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Article

Population fluctuation of some economically important mites on two mango cultivars in Qalyubia governorate, Egypt

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ABSTRACT
Population fluctuation of the most abundant mite species inhabiting mango, *Mangifera indica* L. (Anacardiaceae), as one of the important fruit trees at Qalyubia governorate, Egypt was studied from August 2020 to September 2022. Results indicated the occurrence of 19 mite species from 18 genera in 10 families. Mango bud mite, *Aceria mangiferae* Sayed, mango rust mite, *Metaculus mangiferae* (Attiah) and tetranychid mite, *Oligonychus mangiferus* (Rahman & Sapra) have become important pests on "Naomi" mango cultivar. While, the mango leaf coating mite, *Aceria aegyptindicae* Elhalawany, Amrine & Ueckermann and *Cisaberoptus kenyae* Keifer are important pests on "Heidi" cultivar. *Aceria mangiferae* has two peaks (in mid and late November, and late May and early-June) on buds of "Naomi" cultivar during the two successive seasons. *Metaculus mangiferae* has two peaks on leaves (in mid-October and late May) in the first season and (in late November and May) in the second season. *Oligonychus mangiferus* was recorded in high numbers in spring and autumn on "Naomi" cultivar during the two collection seasons. *Aceria aegyptindicae* and *C. kenyae* have two peaks (in late November and mid-February) in the first season, and (in early December and late April) in the second season on "Heidi" cultivar. Predacious mites are following their associated phytophagous prey with a lag in time. The population of phytophagous mites was significantly affected by combined weather factors and plant age than weather factors alone. Results indicated 'Heidi' is resistant to infestation with *A. mangiferae*, and susceptible to both *A. aegyptindicae* and *C. kenyae*. However, 'Naomi' is susceptible to the first pest and resistant to latter two pests. The changes in the nutritional value of the host plant are more effective on mite population fluctuation than weather factors.

KEYWORDS: Incidence, phenology, plant-feeding mites, predatory mites, weather factors.

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INTRODUCTION

Mango, *Mangifera indica* L. (Anacardiaceae) is one of the most popular fruit crops in Egypt. Mango is of great economic importance and its cultivation in Egypt is concentrated at Ismalia, Sharkia, Giza, Behira, Aswan and Fayoum governorates. The total cultivated area of mango is 304.118 feddans with an annual production of 1.091.535 tons of fruits with an average of 4.111 ton/feddan (Ministry of Agriculture and Land Reclamation statistic 2019).

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In Egypt, different insect and mite pests attack mango, which results in some significant economic losses. Those pests include the spider mite, *Oligonychus mangiferus* (Rhaman & Sapra); the mango bud mite, *Aceria mangiferae* Sayed, the leaf coating mite, *Aceria aegyptindicae* Elhalawany, Amrine & Ueckermann; the leaf coating mite, *Cisaberoptus kenyae* Keifer; the rust mite, *Metaculus mangiferae* (Attiah); *Spinacus pagonis* Keifer (syn.: *Vasates aegyptiacus* Abou-Awad) and *Vareeboona mangiferae* (Keifer), and the bud mite, *Neocalacarus mangiferae* ChannaBasavanna (Marei *et al.* 2020; Elhalawany *et al.* 2021; Abo-Shnaf *el al.* 2022).

The red spider mite, *O. mangiferus* is principally a pest of mango in tropical and sub-tropical regions. It is a polyphagous species reported on about 55 host plants in 22 families of economic importance worldwide. Feeding on leaves may cause serious damage to mango, including dryness and early leaf fall and also affects their content of organic, inorganic and minerals compounds (Jeppson *et al*. 1975; Migeon and Dorkeld 2022). *Aceria mangiferae* feeds on buds and encourages bud reproduction. This mite severely damages young and old mango trees, causing stunted branches and a large number of crowded buds (Jeppson *et al.* 1975). It may serve as a carrier for *Fusarium* spp. — the fungus causing mango deformity (Marasas *et al.* 2006). The rust mite, *M. mangiferae* causes russeting of the terminal leaves, buds and inflorescences where inflorescences and buds stop growing and dry out; high attack levels cause arrested terminal buds. A dense mass of deformed blooms arises from the damage to inflorescences (Abou-Awad 1981). *Aceria aegyptindicae* was found in colonies as an inquiline, under waxy coatings on both leaf surfaces, usually along the midribs, in association with *C. kenyae* (Elhalawany *et al.* 2021).

In Egypt, the predatory mites most frequently associated with plant-feeding mites on mango orchards are the phytoseiid mites: *Amblyseius swirskii* Athias-Henriot and *Euseius scutalis* (Athias-Henriot), the cheyletid mite: *Cheletogenes ornatus* (Canestrini and Fanzago) and stigmaeid mite: *Agistemus exsertus* Gonzalez (Abou-Awad 1981; Marei *et al.* 2020; Abo-Shnaf *el al.* 2022). Therefore, the objective of this study is to estimate the population density of plant-feeding mites inhabiting “Heidi” and “Naomi” mango cultivars for the first time at Qalyubia governorate, Egypt in relation to plant phenology.

