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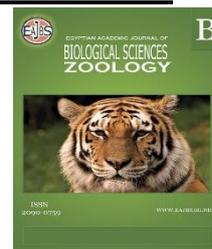


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Population Fluctuations of Mites on Two Pomegranate (*Punica granatum*) Varieties in Three Suburbs of Assiut Governorate, Egypt

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ABSTRACT

Pomegranate, *Punica granatum* L. (Myrtales: Lythraceae), is one of the most important fruits in Egypt, especially in Assiut Governorate. However, little is known about mite fauna and their population fluctuations in pomegranate orchards. In this study, the population fluctuations of two phytophagous mite species, *Tenuipalpus punicae* Pritchard & Baker (Acarida: Tenuipalpidae) and *Oligonychus punicae* Hirst (Trombidiformes: Tetranychidae), and their associated phytoseiid predators, *Euseius scutalis* Athias-Henriot (Mesostigmata: Phytoseiidae) and *Neoseiulus barkeri* Hughes (Acarina: Phytoseiidae), were investigated in two pomegranate varieties (Assiuty and Manfalouty) from three cities that produce pomegranates in Assiut Governorate. Mites were monitored monthly for 2 years beginning in October 2018. Of the phytophagous mites, *T. punicae* was the main mite pest; its population numbers were highest between July and September in both study years. In contrast, *O. punicae* reached its highest density between May and August. Notably, the numbers of both predatory mite species, *E. scutalis*, and *N. barkeri*, were associated with the densities of their prey, i.e., the aforementioned phytophagous mites.

INTRODUCTION

Pomegranates, *Punica granatum* L. (Myrtales: Lythraceae), are liable to be infested with a variety of mite species, the most important of which is the pomegranate false spider mite, *Tenuipalpus punicae* Pritchard & Baker (Acarida: Tenuipalpidae), and the avocado brown mite, *Oligonychus punicae* Hirst (Trombidiformes: Tetranychidae). *Tenuipalpus punicae* is the most serious pomegranate pest in Egypt. It was first recorded by Sayed (1942, 1946) and subsequently by other researchers (e.g., Wafa *et al.*, 1969; Zaher and Yousef 1972). The economic significance of this species has been lessened since its discovery due to the wide use of pesticides to control pomegranate pests (Döker *et al.*, 2013). *Oligonychus punicae* is a tetranychid mite that, when present in large numbers, causes severe defoliation for several pomegranate and grapevine cultivars (Zaher

et al., 1982). The phytoseiids *Euseius scutalis* Athias-Henriot (Mesostigmata: Phytoseiidae) and *Neoseiulus barkeri* Hughes (Trombidiformes: Tetranychidae) are generalist predators (McMurtry *et al.*, 2013) that prey on both of the aforementioned phytophagous species (Abdelgayed *et al.*, 2019, 2020).

For each of these species, information is lacking on their numerical fluctuations, whether harmful or beneficial, especially on pomegranate trees. Such information is important for developing integrated control strategies against pest species. Therefore, this study aims to determine the abundance of each of the two groups of mites, i.e., mite pests and their natural enemies, on two varieties of pomegranates (Assiuty and Manfalouty), as well as their relationship with the plants and the environmental factors that influence their respective population numbers.

MATERIALS AND METHODS

The study was conducted in two pomegranate orchards planted with two varieties of pomegranates: Assiuty and Manfalouty. These orchards are located in three suburbs of Assiut Governorate: Abou-Tig [27°02'38.3"N,31°19'23.7"E], El-Fateh [27°10'32.1"N,31°11'02.5"E], and Manfalout [27°18'46"N,30°58'13"E]. Each of the orchards is at least 35 years old. During the 2 years of the study (October 2018–September 2020), phytosanitary treatments were not applied to three selected marked lines of pomegranate trees. Four pomegranate trees from the two varieties in the three suburbs were randomly selected, and 25 pomegranate leaves (100 leaves per area) were sampled fortnightly. Pomegranate leaves from each variety in each region were placed in separate polyethylene bags and then transferred to the laboratory for examination via a stereoscopic microscope (40–100× magnification). Mites from all species were counted on both surfaces of the pomegranate leaves.

