaban and Chermiti, 2010; Chaaban et al., 2012; Guessoum, 1986; Hussain, 1974; Khoualdia et al., 2001; Palevsky et al., 2003,2005, 2009). However, in SA, the DPM occurrence on date palm trees was only studied during fruiting season (Aldosari, 2009; Al-Jabr et al., 2001).

The factors causing natural death in DPM population, while it is infesting date palm fruits, have not been extensively investigated (Al-Sweedy, 2003). However, at different date palm-growing areas worldwide, some natural enemies of DPM have been recorded on

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.jssas.2018.08.003
1658-077X/

date palm fruits, leaves and on alternative hosts, e.g. give some plants that are considered as DPM alternative hosts (Afshari et al., 2007; Chaaban et al., 2011; Negm et al., 2014, 2015; Palevsky et al., 2009; Idder and Pintureau, 2008).

The development of spider mites is mainly regulated by the environmental factors (Jarošík et al., 2011; Ludwig, 1928). Studying the seasonal occurrence of spider mites could be used as a tool to evaluate all those aforementioned factors causing natural mortality in their populations. However, the scarcity of biological and ecological studies can be an impediment in the proper management of DPM worldwide. Furthermore, searching for DPM-indigenous natural enemies adapted to the arid date palm-growing areas could provide better control of this pest (Negm, 2012).

The occurrence and development of DPM, its alternate hosts, factors causing natural mortality and its association with other mites and insects during off-fruit period have not been previously studied in any region of SA. Thus, the objectives of the present study were to identify (1) the sites/parts of date palm trees or alternate hosts where DPM passes the off-fruit season, (2) the factors involved in its natural mortality during fruit season, and (3) its occurrence in association with other pest and predatory mites. Information obtained from this field study is highly needed, as it is the first step in developing successful IPM programs for managing DPM not only in Saudi Arabia but also worldwide.

2. Materials and methods

2.1. General sampling and extraction protocols

The collected vegetative parts of date palm (leaves, crown fibers etc.) and weed samples were kept individually in plastic bags, labelled properly and brought to the Acarology Laboratory at King Saud University (KSU). Mites were also collected by either moving modified specialized hand-held battery operated aspirators (Bio-Quip®, CA, USA) up and down against the vegetative parts of date palm and weeds or shaking different plant parts on a white sheet of paper. Mites were extracted and observed under a stereomicroscope (Olympus® SZX10, Tokyo, Japan). Some mites were extracted from sampled weeds, date palm trunk and crown fibers through Tullgren funnels. The collected mites were preserved in small vials containing 70% ethanol. A 15-cm in diameter Petri dish, with a black sheet glued at the bottom, was used to count different DPM stages (including eggs, larvae, nymphs, females, and males) under a stereomicroscope. DPM stages were distinguished on the basis of the number of legs in larvae, stage size (e.g. immature mites being smaller than adults and adult males being smaller than adult females), and body shape (adult females had rounded abdomens whereas adult males had posteriorly more pointed abdomens).

All Sampled trees in the present study were almost uniform in phenotypic characters (i.e. size, age, height, and vegetative growth), received the same horticultural practices, naturally infested with DPM, and grown in pesticide-free environment throughout the study periods. The data for seasonal temperature variations was recorded by the help of Honest OBserver by Onset (HOBO) data logger and meteorological weather stations near to the sampled orchards (Riyadh Air Base, Riyadh, Saudi Arabia).

From each surveyed date, individuals of DPM (males and females) and other mite specimens were cleared in Nesbitt's solution, mounted onto glass slides using Hoyer's medium, and then identified under a phase-contrast microscope (BX51, Olympus®, Japan). Mite body parts were pictured with an Auto-montage Software System (SYNCROSCOPY®, Cambridge, UK) attached to the microscope (DM2500, Leica®, Germany). All the collected mite specimens were deposited at King Saud University Museum of Arthropods (KSUMA), (Acarology section), Department of Plant Protection, College of Food and Agriculture Sciences, King Saud University, Riyadh, Saudi Arabia.

2.2. Study procedures

2.2.1. Occurrence of DPM on date palm trees and groundcover weeds during off-fruit period in Riyadh region

(A). The occurrence of DPM on different parts of date palm trees and weeds grown underneath these trees during off-fruit period was observed, fortnightly, from September 2017 to February 2018 in two date palm orchards at Alammaria, Riyadh. During each visit, four trees, from each orchard, were randomly selected. From each tree, two young (close to the tree crown) and two old (away from the tree crown) fronds were selected. From each frond, three pinnae, from outer (apical), middle and inner (basal) section were carefully cut from their base. In addition, 100 gm of tree crown fiber and grasses grown underneath were collected from each. Also, a hand held aspirator with an attached plastic tube was used to extract mites from frond bases, crown fibers, and grasses. All developmental stages of collected DPM were sorted, counted and preserved.