MATERIALS AND METHODS

Occurrence of mites inhabiting mango orchards

The present study was conducted at Nawa village (30° 14' 57.94" N, 31° 17' 07.89" E), Qalyubia governorate, Egypt from mid-August 2020 until early September 2022. Mites were collected from different parts of two cultivars of mango orchards (“Heidi” and “Naomi”) including leaves, stems, buds and flowers. Twenty trees (10 years old) planted with spacing of 6 m × 6 m were selected to survey the occurrence of mites for each mango cultivar. Samples of four leaves and one bud were randomly collected from 10 mango trees (40 leaves and 10 terminal flowering buds). All mites were counted by direct examination under a stereo-microscope (BS-3030B, China). Adult stages were cleared in Nesbitt's fluid for about one hour, then mounted on slides in Hoyer's medium and dried in an oven at 60 °C for one day or for a longer period according to sclerotized specimens for identification. Eriophyid mites were cleared in Keifer's solution at room temperature and mounted on glass-microscopic slides in Keifer's F-medium (Amrine and Manson 1996). The mite specimens were examined under a phase contrast microscope (Carl Zeiss Nr, Germany). Identification of mites was conducted according to the world reference keys (Zaher 1984, 1986; Amrine *et al.* 2003; Abo-Shnaf and Moraes 2014).

Population fluctuation of mites

Forty leaves and 10 terminal flowering buds of 10 long (10–15 cm) twigs from 10 trees were randomly collected from each mango cultivars “Heidi” and “Naomi”. All phytophagous and predacious mites on upper and lower surfaces of each leaf were counted. Daily maximum and

minimum temperatures and mean relative humidity were obtained from the online database (http://www.wunderground.com) throughout the investigation period to determine the peaks of most common phytophagous and predacious mites in relation to weather factors and plant phenology.

Statistical analysis

For clarifying the effect of weather factors and plant phenology, simple correlations and partial regression were used to obtain the amount of variability in the pest activity which could be assigned to the percentages of explained variance (EV%) as the concerted influence of the weather factors. Examining the population fluctuation of mites on perennials requires taking into account the many physiologic growth phases of plants throughout the season (Abou-Setta 2020; Desoky *et al.* 2021). Plant age was taken into account using multiple polynomial regressions, while the impact of weather factors (i.e., minimum and maximum temperatures and RH%) was assessed using simple correlations and partial regressions. The model was presented as:

$$Y = a \pm b1Temp\_max \pm b2\ Temp\_min \pm b3\ RH \pm b4\ Age \pm b5\ Age2 \pm b6\ Age^3$$

for the third degree of the polynomial (where a = constant and b_1, b_2 and b^3 are the slopes of the first, second, and third parts of the response curve). B4, b5 and b6 are the slopes of age of the plant in weeks raised to the second and third degrees of squared Abou-Setta (2020). In addition, correlation analysis was established to determine the relationship between phytophagous and predacious mite population. The collected data were analyzed using Procs Corr. and Reg. in SAS (Anonymous 2003).

RESULTS

Occurrence of mites inhabiting mango orchards at Qalyubia governorate

Occurrence of the most abundant mite species inhabiting mango orchards was surveyed in Qalyubia governorate from August 2020 to September 2022. The data revealed the occurrence of 19 mite species, eight species of which are plant feeders, seven are predaceous and four are of uncertain feeding behavior (Table 1). The potential predators in the current study are *Amblyseius swirskii*, *Typhlodromus egypticus* El-Badry and *Euseius scutalis* (Phytoseiidae) found on the leaves and buds of "Naomi" cultivar associated with *Oligonychus mangiferus* and *Aceria mangiferae*; and on "Heidi" cultivar associated with *Aceria aegyptindicae* and *Cisaberoptus kenyae*. Also, the cosmopolitan predatory mites, *Cheletogens ornatus* (Cheyletidae) and *Agistemus exsertus* (Stigmaeidae) were observed at moderate numbers on buds of "Heidi" cultivar actively feeding on *A. aegyptindicae* and *C. kenyae*.

Population fluctuation of mites

Population fluctuation of the mango bud mite, *Aceria mangiferae*, mango rust mite *Metaculus mangiferae* and mango red mite, *Oligonychus mangiferus* as important pests on "Naomi" mango cultivar at Qalyubia governorate were studied during 2020–2022 seasons (Fig. 1).

Aceria mangiferae

On "Naomi" cultivar, *A. mangiferae* has two peaks in mid and late November and in late May and early June on terminal flowering buds during the two successive seasons (Fig. 1). *Aceria mangiferae* was recorded in mid-August with moderate numbers, and then increased until late October. The population reaches its highest in mid or late November with a total number of respectively 28.80 and 28.00 individuals/ bud at maximum and minimum temperatures of 31.6 and

25.1 & 21.5 and 17.6 °C, and 60.3 and 67.2 RH% in the first and second seasons. The second peak was recorded in late May (24.90 individuals/ bud) and at early of June (27.30 individuals/ bud) in the second season. The populations decrease from early December to mid-March during the two seasons (Fig. 1). The "Heidi" cultivar is resistant to infestation with this mite pest.

Table 1. Mites inhabiting mango orchards at Qalyubia governorate.

Families	Mite taxa	Habitat	Abundance
Eriophyidae	*Aceria mangiferae* Sayed	Buds	+++
	Aceria aegyptindicae Elhalawany, Amrine & Ueckermann	Leaves	+++
	Cisaberoptus kenyae Keifer	Leaves	+++
	Metaculus mangiferae (Attiah)	Buds, Leaves	+++
	Neocalacarus mangiferae ChannaBasavanna	Buds	++
	Vareeboona mangiferae (Keifer)	Leaves	++
Tetranychidae	*Oligonychus mangiferus* (Rahman & Sapra)	Leaves	+++
Tenuipalpidae	*Brevipalpus phoenicis* (Geijskes)	Buds	++
Ameroseiidae	*Kleemannia wahabi* Ibrahim & Abdel-Samed	Leaves	+
Camerobiidae	*Neophyllobius gonzali* Zaher & Gomaa	Leaves	+
Cheyletidae	*Cheletogens ornatus* (Canestrini & Fanzago)	Leaves	++
	Amblyseius swirskii Athias-Henriot	Buds, Leaves	+++
Phytoseiidae	*Typhlodromus egypticus* El-Badry	Leaves	+++
	Euseius scutalis (Athias-Henriot)	Buds, Leaves	+++
Stigmaeidae	*Agistemus exsertus* Gonzalez	Buds, Leaves	++
Acaridae	*Tyrophagus putrescentiae* (Schrank)	Leaves	++
Tarsonemidae	*Tarsonemus smithi* Ewing	Leaves, buds	+
Tydeidae	*Pronematus ubiquitous* (McGregor)	Leaves	+
Oribatidae	*Siculobata sicula* Grandjean	Leaves	+