Individuals from each mite species were mounted in Hoyer's medium on clean microscopic glass slides (Jeppson *et al.*, 1975). Slides of each species were then taxonomically examined using a phase-contrast microscope (2,000× magnification). Mite species were identified according to the illustrated keys of Chant and McMurtry (1994, 2004) and Mesa *et al.*, (2009). The identified specimens were deposited in the Acari collection at the Department of Plant Protection, Faculty of Agriculture, Assiut University, Egypt.

Weather data, such as minimum/maximum temperature (°C) and relative humidity (%), during the studied period, were obtained from the online database Wunderground (The Weather Company, GA, USA). Simple correlation coefficients (*r* values) were determined using SAS statistical software (SAS Institute 2003) to assess the effect of weather factors on the average monthly numbers of mite species.

RESULTS AND DISCUSSION

Population Fluctuation of Phytophagous Mites on Pomegranate Leaves:

Data in Tables 1 and 2 represent the population fluctuations of *T. punicae* and *O. punicae* on two pomegranate varieties in three regions during two successive years (2018–2019 and 2019–2020).

Phytophagous Mites on the Manfalouty Variety:

On the Manfalouty variety (Table 1), *T. punicae* reached the highest densities (individuals/100 leaves) during the period from July to September in 2019 (717.0, 808.5, and 457.0) and 2020 (642.5, 850.0, and 498.5) in the three studied regions (Abou-Tig, El-Fateh, and Manfalout, respectively). Mites completely disappeared during December and January. The highest numbers of *O. punicae* (individuals/100 leaves) were recorded from May to August in 2019 (164.0, 82.5, and 55.5) and 2020 (90.0, 52.5, and 57.5) in the three

aforementioned regions, respectively.

The lack of *T. punicae* in December and January is consistent with results reported by Zaher and Yousef (1972), Al-Mallah and Mohammad (1989), and Marei *et al.* (2020), who each stated that *T. punicae* infestation begins with overwintering adults in May, whereas the other stages appear 2–3 weeks later.

The peak mite infestation on the Manfalouty variety occurred from July to September with the lower surface of pomegranate leaves being more infested than the upper surface. In addition, mites preferred the east direction of trees. The overwintering adults concealed under bark and inside the buds of shoots appeared by the end of November to the early spring of the following year. The mite population gradually increased until it reached its peak during July to September in both seasons. These results are in agreement with those obtained by Al-Gboory (1987), Al-Gboory and El-Haidari (1989a, b), Ananda (2007), Amini (2008), Ananda *et al.* (2009), and Döker *et al.* (2013).

Statistical analysis revealed a significant positive correlation between temperature and *T. punicae* density on the leaves of the Manfalouty variety. In contrast, a significant negative correlation was detected between relative humidity and the population of this species during both study years. For *O. punicae*, significant negative correlations were found between temperature and density and relative humidity and density in both study years in the Abou-Tig area. In Manfalout, however, the temperature was significantly positively correlated with *O. punicae* density in the first season but not in the second season (although a positive trend was detected), whereas relative humidity was significantly negatively correlated with the mite population in both seasons. These results are in agreement with those reported by Zaher and Yousef (1972), Al-Azzazy (2005), Hussian *et al.* (2018), and Marei *et al.* (2020).

