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Scale insects infesting date palm with emphasis on *Avidovaspis phoenicis* (Hemiptera: Diaspididae) as a new economic pest in Egypt

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ABSTRACT

The present study was carried out throughout two successive years (2019-2021) to conduct a survey of scale insects infesting date palm all over Egypt and an investigation on the major date palm scale insects. The results indicated that the date palm trees were infested by 5 species of scale insects. The seasonal activity of *Avidovaspis phoenicis* Gerson and Davidson (Hemiptera: Diaspididae) on date palm was studied during 2019-2020 in Giza and Qalyubiya Governorates. The obtained results showed that both nymphal and adult stages have two periods of seasonal activity per year. The 1st period of nymphal activity occurred in autumn season that peaked in early December in both years. The 2nd period of nymphal activity occurred in summer season that peaked in early July in the 1st year and early June during the 2nd one. The 1st period of adult activity was recorded during autumn-winter seasons with one peak in early February in the 1st and 2nd year. The 2nd period of activity was determined during summer season that peaked in early July in the 1st year and early June in the 2nd one. On the other hand, the duration of seasonal activity for both nymphal and adult stages was affected significantly with the tested weather factors. Eight insecticide compounds were evaluated for their controlling activity on the scale insect as well as its parasitoid *A. mytilaspidis* on date palm in Giza and Qalyubiya during two successive seasons 2019 and 2020. The obtained results revealed that Imidacloprid (Ecomida) has the highest reduction % values for the scale and its parasitoid during the two experimental years. On the other hand deltamethrin (Decis) shows less reduction percentages compared to the scale and its parasitoid during the two successive (2019-2020) years in the two locations.

KEYWORDS: scale insects, date palm, Diaspididae, *Avidovaspis phoenicis*, control measure.

1. INTRODUCTION

The date palm *Phoenix dactylifera* L. (Arecales: Arecaceae) is an important food and cash crop thriving well in hot, arid regions of the world [1]. Date palm has played a significant role in the economy of some date-producing countries. Date palm is one of the most important crops in Egyptian agriculture, and it represents a significant part in the reclamation program. One hundred and thirty two species of insect and mite pests are associated with date palm grown worldwide [2, 3]. Many species of scale insects have been recorded and have infested date palm worldwide [4]. Date palms located in different parts of Egypt are attacked by many species of scale insects, e.g. *Fiorinia phoenicis* Balachowsky (Hemiptera: Diaspididae) [5], *Phoenicococcus marlatti* Cockerell (Hemiptera:Phoenicococcidae) [6-8], *Avidovaspis phoenicis* Gerson and Davidson [9] and *Palmapsis phoenicis* Ramachandra Rao [10].

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Nymphs and adults suck the sap from the leaflet, midribs and the dates. A discolored area appears on the leaflet under each scale insect. Heavy infestation causes the leaflets to turn yellow and contributes to the premature death of the fronds. Respiration and photosynthesis almost stop resulting in early death of the infested leaf. Damage to fruits is easily noticeable and causes economic impacts across a range of crops by reducing yield, quality, and marketability [11, 12]. *A. phoenicis* was first recorded in Egypt by Gerson and Davidson [9]. Male and female of this species occur in large numbers on both sides of date palm pinnae, where they settle along the veins [13].

The aim of the present work is to conduct the survey of scale insects infesting date palm trees as well as the population dynamics and control measure of the new date palm pest *A. phoenicis* in different locations in Egypt.

2. MATERIALS AND METHODS

2.1. Survey of scale insects infesting date palm trees

A survey of scale insects infesting date palm trees was carried out all over Egypt during 2019-2021. Plants infested with scale insects were examined in the field, using a pocket lens. Leaflets were collected and placed separately in paper bags for further examination in the laboratory. Identification of scale insects was made by examining its adult in Canada Balsam, according to Abd-Rabou [6].