(B). For six successive years (from 2010 to 2017), using the same previously mentioned sampling procedures same plant parts of date palm trees and weeds grown underneath trees were observed, fortnightly, and mites were collected from five different localities in Riyadh namely, Imam Muhammad Bin Saud Islamic University (IMSIU) garden, King Saud University (KSU) campus, and date palm orchards in Diriya, Alammaria, and Alwaseel, along with roadside.

2.2.2. DPM alternate hosts in different regions of SA

During eight consecutive years (from 2010 to 2018), the occurrence of the DPM on other host plants (e.g. vegetables, ornamental palms, sorghum, maize, sugar cane, and wild grasses) growing either in the date palm orchards or around them was observed at different localities in several provinces of Saudi Arabia (Ahsa, Baha, Jazan, Makkah, Madina, Riyadh, Tabuk, Qassim, Najran).

2.2.3. Pest and predator mites associated with DPM

During the examination of the collected samples from all the above surveys, mite pests and predators associated with DPM were observed and identified.

2.2.4. Sampling units and sizes

To determine the effects of some natural (abiotic and biotic) factors on the DPM mortality during the fruiting season, five date palm trees were selected. Each sampled tree was divided into four directions (i.e., East, West, North, and South). From each direction, one date fruit bunch was selected and was further divided into three strand positions, outer, middle, and inner. Two strands were sampled from each strand position (six fruit strands were taken from each fruit bunch). Then, five fruits were selected from each fruit strand. The sample size was 600 fruits/week (5 trees $\times$ 4 bunches $\times$ 6 strands $\times$ 5 fruits = 600 fruits/week). Sampling continued every week until the end of the Khilal stage, where no further DPM stages could be observed. At each surveyed date, the mortality caused different factors (e.g. predators, pathogens and moulting/hatching) on each DPM stage was recorded. The eggs and individuals of DPM infected with different pathogens were preserved in sterile vials having agar media. The recovered bacteria and fungi from DPM were identified in plant pathology lab Depart-

ment of Plant Protection, College of Food and Agriculture Sciences, King Saud University, Riyadh, Saudi Arabia.

2.3. Data analysis

The mortality percentage for each factor at each developmental stage of DPM including eggs was obtained by following formula: % mortality = No. of individuals killed by that factor/total number of counted individuals.

3. Results and discussion

3.1. Occurrence of DPM during off fruit season

After harvesting of date fruits, all different developmental stages of DPM were recorded on date palm young-aged pinnae as well as on grasses growing underneath the trees. However, no DPM individuals were detected in date palm samples collected from old-aged pinnae, crown and trunk fiber, and frond bases (Table 1). It has been documented that at the end of the fruiting season, DPM moved toward central (young/new) fronds and even frond bases and remained there during winter months till date fruits appear on plants in early spring (Ben-David et al., 2013; Chaaban et al., 2011; Palevsky et al., 2003).

Unexpectedly, the number of DPM individuals recorded during January 2018 was higher compared to no DPM individuals were collected during November 2017 (Table 1). The average temperature (21 °C) recorded in January 2018 and the frequent rainfall (0.4 mm average) in November 2017 could explain why high numbers of DPM individuals were recorded (Table 1). However, during 2011–2017 years, the field temperatures ranged between 14 and 17 °C in Riyadh and consequently low numbers of all different DPM developmental stages were only observed on young-aged pinnae and grasses during winter months December and January of these years. It was reported that the banks grass mite, *O. pratensis*, a major date palm pest in USA (Gispert et al., 2001; Negm et al., 2015) was recorded on fronds of date palm trees and ground cover grasses even during severe winter months (Carpenter and Elmer, 1978). In Iraq, DPM was recorded on fiber and frond bases in winter, but no overwintering mites were found on the pinnae, offshoots and on ground cover weeds (Hussain, 1969).

The occurrence of different DPM stages (eggs, immatures, adults) on both date palm trees and different alternate hosts during winter could indicate their ability of reproduction even at low temperatures (14–20 °C). The reproduction of DPM slows down and life cycle prolongs as temperature decreases from 35 to 20 °C (Guessoum et al., 2016). However, it has been reported that DPM stays dormant during winter season on date palm and when temperature rises from 22 to 29 °C, it becomes active again and starts feeding on young fruit bunches in early spring (Guessoum et al., 2016).

Since 2011, during the time of date fruit formation and at the fruit stage "Hababok" (between March and April), high numbers of DPM individuals were observed on date palm fronds as compared to different grasses and *Washingtonia* trees. This finding is in agreement with previous study conducted in Riyadh by Aldosari (2009).