Table 1. Population fluctuation of phytophagous mites, *Tenuipalpus punicae* and *Oligonychus punicae*, infesting the Manfalouty (Baladi) variety of pomegranate during two seasons in three cities of the Assiut Governorate

Inspection date	Mean no. of phytophagous mites/100 leaves																	
	2018/2019						2019/2020						Mini temp. (°C)		Max temp. (°C)		Mean RH (%)	
	Abou-Tig city		El-Fateh city		Manfalout city		Abou-Tig city		El-Fateh city		Manfalout city		2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
	<i>T. punicae</i>	<i>O. punicae</i>	<i>T. punicae</i>	<i>O. punicae</i>	<i>T. punicae</i>	<i>O. punicae</i>	<i>T. punicae</i>	<i>O. punicae</i>	<i>T. punicae</i>	<i>O. punicae</i>	<i>T. punicae</i>	<i>O. punicae</i>						
October	316.5	40.0	222.5	60.0	119.5	17.5	309.0	72.5	361.5	51.0	161.5	19.0	18.19	19.54	32.29	33.29	48.25	48.91
November	238.5	38.0	118.5	46.5	116.0	22.5	243.0	59.0	141.0	16.5	112.5	24.5	12.9	14	26.2	28.13	56.19	53.7
December	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	126.0	0.0	0.0	0.0	8.32	8.41	20.51	21.09	64.44	59.39
January	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.09	6	19	18.12	55.23	61.33
February	80.0	35.0	90.5	33.5	0.0	14.0	100.0	36.0	0.0	16.5	0.0	17.0	7.92	7.65	21.42	23.51	53.34	56.73
March	116.5	75.0	155.5	65.5	89.5	28.0	106.5	50.0	54.0	15.5	162.0	24.5	10.03	11.41	24.38	25.58	45.61	46.35
April	142.0	62.0	133.5	73.5	117.0	23.5	163.0	63.0	160.0	17.5	136.5	39.0	14.13	15.16	29.56	29.76	38.76	40.05
May	225.5	84.0	296.5	80.5	175.0	41.0	233.0	90.0	200.0	48.0	180.0	50.5	22.35	19.7	37.35	35	30.18	37.12
June	428.5	90.0	536.0	57.5	228.5	55.5	327.5	57.5	383.0	39.5	295.5	57.5	24.33	23.06	37.3	38.13	33.94	34.85
July	593.0	164.0	808.5	39.5	315.0	40.5	483.5	82.0	534.5	52.5	351.5	56.0	24.8	24.09	38.48	38.25	35.86	36.27
August	717.0	159.0	763.5	82.5	457.0	54.0	507.0	87.5	850.0	74.0	498.5	57.0	25.51	25.2	38.35	39.9	36.31	40.75
September	415.0	89.0	582.0	60.0	280.0	36.0	642.5	47.5	516.5	46.5	466.5	44.5	21.73	22.11	34.73	38.86	46.97	36.04

*Significant at 5% level. Temp,temperature; RH, relative humidity

Phytophagous Mites on The Assiuty Variety:

On the Assiuty variety (Table 2), *T. punicae* reached its highest density (individuals/100 leaves) from June to September in 2019 (666.0, 751.0, and 593.5) and 2020 (750.0, 733.5, and 665.5) in Abou-Tig, El-Fateh, and Manfalout, respectively. Again, *T. punicae* disappeared during December and January in both seasons. However, *O. punicae* reached its highest density (individuals/100 leaves) from May to September in 2019 (87.0, 70.0, and 95.0) and 2020 (78.0, 54.0, and 61.5) in the three respective regions. In slight contrast to *T. punicae*, *O. punicae* completely disappeared from December to February in both seasons (Table 2).

Statistical analysis showed that temperature was significantly positively correlated with *T. punicae* density, whereas the opposite (negative) correlation was found

for relative humidity and *T. punicae* density. These results agree with those of Eichelberger *et al.* (2011) and Johann and Ferla (2012).