2.2. Incidence of *Avidovaspis phoenicis* and its parasitoid

The population dynamics of *A. phoenicis* and its parasitoid were studied on date palm trees cultivated in Giza and Qalyubiya Governorates throughout a period of 24 months extending from early January, 2019 until December, 2020. The date palm orchard was kept out of any insecticidal sprays during the present investigation and received the normal agricultural practices. Four date palm trees similar in age, height, vigor and growth were randomly selected. Fortnightly samples were taken for two successive years (2019-2020). The samples (20 leaflets) were picked up at random from all directions of palm trees with a rate of five leaflets/tree (Each leaflet was about 30 cm in length). The collected samples were transferred to the laboratory for examination by using a stereomicroscope. In each sample, the alive individuals were counted and sorted into nymphs and adults. The half monthly means of nymphs and adults/10 leaflets were graphically illustrated. The meteorological data, viz., half monthly mean maximum and minimum temperatures and relative humidity (% RH.) were obtained from the meteorological central laboratory. Simple correlation and regression analysis, as well as partial regression, were done by using a computer to study the relationship between the insect population and weather factors.

2.3. Control measure of *Avidovaspis phoenicis* and its parasitoid

2.3.1. Insecticides used

Mineral oil (Tiger), Hydrocarbon composition, **Formulation:** 97% EC, **Application rate** 1 L/100 L.

Lufenuron (Match), IGR, **Formulation:** 5% EC, **Application rate:** 160 ml/Fed.

Malathion (Ictathion), Organophosphate, **Formulation:** 57%, **Application rate:** 150 ml/100 L. **Deltamethrin** (Decis), Pyrethroid, **Formulation:** 2.5% EC, **Application rate:** 500 ml/100L.

Chlorpyrifos (Dursban H), Organophosphate, **Formulation:** 48% EC, **Application rate:** 1 L /Fed.

Imidacloprid (Ecomida), Neonicotinoids, **Formulation:** 30.5% SC, **Application rate:** 60 ml/100 L.

Thiamethoxam (Actara), Neonicotinoids, **Formulation:** 25% WG, **Application rate:** 25 g/100 L.

Buprofezin (Applaud), Buprofezin, **Formulation:** 25% SC, **Application rate:** 600 ml/Fed.

2.3.2. Experimental design

This study was conducted in Giza and Qalyubiya Governorates, Egypt, using date palm infested by *A. phoenicis*. Four experiments were conducted in October 2019 and 2020. In each treatment, 10 trees (Replicates) were sprayed with one of the tested compounds or water (Control). The compounds were applied using a knapsack

sprayer (20 liters). The sample consists of 60 leaflets, which were randomly collected. *A. phoenicis* and its parasitoid were counted just before spraying and 15, 30, and 45 days after spraying. The samples were kept in finely perforated paper bags and transferred to the laboratory for careful examination; populations of the pest and its parasitoid were counted with the aid of a stereomicroscope. Each leaflet was stored in a glass emergence tube and monitored daily for parasitoid emergence.

2.3.3. Statistical analysis

In the four experiments, the percent reduction of infestation was calculated according to the equation of [14]. The data were subjected to analysis of variance (ANOVA) and the means were compared with an LSD test at a 0.05 level, using the SAS program [15].

3. RESULTS AND DISCUSSION

3.1. Survey of scale insects infesting date palm trees in Egypt

As shown in Table 1 the results indicated that the date palm trees were infested by 5 species of scale insects, 2 species belonging to the Family Diaspididae, and one species each belonging to families Asterolecaniidae, Halimococcidae, and Phoenicococcidae.

Key to the economic scale insect species infesting date palm

1. Tubular ducts 8-shaped **3**

- Tubular ducts different, body of slide-mounted adult female pyriform to elongate pyriform, membranous, with two-bar ducts; fringed plates extending as far forward as abdominal segment 2; and submarginal duct tubercles absent from prosoma …… **2**

3. Pygidium with three pairs of unilibulate lobes; 3 plates present between third and fourth lobes on each side, and without any submedian macroducts within the frame formed by the preivulvar pores ..... ***Parlatoria blanchardi*** **(Targioni-Tozzetti)**