Thus, it can be inferred from the results of the present study and previous reports (Ben-David et al., 2013; Chaaban et al., 2011; Gispert et al., 2001; Hussain, 1969; Palevsky et al., 2003) that the variations in temperature and duration of day length can affect DPM reproduction (different developmental stages) and its abundance (number of individuals) and may explain its occupation preferences.

3.2. DPM alternate hosts

Over a period of more than seven years, different vegetable plants, ornamental (trees, shrubs, wild vegetation) and fruit trees growing either in or around the date palm orchards as well as along roadside were sampled for DPM occurrence in seven different provinces of SA. Overall, different developmental stages of DPM were recorded on plants belonging only to two plant families; Arecaceae and Poaceae. For the first time, the DPM was recorded on *Hyphaene thebaica*, *Phoenix canariensis* (Arecaceae), *Cenchrus ciliaris*, *Dichanthium annulatum*, *Hilaria* sp., *Hyparrhenia hirta*, *Pennisetum ciliarae*, *P. divisum*, *Pennisetum* sp. and *Aeluropus littoralis* (Poaceae). However, previous studies showed that DPM was recorded on plants belonging to the same two families including *C. dactylon* (Ben-David et al., 2013; Palevsky et al., 2003), *Sorghum bicolor*, *Sorghum* sp., *Saccharum officinarum* (Ben-David et al., 2013; Chaaban et al., 2011), *Zea mays*, *Imperata cylindrical*, *Lollium* sp. (Estebanes and Baker, 1968), *Phragmites communis* (Guessoum et al., 2016), *Stenotaphrum secundatum* and *Washingtonia filifera* (Palevsky et al., 2003). Another important date palm pest mite, *O. pratensis*, was recorded on *P. dactylifera*, *Sorghum* sp. and other grasses grown in the date palm orchards (Alatawi and Kamran, 2018; Martin 1972).

Furthermore, in the present study, DPM was not recorded on other economically important plants e.g. *Punica granatum* (Lythraceae), *Citrus* sp. (Rutaceae), *Ficus* sp. (Moraceae), *Tamarix* sp. (Tamaricaceae), *Acacia* sp. (Fabaceae) usually grown nearby date palm trees. Also, DPM was not recorded on *Conocarpus* sp. (Combretaceae), which is widely mistaken as DPM alternate host plant. However, the only mite species found abundantly on *Conocarpus* was *Oligonychus punicae* (Hirst) that is morphologically different from DPM. *Oligonychus* (*Oligonychus*) *punicae* (Hirst), was reported abundantly on *Conocarpus* spp., *Juniperus procera* Hochst. Ex Endl (Cupressaceae), *Morus* sp. (Moraceae) from Riyadh, Madinah, Tabuk and Baha.

It seems that species of the genus *Oligonychus* are specific in their host ranges. The two important *Oligonychus* species on date palms are *O. afrasiaticus* and *O. pratensis*. They were also found on narrow leaf plant species. Similarly, *O. punicae* is recorded on broad leaf plant species including *Cucumis melo*, *Cucumis* sp. (Cucurbitaceae), *Ficus* sp. (Moraceae), *Vitis* sp. (Vitaceae), *Solanum melongena* (Solanaceae) and *Convolvulus arvensis* (Convolvulaceae) (Bolland et al., 1998).

Table 1
Total number of DPM (all developmental stages) collected from eight trees in two date palm orchards at Al.Ammariya, Riyadh, during off-fruit season (Sept. 2017-Feb. 2018).

Year	Month	Date Palm Part					
		New aged fronds	Frond base	Crown fiber	Trunk fiber	Grasses	Avg. temperature (°C)
2017	September	52	0	0	0	0	41
	October	96	0	0	0	0	36
	November	0	0	0	0	0	27
	December	212	0	0	0	0	22
2018	January	335	0	0	0	22	21
	February	213	0	0	0	15	20

In SA, it was reported that DPM can attack cucumber, citrus, eggplants, beans and strawberry (Al-Shammery, 2008), but the study did not mention DPM stages founded on plants. However, Al-Atawi (2011) reported that DPM was not found on 14 different species of vegetable crops, usually grown in date palm orchards, covering five major production localities in Riyadh. Moreover, DPM could not reproduce on peach, *Citrus* spp., guava, *Conocarpus* sp., eggplants, blueberries and grapes (unpublished data). Therefore, the presence DPM could be accidental on these broad leaf plant species or its possible misidentification particularly with other *Oligonychus* species usually colonizing broad leaf plants.