+: Low population (1–4 individuals/10 leaves or buds)
++: Moderate population (5–10 individuals/10 leaves or buds)
+++: High population (>10 individuals/10 leaves or buds)

Population fluctuations of *A. mangiferae* on "Naomi" cultivar during the two seasons were not affected significantly by weather factors, except for the period from February to August which has a significant negative correlation with relative humidity (−0.74 to −0.82). The plant age explained variance (EV) is 70.36 to 96.34%; while in combination with weather factors, revealed EV ranged 76.29 to 98.66% over the two seasons, respectively (Table 2).

Metaculus mangiferae

Population of *M. mangiferae* was recorded with moderate numbers on leaves during mid-August, then increased until the end of September during the two seasons on “Naomi” cultivar. The leaves were curled and rolled over themselves at high infestation levels. *Metaculus mangiferae* has two peaks during mid-October and late May with a total mean of 5.70 and 6.15 individuals/leaf at maximum and minimum temperatures of 34.7 & 24.4 and 33.2 & 19.4°C, and 58.6 & 47.9 RH% during the first season, respectively. During the second season, it has two peaks in late November and late May with mean numbers of 6.30 and 6.08individuals/leaf (Fig. 1).

Metaculus mangiferae was recorded with few numbers on leaves of “Heidi” cultivar than “Naomi” one during the two seasons (Fig. 2). It has two peaks during mid-October and late May with total numbers of 3.60 and 3.50 individuals/leaf in the first season. In the second season, it has two peaks in late November and early June with total numbers of 4.03 and 3.08 individuals/leaf on “Heidi” cultivar.

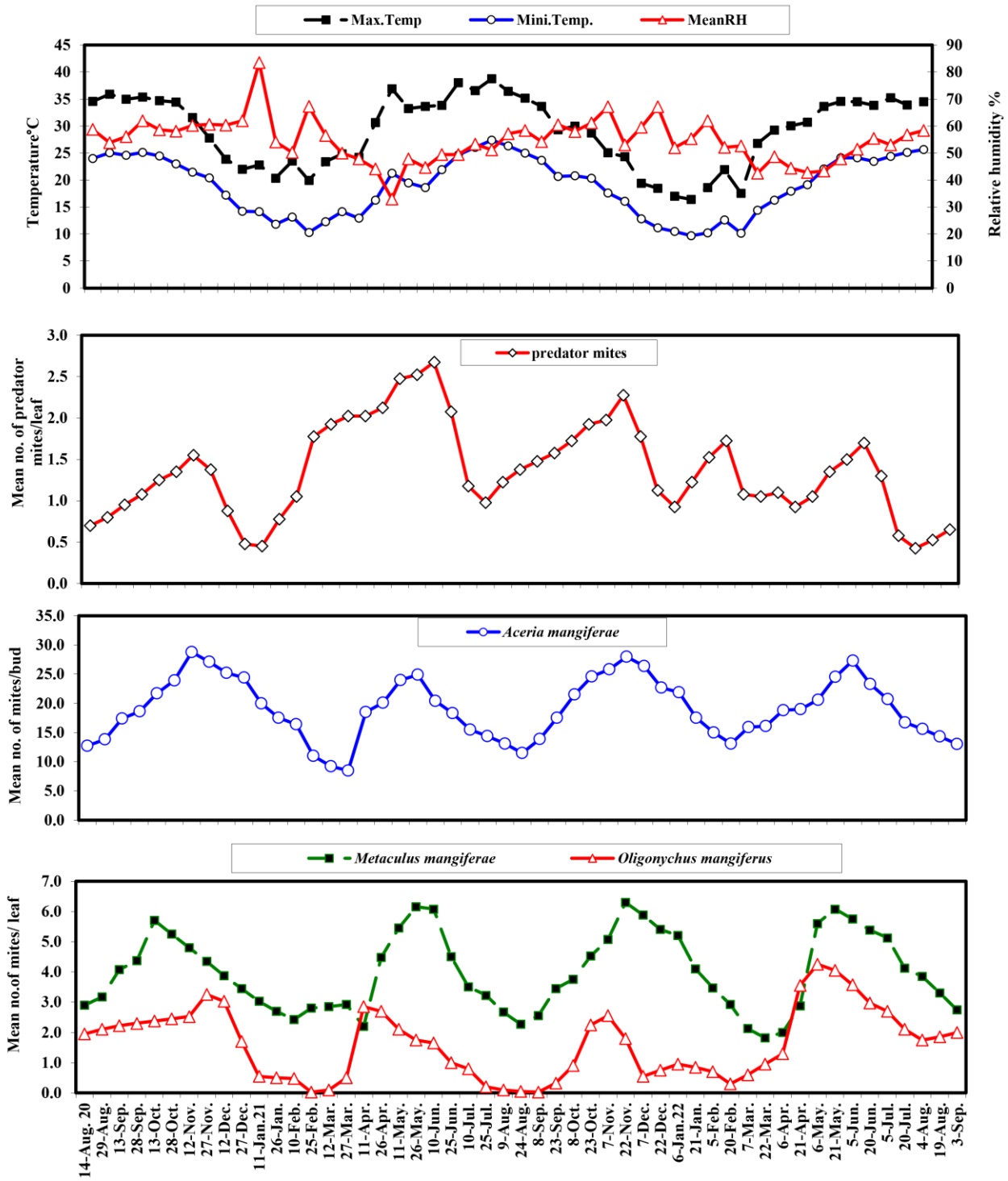

Figure 1. Population fluctuation of plant-feeding and predacious mites on "Naomi" mango cultivar at Qalyubia governorate during 2020–2022 seasons.