- Pygidium different in shapes …… ***Avidovaspis phoenicis*** **Gerson and Davidson**

3. Tubular ducts divided longitudinally; adult female is completely enclosed in a reddish brown hard rigid puparium. The sac is broadly oval, strongly convex above and flattened below. Female body semi-circular or slightly ovate, about 0.8 mm long and 0.7 mm wide. Body segmentation quite obscure and outer margin smooth. Derm membranous, so thin and delicate that it is extremely difficult to extract without rupturing ..... ***Halimococcus thebaicae*** **Hall**

- Tubular ducts divided different **4**

4. Anal ring with pores, 2 anal-ring setae; marginal 8-shaped pores forming continuous single band on head, thorax, and anterior abdomen; quinquelocular pores present near spiracles and in submarginal areas near spiracles, absent from posterior end of body; multilocular pores absent from vulvar area; discoidal pores scattered over dorsum but not forming submarginal row. Other characters: Legs absent; antennae 1-segmented; without a pygidium; 8-shaped pores prevalent ..... ***Palmaspis phoenicis*** **(Ramachandra Rao)**

- Anal ring without pores, Body margin with series of dermal papillae; 8-shaped tubular ducts present;

Table 1. List of scale insects infesting date palm trees in Egypt.

No.	Family	Species
1	Asterolecaniidae	*Palmaspis phoenicis* (Ramachandra Rao)
2 3	Diaspididae	*Avidovaspis phoenicis* Gerson and Davidson *Pariatoria blanchardii* (Targioni-Tozzetti)
4	Halimococcidae	*Halimococcus thebaicae* Hall
5	Phoenicococcidae	*Phoenicococcus marlatti* Cockerell

with setae; legs absent; spiracles with bar and no associated sclerotized area; antennae with 1 segment ..... ***Phoenicococcus marlatti*** **Cockerell**

One hundred and thirty two species of insects and mites have been reported to be associated with date palm [16-23]. About 23 scale insect species infest date palm worldwide [24]. Table 1 records 5 species of scale insects that infested date palm in Egypt. Many authors have recorded scale insects infesting date palm in different locations in Egypt, e.g. *Fiorinia phoenicis* Balachowsky (Hemiptera: Diaspididae) [5], *Phoenicococcus marlatti* Cockerell (Hemiptera:Phoenicococcidae) [6-8], *Avidovaspis phoenicis* Gerson and Davidson [9] and *Palmapsis phoenicis* Ramachandra Rao [10] and *Avidovaspis phoenicis* Gerson and Davidson [25].

3.2. Incidence of the *Avidovaspis phoenicis* and its parasitoid

The results of *A. phoenicis* population dynamics and its parasitoid *Aphytis mytilaspidis* (Le Baron) (Hymenoptera, Aphelinidae) on date palm trees in Giza Governorate over 2019 and 2020 years are presented in Figures 1 and 2. The average numbers of individuals were 1889, 848.6, and 12.3 individuals for nymphs, adults, and parasitoid of *A. phoenicis*, respectively, during 2019. Nymph density reached its maximum in mid-August, 2019, showing 5590 nymphs/sample. The lowest nymph density occurred during the period of mid of January showing 1 nymph/sample. Adult density was highest on September 1st, 2019 at 3911 Adults/sample. The lowest population of an adult was observed during mid of January, 2019 with one adult/sample. The parasitoid density reached its maximum in mid-September, 2019, showing 53 individuals/sample. The lowest parasitoid density occurred during the period of mid-April showing 2 individuals/sample.

The average numbers of individuals were 2253.1, 1037.9, and 21.9 individuals for nymphs, adults and parasitoid of *A. phoenicis*, respectively during 2020 (Figures 3 and 4). Nymph density reached its maximum on the 1st of September, 2020, showing 6984 Nymphs/sample. The lowest nymph density occurred on the 1st of January showing 5 nymphs/sample. Adult density was highest on September 1st, 2020 at 4310 adults/ sample. The lowest population of adult was observed during 1st of February, 2020 with 1 adult/sample. The parasitoid density reached its maximum on 1st of September, 2020, showing 71 individuals /sample. The lowest parasitoid density occurred during the period of mid-April showing 10 individuals /sample (Table 2).