Table 2. Population fluctuation of phytophagous mites, *Tenuipalpus punicae* and *Oligonychus punicae*, infesting the Assiuty pomegranate variety during two seasons in three cities of Assiut Governorate

Inspection date	Mean no. of phytophagous mites/100 leaves																	
	2018/2019						2019/2020						Mini temp. (°C)		Max temp. (°C)		Mean RH (%)	
	Abou-Tig city		El-Fateh city		Manfalout city		Abou-Tig city		El-Fateh city		Manfalout city		2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
	<i>T. punicae</i>	<i>O. punicae</i>	<i>T. punicae</i>	<i>O. punicae</i>	<i>T. punicae</i>	<i>O. punicae</i>	<i>T. punicae</i>	<i>O. punicae</i>	<i>T. punicae</i>	<i>O. punicae</i>	<i>T. punicae</i>	<i>O. punicae</i>						
October	318.5	31.0	212.5	40.0	319.5	68.0	218.5	62.5	363.5	39.0	357.5	46.0	18.19	19.54	32.29	33.29	48.25	48.91
November	220.5	32.5	126.0	60.0	216.5	62.0	229.5	27.5	252.5	11.5	200.0	12.5	12.9	14	26.2	28.13	56.19	53.7
December	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.32	8.41	20.51	21.09	64.44	59.39
January	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.09	6	19	18.12	55.23	61.33
February	0.0	0.0	128.5	30.0	0.0	0.0	0.0	32.5	0.0	0.0	0.0	0.0	7.92	7.65	21.42	23.51	53.34	56.73
March	114.0	44.0	251.0	40.0	60.0	30.0	91.5	49.5	129.5	17.5	177.0	30.0	10.03	11.41	24.38	25.58	45.61	46.35
April	143.0	41.5	251.5	50.5	116.5	60.0	152.5	39.5	159.0	27.5	183.0	36.0	14.13	15.16	29.56	29.76	38.76	40.05
May	129.5	40.0	112.0	70.0	195.0	62.0	174.5	56.0	101.5	15.0	221.5	38.5	22.35	19.7	37.35	35	30.18	37.12
June	267.0	58.0	751.0	66.0	363.5	65.0	361.0	49.0	355.5	54.0	349.5	61.5	24.33	23.06	37.3	38.13	33.94	34.85
July	383.0	87.0	563.5	60.5	593.5	70.0	483.0	44.5	372.0	39.5	481.0	39.5	24.8	24.09	38.48	38.25	35.86	36.27
August	666.0	49.0	421.5	47.0	537.5	80.0	750.0	40.0	733.5	47.0	327.5	25.5	25.51	25.2	38.35	39.9	36.31	40.75
September	415.0	72.5	502.0	48.5	408.0	95.0	632.0	78.0	439.0	40.5	665.5	17.5	21.73	22.11	34.73	38.86	46.97	36.04

*Significant at 5% level. Temp,temperature; RH, relative humidity

Population Fluctuations Of Predaceous Mites On Pomegranate Leaves: Predaceous Mites on The Manfalouty Variety:

The phytoseiid mite *E. scutalis* was recorded on pomegranate leaves during the period from November to February in association with different pests (Table 3). It reached its highest density between July and September in both seasons in the three studied areas. Subsequently, its numbers decreased until the end of November and then it disappeared between December and January. *Neoseiulus barkeri* also reached its highest numbers between June and September (Table 3). Similarly, its numbers began to gradually decrease until the end of November, and then it disappeared during December and January in both seasons.

Statistical analysis showed that temperature had a significant positive correlation with the population density of both predaceous mite species. In contrast, relative humidity had a significant negative correlation with these mite populations during the two studied seasons. These findings are in agreement with those of Abdallah *et al.* (2001).