Statistical data analysis obtained from Table 3 showed that population of *M. mangiferae* was insignificantly affected by temperature and relative humidity on "Naomi" cultivar in the two seasons. However, plant age had significant effect reveled EV which ranged 64.00 to 91.70%, while

the combination between plant age and weather factors, the revealed EV was 81.68 to 96.09% over the two seasons, respectively.

Table 2. Simple correlation and multiple regression analysis of the effect of weather factors and plant age on *Aceria mangiferae* populations on "Naomi" mango cultivar during 2020–2022 seasons.

Season	Factor	Level	Simple		Multiple regression				
			R	P	b	P	F	P	EV (%)
Aug. 2020 to Feb. 2021	Weather	Temp. max.	−0.22	0.4645	−20.02	0.1331			
		Temp. min.	−0.12	0.6821	22.39	0.1552	1.16	0.3762	27.95
		RH	0.23	0.4343	0.62	0.7451			
	Plant age	Age-Age^3	-	-	-	-	28.59	0.0001	90.50
	Combined		-	-	-	-	22.72	0.0007	95.78
Feb. to Aug. 2021	Weather	Temp. max.	0.38	0.1901	18.9	0.0902			
		Temp. min.	0.14	0.6323	−18.6	0.0924	6.13	0.1148	67.133
		RH	−0.74	0.0043	−0.93	0.7177			
	Plant age	Age-Age^3	-	-	-	-	7.12	0.0095	70.36
	Combined		-	-	-	-	3.22	0.0904	76.29
Aug. 2021 to Feb. 2022	Weather	Temp. max.	0.12	0.7010	−44.3	0.0636			
		Temp. min.	0.18	0.5756	54.5	0.0577	2.17	0.1701	44.81
		RH	0.30	0.3454	2.90	0.3159			
	Plant age	Age-Age^3	-	-	-	-	70.27	0.0001	96.34
	Combined		-	-	-	-	61.27	0.0002	98.66
Feb. to Aug. 2022	Weather	Temp. max.	0.18	0.5520	−7.78	0.2372			
		Temp. min.	0.01	0.9635	11.24	0.1349	12.64	0.0014	80.82
		RH	−0.82	0.0006	−9.36	0.0011			
	Plant age	Age-Age^3	-	-	-	-	10.18	0.0030	77.25
	Combined		-	-	-	-	15.83	0.0019	94.06

Table 3. Simple correlation and multiple regression analysis of the effect of weather factors and plant age on *Metaculus mangiferae* populations on "Naomi" mango cultivar during 2020–2022 seasons.

Season	Factor	Level	Simple		Multiple regression				
			R	P	b	P	F	P	EV (%)
Aug. 2020 to Feb. 2021	Weather	Temp. max.	0.54	0.0551	−5.83	0.5352			
		Temp. min.	0.59	0.0321	11.71	0.2965	1.98	0.18	39.74
		RH	0.015	0.9634	0.44	0.7547			
	Plant age	Age-Age^3	-	-	-	-	27.19	0.0001	90.06
	Combined		-	-	-	-	12.35	0.0037	92.51
Feb. to Aug. 2021	Weather	Temp. max.	0.38	0.2749	32.4	0.0060			
		Temp. min.	0.07	0.8166	−32.3	0.0059	8.85	0.0048	74.68
		RH	−0.61	0.0238	2.48	0.3058			
	Plant age	Age-Age^3	-	-	-	-	5.33	0.0219	64.00
	Combined		-	-	-	-	4.46	0.0458	81.68
Aug. 2021 to Feb. 2022	Weather	Temp. max.	−0.21	0.5023	−43.2	0.3692			
		Temp. min.	−0.15	0.6351	50.1	0.0568	2.34	0.1496	46.74
		RH	0.31	0.3124	2.69	0.3105			
	Plant age	Age-Age^3	-	-	-	-	29.44	0.0001	91.70
	Combined		-	-	-	-	20.47	0.0023	96.09
Feb. to Aug. 2022	Weather	Temp. max.	0.59	0.0325	−10.4	0.3692			
		Temp. min.	0.49	0.0858	20.06	0.1360	7.32	0.0087	70.94
		RH	−0.44	0.1229	−10.70	0.0143			
	Plant age	Age-Age^3	-	-	-	-	9.46	0.0038	75.93
	Combined		-	-	-	-	5.72	0.0260	85.12