The results of *A. phoenicis* population dynamics and its parasitoid *A. mytilaspidis* on date palm trees in Qalyubiya Governorate over 2019, and 2020 years are presented in Figures 1 and 2. The average numbers of individuals were 1563.9, 697.3, and 37.3 individuals for nymphs, adults, and parasitoid of *A. phoenicis*, respectively during 2019. Nymph density reached its maximum in mid-August, 2019, showing 4950 nymphs/sample. The lowest nymph density occurred on the 1st of January showing 9 nymphs/sample. Adult density was highest on mid-September, 2019 at 2518 adults/sample. The lowest population of adults was observed on the 1st of January, 2019 with 1 adult/sample. The parasitoid density reached its maximum on the 1st of October, 2019, showing 146 individuals/sample. The lowest parasitoid density occurred during the period of mid-February showing 1 individual/sample (Table 2).

The average numbers of individuals were 1421.8, 571.3 and 31.8 individuals for nymphs, adults and parasitoid of *A. phoenicis*, respectively during 2020. Nymph density reached its maximum on mid-August, 2020, showing 4300 nymphs/sample. The lowest nymph density occurred on the 1st of January showing 15 nymphs/sample. Adult density was highest on mid-September, 2020 with 2100 adults/sample. The lowest population of adults was observed during mid of January, 2020 with 2 adults/sample. The parasitoid density reached its maximum on the 1st of September, 2020, showing 154 individuals/sample. The lowest parasitoid density occurred during the period of mid of February showing one individual/sample.

Statistical analysis of the effect of weather factors on the population of *A. phoenicis* and its parasitoid during the two years under consideration is shown in Tables 2-5. It is concluded that maximum and minimum temperatures were significant in the population of *A. phoenicis* and its parasitoid,