Table 3. Population fluctuation of predaceous mites, *Euseius scutalis* and *Neoseiulus barkeri*, associated with phytophagous mites infesting the Manfalouty (Baladi) pomegranate variety during two seasons in three cities of Assiut Governorate

Inspection date	Mean no. of predaceous mites/100 leaves																	
	2018/2019						2019/2020						Mini temp. (°C)		Max temp. (°C)		Mean RH (%)	
	Abou-Tig city		El-Fateh city		Manfalout city		Abou-Tig city		El-Fateh city		Manfalout city		2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>						
October	19.5	33.0	12.5	21.5	11.5	11.0	19.0	21.5	26.0	25.5	12.5	12.5	18.19	19.54	32.29	33.29	48.25	48.91
November	12.5	16.0	16.0	22.5	14.0	13.5	24.0	26.0	15.0	15.0	11.0	10.0	12.9	14	26.2	28.13	56.19	53.7
December	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.32	8.41	20.51	21.09	64.44	59.39
January	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.09	6	19	18.12	55.23	61.33
February	11.0	0.0	13.5	0.0	0.0	0.0	0.0	0.0	22.0	10.0	17.5	24.0	7.92	7.65	21.42	23.51	53.34	56.73
March	19.0	11.0	10.0	21.5	0.0	0.0	25.0	22.0	25.0	21.5	16.5	24.5	10.03	11.41	24.38	25.58	45.61	46.35
April	10.0	19.0	24.0	22.5	10.0	11.0	25.5	26.0	25.5	24.5	13.0	15.5	14.13	15.16	29.56	29.76	38.76	40.05
May	10.0	14.0	24.5	21.5	20.0	14.0	26.5	33.5	25.0	26.0	14.5	24.5	22.35	19.7	37.35	35	30.18	37.12
June	12.0	15.0	24.5	32.0	30.0	14.0	26.0	37.5	38.0	28.0	27.0	16.5	24.33	23.06	37.3	38.13	33.94	34.85
July	21.5	28.0	20.0	35.0	34.0	17.5	27.5	39.5	38.5	37.5	27.0	28.0	24.8	24.09	38.48	38.25	35.86	36.27
August	15.5	26.0	31.5	37.5	35.0	15.0	28.5	37.0	36.5	37.5	27.5	36.5	25.51	25.2	38.35	39.9	36.31	40.75
September	13.5	36.5	34.0	32.5	34.0	12.5	26.0	36.5	36.5	35.0	26.5	34.0	21.73	22.11	34.73	38.86	46.97	36.04

*Significant at 5% level. Temp,temperature; RH, relative humidity

Predaceous Mites on The Assiuty Variety:

On the Assiuty variety (Table 4), *E. scutalis* reached its peak during the period from June to September in both seasons in the three studied areas, whereas *N. barkeri*

reached its peak from July to September. Subsequently, mite species numbers gradually decreased before they disappeared during December and January.

Statistical analysis showed that temperature and population density were significantly positively correlated in both predatory mite species, whereas relative humidity and population density were significantly negatively correlated.

Table 4. Population fluctuation of predaceous mites, *Euseius scutalis* and *Neoseiulus barkeri*, associated with some phytophagous mites infesting Assiuty pomegranate variety during two seasons in three cities of Assiut Governorate