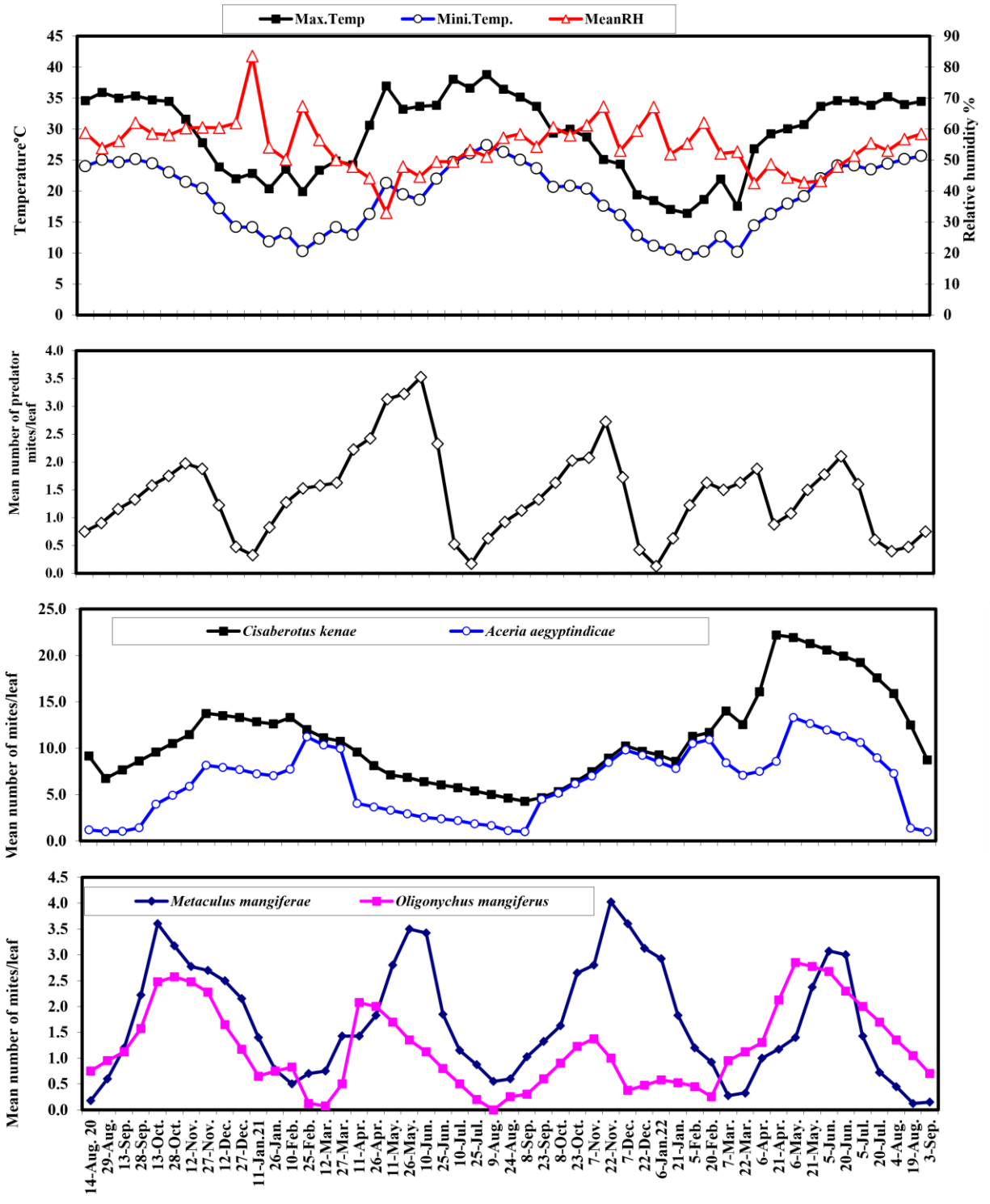

Figure 2. Population fluctuation of plant-feeding and predacious mites on "Heidi" mango cultivar at Qalyubia governorate during 2020–2022 seasons.

Oligonychus mangiferus

Oligonychus mangiferus was recorded with high numbers on upper leave surface of "Naomi" cultivar during the two seasons. The data showed that there are two peaks during late November and mid-April which recorded 3.25 and 2.85 individuals/leaf in the first season; while in the second season, it reached the peak in early November and May recording 2.55 and 4.25 individuals/leaf

respectively (Fig. 1). *Oligonychus mangiferus* appeared in few numbers on leaves in August and increased to November, then decreased from December to April during the two seasons on "Heidi" cultivar. *Oligonychus mangiferus* was recorded with few numbers on leaves. It has two peaks in late October and mid-April with total numbers of 2.58 and 2.08 individuals/leaf in the first season. While in the second season, it has two peaks in early November and early May with total numbers of 1.38 and 2.85 individuals/leaf (Fig. 2).

Results showed that the population fluctuations of *O. mangiferus* on "Naomi" cultivar during 2020–2022 seasons were not affected significantly by weather factors, the explained variance (EV%) ranged from 34.81 to 84.53%. The single effect of applying the third-degree polynomial model using plant age revealed explained variance was ranged from 63.67 to 80.07% with P-value ranged from 0.0361 to 0.0017. The combined effect of weather factors and plant age was more significant than plant age alone as it ranged from 75.03 to 98.07% (Table 4).

Table 4. Simple correlation and multiple regression analysis of the effect of weather factors and plant age on *Oligonychus mangiferus* populations on "Naomi" mango cultivar during 2020–2022 seasons.

Season	Factor	Level	Simple		Multiple regression				
			R	P	b	P	F	P	EV (%)
Aug. 2020 to Feb. 2021	Weather	Temp. max.	0.52	0.0634	−19.79	0.0009			
		Temp. min.	0.66	0.0132	27.75	0.0003	16.39	0.0005	84.53
		RH	−0.13	0.6590	−0.82	0.2316			
	Plant age	Age-Age^3	-	-	-	-	9.59	0.0037	76.17
	Combined		-	-	-	-	50.84	0.0001	98.07
Feb. to Aug. 2021	Weather	Temp. max.	−0.01	0.9615	3.35	0.6625			
		Temp. min.	−0.24	0.4161	−6.29	0.4158	6.64	0.0117	68.88
		RH	−0.71	0.0061	−3.46	0.0974			
	Plant age	Age-Age^3	-	-	-	-	10.83	0.0024	78.30
	Combined		-	-	-	-	4.91	0.0370	83.07
Aug. 2021 to Feb. 2022	Weather	Temp. max.	0.10	0.7406	−21.9	0.1504			
		Temp. min.	0.15	0.6324	27.0	0.1393	1.42	0.3057	34.81
		RH	0.33	0.2857	2.04	0.2942			
	Plant age	Age-Age^3	-	-	-	-	4.67	0.0361	63.67
	Combined		-	-	-	-	2.50	0.1664	75.03
Feb. to Aug. 2022	Weather	Temp. max.	0.46	0.137	7.51	0.4309			
		Temp. min.	0.28	0.3492	−3.36	0.7692	4.37	0.0370	59.29
		RH	−0.55	0.0474	2.04	0.1788			
	Plant age	Age-Age^3	-	-	-	-	12.05	0.0017	80.07
	Combined		-	-	-	-	5.57	0.0277	84.79