3.3. Mite pests and predators associated with DPM

In the present study, for the first time in Riyadh, SA, DPM was found abundantly on date palm leaves in association with *Eutetranychus orientalis* and *E. palmatus* (Tetranychidae), even during winter season. *E. palmatus* has been reported as pest mite of date palm damaging date fruits (Palevsky et al., 2010). Individuals of *Tetranychus* sp. were infesting date fruits in Alhassa (Al-Jabr et al., 2001). However, in the present study, even from the same region, DPM was only collected from the date fruits. Generally, several tetranychid, tenuipalpid, and eriophyid mites were reported from date palm agroecosystem in SA (Al-Atawi et al., 2014; Alatawi et al, 2015; Alatawi and Kamran, 2018).

In the present study, the two predatory mites, *Spinibdella cronini* (Bdellidae) and *Cydnoseius negevi* (Phytoseiidae) were abundantly found to be associated with DPM on date fruits and on grasses, respectively, in all surveyed regions. Previously, different Mesostigmatic and Prostigmatic predatory mites were found in date palm Saudi agroecosystem (Alatawi and Kamran, 2017; Alatawi et al., 2017; Al-Atawi et al., 2018).

3.4. Natural mortality factors of DPM on date fruits

The mortality percentage of different DPM stages, infesting date fruits under field conditions, due to different factors are presented in Table 2. Three natural mortality factors of DPM were observed, viz. insect and mite predators, pathogens, and immature mite molting/hatching egg. Also, some unknown environmental mortality factors were considered.

The highest mortality percentage, among the known factors, for all stages of DPM was caused by pathogens (viral and fungal) followed by predators (Table 2). The pathogens killed more DPM larvae, nymphs and adults (30.96%, 23.35% and 33.44%, respectively) compared to eggs (5.26%). However, predators killed more DPM nymphal and adult stages (10.38% and 10.6%, respectively) compared to eggs and larval stages (5.26% and 30.96%, respectively). Moreover, more larval stages (10.10%) died during molting followed by nymphs (6.6%) and eggs (0.81%) during hatching. The differences in the percentages of DPM stages killed by pathogens and predators could be due to the ability to see DPM corpses that were killed by pathogens while those killed by predators either partially or completely disappeared, i.e. very hard to be counted. Also, it is most probable that the predator population increases with the increase of prey. The results of the mortality percentages caused by predators for the larval and nymphal stages during the present study are close to that reported by Al-Sweedy (2003). It is assumed that high egg mortality can be associated with many factors, e.g. very hot and dry climatic conditions and the sudden weather changes in Saudi Arabia. In addition, Al-Sweedy (2003) assumed that the egg mortality could be due to some physiological, genetic and climatic factors. However, different unknown environmental factors can also be responsible for higher mortality percentages for all DPM stages and may have relatively equal effects against all the stages (Table 2).

Table 2
Mortality percentages of different DPM stages caused by different factors on date palm fruits under field conditions in Riyadh city during 2011.

Stage	Predator	Pathogen	Moulting/Hatching	Unknown factors
Egg	3.24	5.26	0.81	90.69
Larva	5.13	30.96	10.10	53.81
Nymph	10.38	23.35	6.60	59.67
Adult	10.60	33.44	0	55.95

Overall, during the present study, four different fungal genera (*Alternaria* sp., *Aspergillus* sp., *Fusarium* sp., and *Penicillium* sp.), five predatory mite families (Bdellidae, Cheyletidae, Phytoseiidae, and Stigmaeidae), and two predacious insects belonging to two families (Chrysopidae and Coccinellidae) were found in association with DPM on date fruits. Al-Jboory (2007) recorded 12 predatory mite families that were associated with date palm trees in Iraq, in addition to two different entomophagous pathogens, *Beauvaria bassiana* fungus and Oryctes-like virus.

4. Conclusion

Based on the present study, it is concluded that individuals of DPM remain on date palm trees (fronds and pinnae) during off-fruit period and winter months and can passively reproduce due to low temperatures. In early spring where fruits start to develop, DPM individuals move towards young immature fruits, at Kimri stage. It is recommended that DPM-infested date palm trees should be chemically treated after the harvesting of date fruits to avoid the next season DPM infestations. In addition, the alternate hosts of the plant families Arecaceae and Poaceae serving as shelter for DPM during off-fruit season should be removed from orchards. Moreover, the date palm trees grown along the roadside are important sources of DPM infestation and need to be chemically treated. As the DPM started to appear on date palm fronds during March, it is recommended to sample them for early detection of DPM infestation on fruits. Determination of unknown factors are very important in this research and can open more successive research. Furthermore, attention should be given to search for indigenous predators that can be used efficiently in IPM program against DPM.

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