Inspection date	Mean no. of predaceous mites/100 leaves														Mini temp. (°C)		Max temp. (°C)		Mean RH (%)	
	2018/2019						2019/2020						2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020		
	Abou-Tig city		El-Fateh city		Manfalout city		Abou-Tig city		El-Fateh city		Manfalout city									
	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>	<i>E. scutalis</i>	<i>N. barkeri</i>						
October	20.5	20.0	10.0	10.0	11.5	12.5	12.5	10.0	13.5	13.5	24.0	13.0	18.19	19.54	32.29	33.29	48.25	48.91		
November	12.5	10.0	19.0	10.0	11.5	14.0	14.0	11.5	11.5	13.5	22.5	11.5	12.9	14	26.2	28.13	56.19	53.7		
December	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.32	8.41	20.51	21.09	64.44	59.39		
January	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	6.09	6	19	18.12	55.23	61.33		
February	10.0	10.0	13.5	20.0	10.0	0.0	22.5	1.5	13.0	11.0	10.5	0.0	7.92	7.65	21.42	23.51	53.34	56.73		
March	19.0	10.0	10.0	20.0	14.5	20.0	23.5	14.0	15.0	22.5	15.0	11.5	10.03	11.41	24.38	25.58	45.61	46.35		
April	16.0	11.5	13.5	13.0	26.0	22.5	11.5	13.5	14.0	23.0	24.5	22.5	14.13	15.16	29.56	29.76	38.76	40.05		
May	16.5	20.0	15.5	10.0	26.0	20.5	14.0	25.0	24.5	24.0	14.0	23.0	22.35	19.7	37.35	35	30.18	37.12		
June	29.0	20.0	10.5	20.0	20.0	34.5	25.0	24.5	26.5	35.0	35.5	24.5	24.33	23.06	37.3	38.13	33.94	34.85		
July	26.0	32.0	10.0	30.0	33.5	35.0	36.5	26.0	28.0	39.0	35.0	38.0	24.8	24.09	38.48	38.25	35.86	36.27		
August	30.0	27.0	21.5	32.0	36.5	11.0	34.0	33.0	36.5	37.0	34.0	33.5	25.51	25.2	38.35	39.9	36.31	40.75		
September	30.5	22.0	39.5	30.0	30.0	34.0	36.0	33.5	31.5	34.5	34.5	33.0	21.73	22.11	34.73	38.86	46.97	36.04		

*Significant at 5% level. Temp,temperature; RH, relative humidity

Relationships between Population Fluctuations of Phytophagous and Predaceous Mites on Two Varieties of Pomegranate Leaves Over 2 Years:

Relationships on the Manfalouty Variety:

On the Manfalouty variety, both predatory mite species reached their highest densities (individuals/100 leaves) during the following months in both study years: July, August, and October in Abou-Tig city (2018–2019, 52.5; 2019–2020, 67.0), July and August in El-Fateh city (2018–2019, 69.50; 2019–2020, 76.0), and July and August in Manfalout city (2018–2019, 51.5; 2019–2020, 64.0) (Table 5).

The numbers of phytophagous mites and the corresponding numbers of their associated predators during the two study years in the three cities are shown in Table 5. Statistically significant correlations were found between the population densities of both phytophagous and predacious mites during the two seasons.

Table 5. Monthly mean numbers of phytophagous and predaceous mites associated with pomegranate leaves of the Manfalouty (Baladi) variety during two seasons in three cities of Assiut Governorate

Inspection date	Mean no. of moving stages/100 leaves																	
	2018/2019				2019/2020				2018/2019				2019/2020					
	Abou-Tig city		El-Fateh city		Manfalout city		Abou-Tig city		El-Fateh city		Manfalout city		Abou-Tig city		El-Fateh city		Manfalout city	
	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites
October	316.5	40.0	52.5	309.0	72.5	40.5	222.5	60.0	34.0	361.5	51.0	51.5	119.5	17.5	22.5	161.5	19.0	25.0
November	238.5	38.0	28.5	243.0	59.0	50.0	118.5	46.5	38.5	141.0	16.5	30.0	116.0	22.5	27.5	112.5	24.5	21.0
December	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	126.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
January	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
February	80.0	35.0	11.0	100.0	36.0	0.0	90.5	33.5	13.5	0.0	16.5	32.0	0.0	14.0	0.0	0.0	17.0	41.5
March	116.5	75.0	30.0	106.5	50.0	47.0	155.5	65.5	31.5	54.0	15.5	46.5	89.5	28.0	0.0	162.0	24.5	41.0
April	142.0	62.0	29.0	163.0	63.0	51.5	133.5	73.5	46.5	160.0	17.5	50.0	117.0	23.5	21.0	136.5	39.0	28.5
May	225.5	84.0	24.0	233.0	90.0	60.0	296.5	80.5	46.0	200.0	48.0	51.0	175.0	41.0	34.0	180.0	50.5	39.0
June	428.5	90.0	27.0	327.5	57.5	63.5	536.0	57.5	56.5	383.0	39.5	66.0	228.5	55.5	44.0	295.5	57.5	43.5
July	593.0	164.0	49.5	483.5	82.0	67.0	808.5	39.5	55.0	534.5	52.5	76.0	315.0	40.5	51.5	351.5	56.0	55.0
August	717.0	159.0	41.5	507.0	87.5	65.5	763.5	82.5	69.0	850.0	74.0	74.0	457.0	54.0	50.0	498.5	57.0	64.0
September	415.0	89.0	50.0	642.5	47.5	62.5	582.0	60.0	66.5	516.5	46.5	71.5	280.0	36.0	46.5	466.5	44.5	60.5