Aceria aegyptindicae

Aceria aegyptindicae had two annual peaks on "Heidi" cultivar during late November (8.15 individuals/leaf) and late February (11.23 individuals/leaf) in the first season 2020–2021. Whereas, in the second season the highest population was in early December (9.80 individuals/leaf) and early May (13.33 individuals/leaf) (Fig. 2).

Statistical data analysis showed that population of *A. aegyptindicae* had a significant negative correlation with Max. and Min. temperatures, respectively (−0.86 & −0.88 and −0.81 & −0.93) whereas, RH% had an insignificant positive correlation with the same mites species (r = 0.22 and 0.46) respectively in the first season. Max. and Min. temperatures had a significant negative effect on the population in the first half of the second season as single factor (−0.85), while it was an insignificant negative correlation in the second half (−0.03 & −0.21), the explained variance of weather factor ranged from 56.89 to 78.44%. The plant age as third polynomial degree had a significant effect than weather factor with an EV range between (87.38 – 93.90%); while the

combination of plant age and weather factors revealed EV between (88.83–99.03%) over the two seasons, respectively (Table 5).

Table 5. Simple correlation and multiple regression analysis of the effect of weather factors and plant age on *Aceria aegyptindicae* populations on "Heidi" mango cultivar during 2020–2022 seasons.

Season	Factor	Level	Simple		Multiple regression				
			R	P	b	P	F	P	EV (%)
Aug. 2020 to Feb. 2021	Weather	Temp. max.	−0.86	0.0002	−27.7	0.1254			
		Temp. min.	−0.81	0.0006	13.5	−0.5027	9.22	0.0042	75.45
		RH	0.22	0.4651	−0.02	00.9936			
	Plant age	Age-Age^3	-	-	-	-	46.16	0.0001	93.90
	Combined		-	-	-	-	101.7	0.0001	99.03
Feb. to Aug. 2021	Weather	Temp. max.	−0.88	0.0007	−13.12	0.5559			
		Temp. min.	−0.83	0.0004	−6.05	0.7823	10.91	0.0024	78.44
		RH	0.46	0.1078	2.53	0.6500			
	Plant age	Age-Age^3	-	-	-	-	36.01	0.0001	92.31
	Combined		-	-	-	-	1.14	0.0026	93.39
Aug. 2021 to Feb. 2022	Weather	Temp. max.	−0.85	0.0004	−4.88	0.8817			
		Temp. min.	−0.85	0.0004	−11.69	0.7661	7.39	0.0108	73.50
		RH	0.09	0.7629	1.27	0.7687			
	Plant age	Age-Age^3	-	-	-	-	34.03	0.0001	92.73
	Combined		-	-	-	-	11.80	0.080	93.40
Feb. to Aug. 2022	Weather	Temp. max.	−0.03	0.9111	0.61	0.988			
		Temp. min.	−0.21	04891	0.92	0.9807	3.96	0.0471	56.89
		RH	−0.75	0.0030	−21.8	0.0712			
	Plant age	Age-Age^3	-	-	-	-	20.76	0.0002	87.38
	Combined		-	-	-	-	7.96	0.0117	88.83

Cisaberoptus kenyae

Cisaberoptus kenyae has two peaks in late November and early December and in mid-February and 3rd of April on "Heidi" cultivar (Fig. 2). *Cisaberoptus kenyae* was recorded in mid-August 2020 in high numbers. The populations increased in late-August to late November, then it fluctuated and reached the second peak in mid-February with 13.33 individuals/leaf in the first season. While in the second season, the first peak was recorded in early December with 10.25 individuals/leaf, then the population fluctuated and reached the second peak during the third week of April with 22.20 individuals/leaf.

Statistical data analysis showed that population of *C. kenyae* had significantly negative correlation with Max. and Min. temperatures, but in the second half of the second season it was insignificant. Relative humidity had insignificantly positive correlation with the mite. In combination with weather factors, a significant indicated EV ranged from 67.18 to 93.85% during two seasons. Plant age reveled EV which ranged from 89.07 to 98.57%, while in combination with weather factors, the revealed EV ranged from 92.14 and 99.37% over the two seasons (Table 6).

Population fluctuation of predatory mites

The predatory mites *Amblyseius swirskii*, *Typhlodromus egypticus*, *Euseius scutalis* and *Agistemus exsertus* are the most dominant on leaves and buds of "Naomi" and "Heidi" mango cultivars. The populations of predatory mites have two peaks in mid-November and 2nd week of June (1.55 and 2.68 individuals/leaf) in the first season on "Naomi" cultivar (Figs.1, 2). While in the second season, it has two peaks in late November and 3rd of June (2.28 and 1.70 individuals/leaf), respectively (Fig. 1).