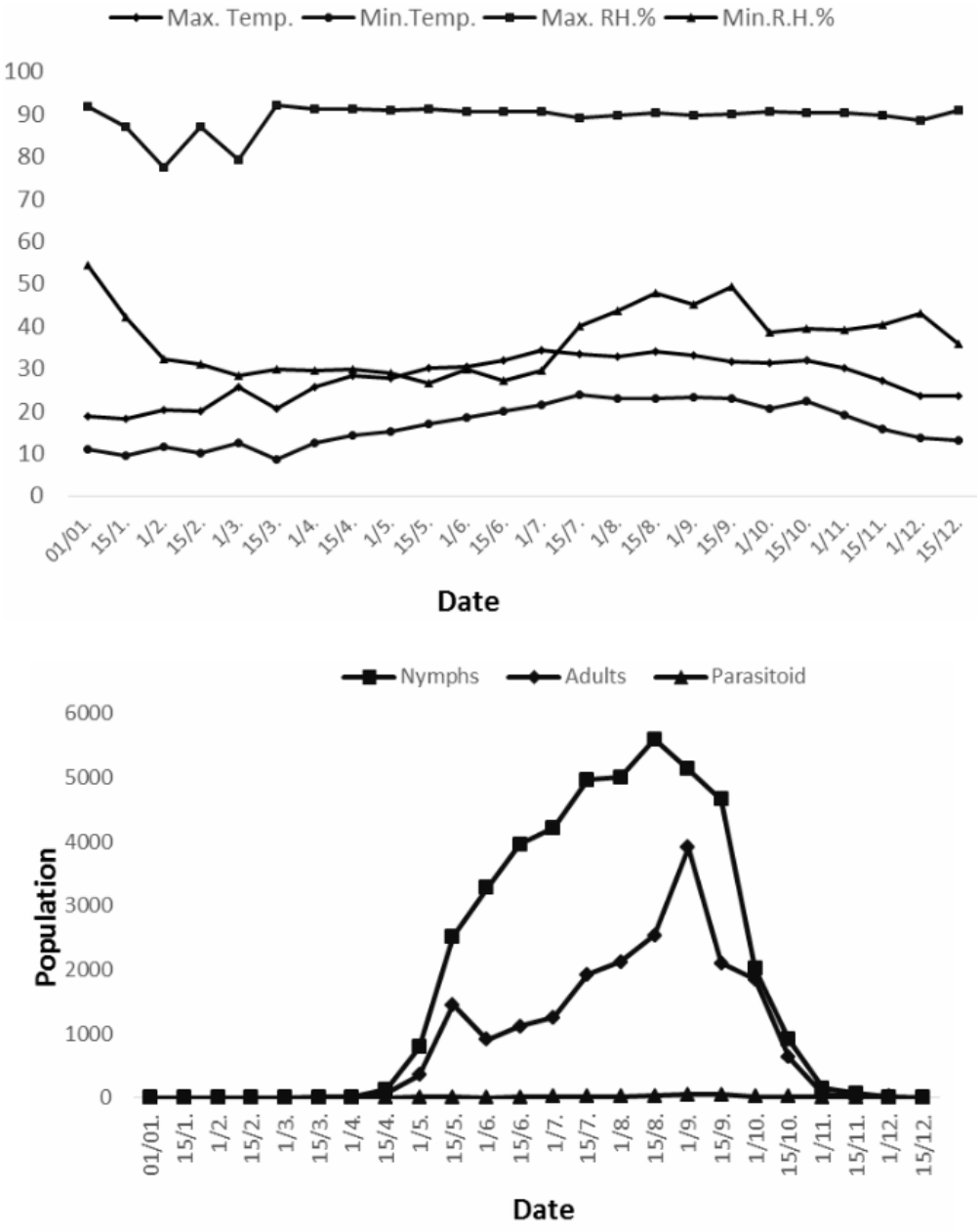

Figure 1. Half monthly count of different stages of the scale *Avidovaspis phoenicis* infesting date palm trees in Giza during 2019 season.

A. mytilaspidis while the percent of relative humidity is non-significant.

The obtained results showed that, both nymphal and adult stages have two periods of seasonal activity per year. The 1st period of nymphal activity that occurred in the autumn season peaked in early December in both years, respectively. The 2nd period of nymphal activity that occurred in the summer season peaked in early July in the 1st year and early June during the 2nd one. The 1st period of adult activity was recorded during the autumn-winter seasons with one peak in early February in the 1st and 2nd year, respectively. The 2nd period of activity was determined during the summer season that peaked in early July in the 1st year and early June in the 2nd one. These results are in