Both predatory mites had significant positive effects on the population density of *T. punicae* according to correlation coefficients (*r* values) in 2019 (0.77, 0.84, and 0.91) and 2020 (0.78, 0.77, and 0.84) in the three studied cities, Abou-Tig, El-Fateh, and

Manfalout, respectively. Data in Table 5 show that the phytoseiid populations had a positive effect on the population of *O. punicae* in both seasons. Correlation coefficients (*r* values) from 2019 (0.69, 0.80, and 0.84) and 2020 (0.84, 0.86, and 0.83) showed significant correlations between the population fluctuations of *O. punicae* and its predatory mites during both seasons in the three aforementioned cities, respectively.

On the Manfalouty variety, the relationships between the population densities of phytoseiid and phytophagous mites during the two seasons were significant as shown by positive correlation coefficients (*r* values) from 2019 (0.76, 0.87, and 0.91) and 2020 (0.82, 0.78, and 0.86) in Abou-Tig, El-Fateh, and Manfalout, respectively (Table 7).

Relationships on the Assiuty variety

On the Assiuty variety, predatory mites reached their highest numbers (individuals/100 leaves) during July to September (58.0, 69.5, and 69.5) in the first season and from July to August (73.5, 68.5, and 73.0) in the second season in Abou-Tig, El-Fateh, and Manfalout, respectively (Table 6). The numbers of phytophagous mites and the corresponding numbers of associated predators are shown in Table 6.

Table 6. Monthly mean numbers of phytophagous and predaceous mites associated with pomegranate leaves of the Assiuty variety during two seasons in three cities of Assiut Governorate

Inspection date	Mean no. of moving stages/100 leaves																	
	2018/2019			2019/2020			2018/2019			2019/2020			2018/2019			2019/2020		
	Abou-Tig city						El-Fateh city						Manfalout city					
	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of pred. mites
October	318.5	31.0	40.5	218.5	62.5	22.5	212.5	40.0	20.0	363.5	39.0	27.0	319.5	68.0	24.0	357.5	46.0	37.0
November	220.5	32.5	22.5	229.5	27.5	25.5	126.0	60.0	29.0	252.5	11.5	25.0	216.5	62.0	25.5	200.0	12.5	34.0
December	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
January	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0
February	0.0	0.0	20.0	0.0	32.5	24.0	128.5	30.0	33.5	0.0	0.0	24.0	0.0	0.0	10.0	0.0	0.0	10.5
March	114.0	44.0	29.0	91.5	49.5	37.5	251.0	40.0	30.0	129.5	17.5	37.5	60.0	30.0	34.5	177.0	30.0	26.5
April	143.0	41.5	27.5	152.5	39.5	25.0	251.5	50.5	26.5	159.0	27.5	37.0	116.5	60.0	48.5	183.0	36.0	47.0
May	129.5	40.0	36.5	174.5	56.0	39.0	112.0	70.0	25.5	101.5	15.0	48.5	195.0	62.0	46.5	221.5	38.5	37.0
June	267.0	58.0	49.0	361.0	49.0	49.5	751.0	66.0	30.5	355.5	54.0	61.5	363.5	65.0	54.5	349.5	61.5	60.0
July	383.0	87.0	58.0	483.0	44.5	62.5	563.5	60.5	40.0	372.0	39.5	67.0	593.5	70.0	68.5	481.0	39.5	73.0
August	666.0	49.0	57.0	750.0	40.0	67.0	421.5	47.0	53.5	733.5	47.0	73.5	537.5	80.0	47.5	327.5	25.5	67.5
September	415.0	72.5	52.5	632.0	78.0	69.5	502.0	48.5	69.5	439.0	40.5	66.0	408.0	95.0	64.0	665.5	17.5	67.5