Populations of predatory mites, *A. swirskii*, *T. egypticus*, *E. scutalis* and *A. exsertus* have two

peaks in mid-November and 2nd week of June (1.98 and 3.53 individuals) in the first season on "Heidi" cultivar. While, it has three peaks in the second season in late November, early April and late June (2.73, 1.88 and 2.10 ind./leaf), respectively (Fig. 2).

Statistical analysis indicated that a positive correlation was noted between the incidence of the plant-feeding mites (Tetranychidae and Eriophyidae) and associated predators on the same buds and leaves of "Naomi" mango cultivar. While the relationship between the phytoseiid mite populations and the eriophyid mites, *C. kenyae* and *A. aegyptindicae* was insignificantly negative on "Heidi" cultivar during the two seasons (Table 7).

Table 6. Simple correlation and multiple regression analysis of the effect of weather factors and plant age on *Cisaberoptus kenyae* populations on "Heidi" mango cultivar during 2020–2022 seasons.

Season	Factor	Level	Simple		Multiple regression				
			R	P	b	P	F	P	EV (%)
Aug. 2020 to Feb. 2021	Weather	Temp. max.	−0.87	0.0001	−25.4	0.0789			
		Temp. min.	−0.82	0.0005	14.0	0.3807	10.88	0.0024	78.38
		RH	0.25	0.4089	0.24	0.9074			
	Plant age	Age-Age^3	-	-	-	-	28.18	0.0001	90.38
	Combined		-	-	-	-	2.32	0.0004	96.58
Feb. to Aug. 2021	Weather	Temp. max.	−0.95	0.0001	−12.1	0.1630			
		Temp. min.	−0.95	0.0001	−4.0	0.6207	45.76	0.0001	93.85
		RH	0.32	0.2770	−1.0	0.6052			
	Plant age	Age-Age^3	-	-	-	-	207.2	0.0001	98.57
	Combined		-	-	-	-	157.7	0.0001	99.37
Aug. 2021 to Feb. 2022	Weather	Temp. max.	−0.88	0.0001	5.69	0.8198			
		Temp. min.	−0.89	0.0001	−22.9	0.9511	10.87	0.0034	80.30
		RH	0.10	0.7418	1.33	0.6861			
	Plant age	Age-Age^3	-	-	-	-	22.91	0.0003	89.57
	Combined		-	-	-	-	9.77	0.0121	92.14
Feb. to Aug. 2022	Weather	Temp. max.	0.20	0.5050	52.6	0.1352			
		Temp. min.	−0.02	0.9249	−49.6	0.1984	6.14	0.0147	67.18
		RH	−0.72	0.0055	−12.2	0.2673			
	Plant age	Age-Age^3	-	-	-	-	24.44	0.0001	89.07
	Combined		-	-	-	-	25.89	0.0005	96.28

Table 7. Correlation analysis of weather factors and phytophgous mite effects on population of predatory mites on "Naomi" and "Heidi" mango during 2020–2022 seasons.

Biotic and abiotic factors	Correlation coefficient	
	Season 2020–2021	Season 2021–2022
Naomi cultivar		
Aceria mangiferae	0.05	0.59
Metaculus mangiferae	0.47	0.38
Oligonychus mangiferus	0.06	0.09
Maximum temperature (°C)	0.12	−0.16
Minimum temperature (°C)	−0.15	−0.11
Mean relative humidity (%)	−0.64	0.23
Heidi cultivar		
Aceria aegyptindicae	−0.02	0.23
Cisaberoptus kenyae	−0.13	−0.01
Metaculus mangiferae	0.64	0.41
Oligonychus mangiferus	0.45	0.19
Maximum temperature (°C)	0.08	0.04
Minimum temperature (°C)	−0.15	0.02
Mean relative humidity (%)	−0.56	−0.07

DISCUSSION

Fourteen eriophyoid mite species have been described from mango orchards worldwide. Seven of which have been recorded in Egypt (Elhalawany *et al.* 2021). Mite taxa collected in the current study are in parallel with Abdallah (2008) and Abo-Shnaf *el al.* (2022) who collected the same mite families inhabiting mango orchards at different localities in Egypt (Giza, Fayoum and Ismailia governorates). Mahmoud *et al.* (2020) recorded the occurrence of 49 mite species belonging to 25 genera and 11 families on mango orchards at Assuit and Sohag governorates. Marei *et al.* (2020) reported about 67 mite species in 52 genera and 30 families on mango orchards at Assuit governorate, Egypt.

The “Naomi” mango cultivar is infested with *A. mangiferae*, while "Heidi" cultivar is resistant to infestation. The population fluctuations of *A. mangiferae* recorded in the current result agrees with Mahgoob (2006) who reported that “Zebda, “Taimour”, “Ewais”, and “Arnaba” cultivars are the most susceptible to *A. mangiferae* infestation; “Mabrouka, “Company”, “Excellent Succari”, and “White Succari” are resistant; while, “Alphonse”, “Mesk”, and “Geolck” are the least susceptible to mite infestation.

There are conflicting reports on the peak times of population density of some mites in Egypt including *A. mangiferae* due to wide range variability of cultivars. According to environmental factors, the mite formed two seasonally population peaks in February and September on “Timour” cultivar (Zaher and Osman 1970). Abou-Awad (1981) recorded population peaks in late May and October. Mahgoob (2006) indicated that the maximum mite population occurred from September-January and February, and the lowest during March-June. Abdallah (2008) recorded two annual peaks in May and November on different mango cultivars at Giza governorate, and in April and November at Fayoum governorate. On "Alphonso" it has three peaks (in May, August, and November) (Abou-Awad *et al.* 2011).