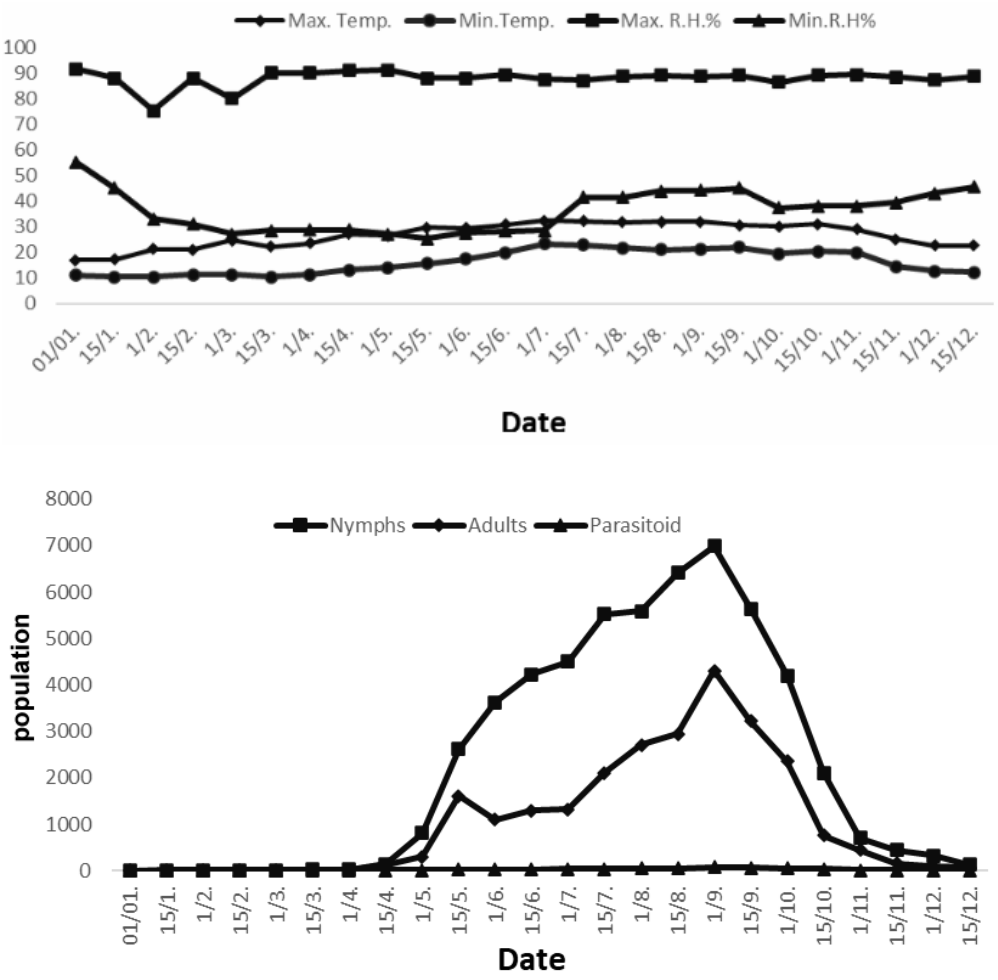

Figure 2. Half monthly count of different stages of the scale *Avidovaspis phoenicis* infesting date palm trees in Giza during 2020 season.

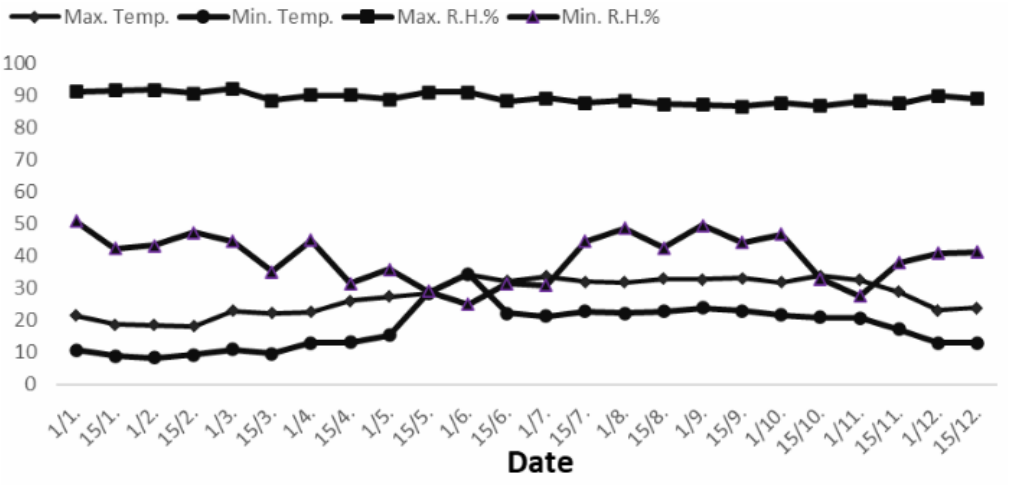

Figure 3

Figure 3 continued..