Table 7. Simple correlation coefficient values of phytophagous mites infesting pomegranate leaves of the Manfalouty (Baladi) variety during two seasons in three cities of Assiut Governorate

	2018/2019			2019/2020			2018/2019			2019/2020			2018/2019			2019/2020		
	Abou-Tig city						El-Fateh city						Manfalout city					
	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites
(r)	0.77*	0.69*	0.76**	0.78**	0.84**	0.82**	0.84**	0.80**	0.87**	0.77**	0.86**	0.78**	0.91**	0.84**	0.91**	0.84**	0.83**	0.86**

*Significant at 5% level.

Data in Table 8 show the relationships between the numbers of the phytoseiids and *T. punicae*, which were significant positive correlations (*r* values) in the three aforementioned cities, respectively, in 2019 (0.85, 0.65, and 0.78) and 2020 (0.89, 0.79, and 0.88). Similarly, the numbers of phytoseiids were positively correlated with the numbers of *O. punicae* populations in the three respective areas in 2019 (0.88, 0.58, and 0.84) and 2020 (0.73, 0.83, and 0.66).

Overall, relationships between the population densities of phytoseiid and phytophagous mites on the Assiuty variety were positive in 2019 (0.88, 0.67, and 0.80) and 2020 (0.91, 0.80, and 0.89) in the three respective cities (Table 8).

Table 8. Simple correlation coefficient values of phytophagous mites infesting pomegranate leaves of the Assiuty variety during two seasons in three cities of Assiut Governorate

(r)	2018/2019			2019/2020			2018/2019			2019/2020			2018/2019			2019/2020		
	Abou-Tig city						El-Fateh city						Manfalout city					
	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites	<i>T. punicae</i>	<i>O. punicae</i>	Mean no. of phyto. mites
	0.85**	0.88**	0.88**	0.89**	0.73*	0.91**	0.65*	0.58*	0.67*	0.79**	0.83**	0.80**	0.78**	0.84**	0.80**	0.88**	0.66*	0.89**

*Significant at 5% level.

Generally, the population fluctuations of phytoseiids and both phytophagous mite species (especially for *T. punicae*) were significantly associated during the successive study seasons, which is wholly in agreement with the findings of Ghoshal *et al.* (2011), Elhalawany and Abou-Setta (2013), and Elhalawany *et al.* (2020). Furthermore, significant positive correlations between the phytoseiids and *O. punicae* were previously reported by Elhalawany (2001), Rasmy *et al.* (2003), Abou-Awad *et al.* (2005), and Amini (2008).

Conclusion

Environmental factors did not significantly affect the population dynamics of the two studied phytophagous mite species. In Assiut Governorate, Egypt, *T. punicae* is the most important phytophagous mite on pomegranate, with outbreaks typically occurring from July to September. High predator diversity was observed in association with plant feeder mites in pomegranate orchards, indicating the important role of natural predators in the control of *T. punicae* and *O. punicae* on pomegranates. Thus, further studies are required to assess the control of both phytophagous mites using *E. scutalis* and *N. barkeri*. Clarifying the role of these natural predators will be necessary for the development and application of biological control programs, such as mass rearing and release of such biocontrol agents in pomegranate orchards, against these two phytophagous mite pests.

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Author contribution

The authors contribute equally to the work.

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