Abdallah (2008) reported that *M. mangiferae* has two annual peaks in May and November on different mango cultivars at Giza governorate, Egypt which is in agreement with our results. Abou-Awad *et al.* (2011) found three seasonal peaks of this mite pest on “Alphonso” cultivar (in early January-February, mid-June, and mid-October).

There are differing reports on the population peak periods of *O. mangiferus* in Egypt according to cultivar and locality. Our results agree with Abdallah (2008) who reported two peaks for this mite pest in April and November on different mango cultivars at Fayoum governorate. Mahmoud *et al.* (2020) reported two annual peaks in March and July on “Balady” cultivar, and in April and July at Sohag governorate, while it was in March and August on “Hindi” cultivar at Assiut governorate. Marei *et al.* (2020) found the population peak of this mite pest during October on “Taimoor” cultivar and in November on “Zebda” cultivar in Egypt.

Aceria aegyptindicae has two annual peaks on “Heidi” cultivar in late both of (November and February) in the first season and in early both of (December and May) in the second season. Ehlalawany *et al.* (2021) reported three annul peaks on “Alphonso” cultivar (in early both of January and May) and mid-November. Elhalawany *et al.* (2021) observed that Max. and Min. temperatures had an insignificant negative correlation with *A. aegyptindicae*, while RH% had an insignificant positive correlation, which resembles what reported in the current study.

Several works have reported the peaks time of population density of *C. kenyae* on mango orchards in Egypt which are different related to cultivars and weather factors. Abdallah (2008) indicated one annual peak in November on “Ewais”, “Alphonso”, “Mabrouka” and “Zebd” cultivars at Fayoum governorate. Mahmoud *et al.* (2020) reported three annual peaks in April, August and December on “Balady” cultivar at Assiut and Sohag governorates; and in April, July and January on “Hindi” cultivar. According to Elhalawany *et al.* (2021) *C. kenyae* had three seasonal peaks in January, May and November on “Alphonso” cultivar at Qalyubia governorate.

The effect of phytoseiids population on *C. kenyae* and *A. aegyptindicae* is insignificantly negative through the two seasons. These results are in accordance with those reported by Abdallah (2008); Abou-Awad *et al.* (2011); Mahmoud *et al.* (2020) and Elhalawany *et al.* (2020, 2021) who indicated similar results.

CONCLUSION

The results showed that the infestation of "Naomi" mango cultivar is highly susceptible to infestation with *A. mangiferae*, *M. mangiferae* and *O. mangiferus*. These mite pests were recorded in high numbers in spring and autumn on "Naomi" cultivar during the two seasons of 2020–2022. The two mango leaf coating mites, *A. aegyptindicae* and *C. kenyae* have two peaks in autumn and winter on "Heidi" cultivar. The phytophagous mite population was significantly affected by combination of weather factors and plant age than the weather factors alone. The change in the nutritional value of the host plant has highly effect on population of mites than the environmental factors.

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نوسانات جمعیت برخی کنه‌های مهم اقتصادی روی دو رقم انبه در استان قالیوبیه مصر

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چکیده

نوسانات جمعیت فراوان‌ترین گونه کنهٔ انبه، *Mangifera indica* L. (Anacardiaceae)، به عنوان یکی از درختان میوه مهم در استان قالیوبیه، مصر از آگوست ۲۰۲۰ تا سپتامبر ۲۰۲۲ مورد مطالعه قرار گرفت. ۱۹ گونه از ۱۸ جنس در ۱۰ خانواده شناسایی شدند. کنهٔ جوانه انبه، *Aceria mangiferae* Sayed، کنهٔ زنگار انبه، *Metaculus mangiferae* (Attiah) و کنهٔ تارتن، *Oligonychus mangiferus* (Rahman & Sapra) به آفات مهم رقم انبه «نائومی» تبدیل شده‌اند. در حالی که کنه پوششی برگ انبه، *Aceria aegyptindicae* Elhalawany, Amrine & Ueckermann و *Cisaberoptus kenyae* Keifer از آفات مهم رقم «هایدی» هستند. کنهٔ *Aceria mangiferae* دارای دو اوج ظهور (در اواسط و اواخر نوامبر و اواخر می و اوایل ژوئن) در جوانه‌های رقم «نائومی» در دو فصل پیاپی بود. کنهٔ *Metaculus mangiferae* دارای دو اوج ظهور روی برگ‌ها (اواسط اکتبر و اواخر می) در فصل نخست و (اواخر نوامبر و می در فصل دوم) بود. کنهٔ *Oligonychus mangiferus* در دو فصل بهار و پاییز روی رقم «نائومی» به تعداد زیاد ثبت شد. گونه‌های *Aceria aegyptindicae* و *C. kenyae* دو اوج ظهور (اواخر نوامبر و اواسط فوریه) در فصل نخست و (اوایل دسامبر و اواخر آوریل) در فصل دوم در رقم «هایدی» داشتند. کنه‌های شکارگر طعمه‌های گیاهخوار خود را با تاخیر زمانی دنبال می‌کنند. جمعیت کنه‌های گیاهخوار به طور معنی‌داری تحت تأثیر عوامل ترکیبی آب و هوا و سن گیاه نسبت به عوامل آب و هوایی به تنهایی قرار گرفت. نتایج نشان داد که رقم «هایدی» به آلودگی با *A. mangiferae* مقاوم است و به *A. aegyptindicae* و *C. kenyae* حساس است. با این حال، رقم «نائومی» در برابر آفت نخست حساس است و به دو آفت آخر مقاوم است. تغییرات ارزش غذایی گیاه میزبان بیشتر از عوامل آب و هوایی بر نوسانات جمعیت کنه موثر است.

واژگان کلیدی: بروز، فنولوژی، کنه‌های گیاهخوار، کنه‌های شکارگر، عوامل آب و هوایی.

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