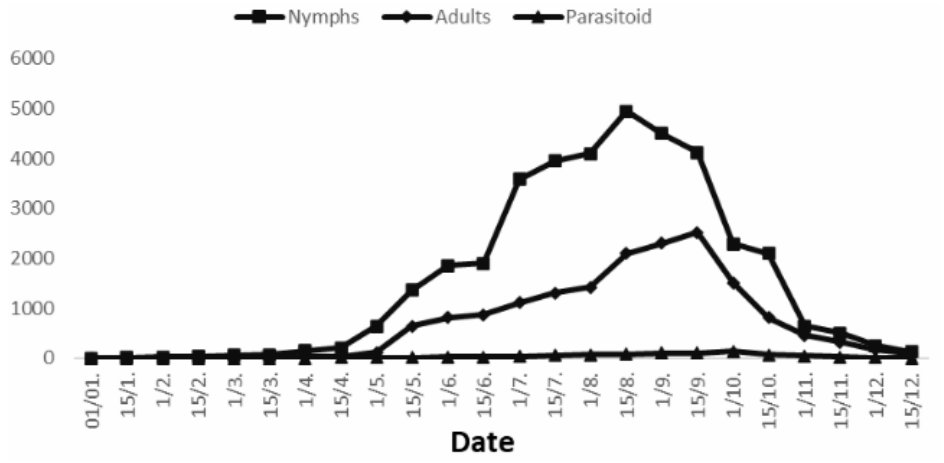

Figure 3. Half monthly count of different stages of the scale *Avidovaspis phoenicis* infesting date palm trees in Qalyubiya during 2019 season.

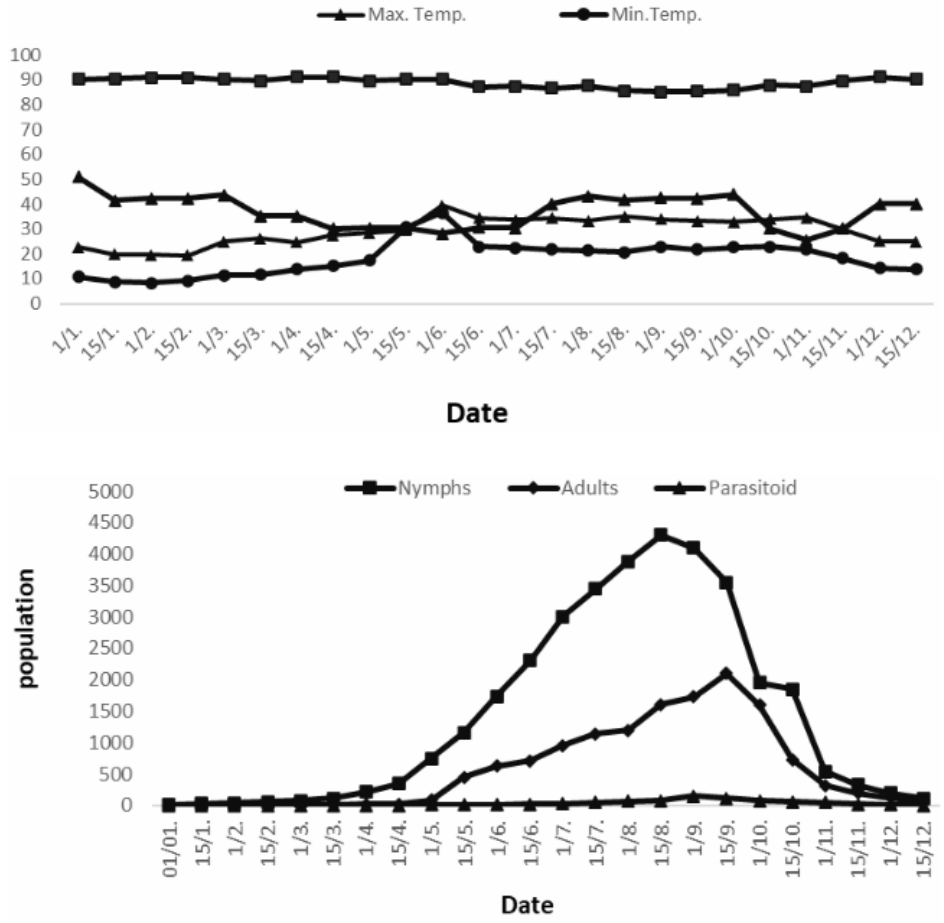

Figure 4. Half monthly count of different stages of the scale *Avidovaspis phoenicis* infesting date palm trees in Qalyubiya during 2020 season.

Table 2. Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Avidovaspis phoenicis* infesting date palm trees in Giza during 2019 season.

Variable	Nymphs	Adult
Parasitoid	0.8***	0.9***
Max. Temp. ºC	0.8***	0.7***
Min. Temp. ºC	0.8***	0.8***
Max. RH. %	0.2	0.2
Min. RH. %	0.2	0.4

***Highly significant.

Table 3. Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Avidovaspis phoenicis* infesting date palm trees in Giza during 2020 season.

Variable	Nymphs	Adult
Parasitoid	0.9***	0.96 ***
Max. Temp. ºC	0.8 ***	0.75***
Min. Temp. ºC	0.9***	0.8***
Max. RH. %	0.1	0.1
Min. RH. %	0.2	0.2

***Highly significant.

Table 4. Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Avidovaspis phoenicis* infesting date palm trees in Qalyubiya during 2019 season.

Variable	Nymphs	Adult
Parasitoid	0.8***	0.9***
Max. Temp. ºC	0.8***	0.75***
Min. Temp. ºC	0.7***	0.7***
Max. RH. %	-0.6***	-0.7***
Min. RH. %	0.1	0.2

***Highly significant.

agreement with Al-Hafidh *et al.* [26], who stated that the armored scale *Parlatoria blanchardii* (Tarq.) infested date palms in central and southern Iraq. The population dynamics indicated that peak densities occurred in May-June for all stages. Also, Khoualdia *et al.* and Abivardi [27, 28] recorded that parlatoria scale has three to five overlapping generations annually and in Iran, it has three to four generations per year, respectively. The seasonal incidence of *P. blanchardii* on date palm was mild during May and June and then with the onset of monsoon, its population increased and reached the maximum during December and January months. The highest population of this pest was recorded during the month of January while, the least

Table 5. Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Avidovaspis phoenicis* infesting date palm trees in Qalyubiya during 2020 season.

Variable	Nymphs	Adult
Parasitoid	0.8***	0.9***
Max. Temp. ºC	0.75***	0.7***
Min. Temp. ºC	0.6***	0.6**
Max. RH. %	-0.9***	-0.9***
Min. RH. %	0.1	0.2

**Significant; ***Highly significant.

population in the month of June [29]. Gharib [30] stated that *Palmaspis phoenicis* (Green) has two short generations in spring and summer and one long one in autumn and winter, overwintering as an immature female and paring in the following May. *P. blanchaidii* was found together with *P. phoenicis*.

On the other hand, the duration of seasonal activity for both nymphal and adult stages was affected significantly by the tested weather factors (Daily mean maximum and minimum temperatures and % RH). These results are in agreement with Latifian and Zearea [31] who reported that a significant correlation was observed between population dynamics and weather conditions including temperature and relative humidity. The present findings partially agree with that of Idder-Ighili *et al.* [32] who reported that minimum temperature had a negative effect on population density, while high maximum temperature showed positive influence in date palm scale population fluctuations. Also, El-Said [12] reported that the effect of maximum temperature on *P. blanchardii* was highly significant in the first year and insignificant in the second year, whereas El-Said [33] reported a significant positive effect of mean relative humidity on scale population, and a significant negative effect in the first year and a significant positive effect in the second year of minimum temperature. Later Kumar *et al.* [29] found that the scale population showed a significant negative correlation with maximum and minimum temperatures and a non-significant negative correlation between maximum relative humidity and rainfall. However, minimum relative humidity had a significant negative correlation.

3.3. Control measure for *Avidovaspis phoenicis* and its parasitoid *Aphytis mytilaspidis*

3.3.1. In Giza

The obtained data shown in Tables 6 & 7 revealed that the treatment with imidacloprid (Ecomida) was the most effective against *A. phoenicis* throughout the experiment period 2019 and 2020. The reduction percentage for imidacloprid (Ecomida) was 92.56 and 91.19, respectively. In addition, Malathion gave 90.82 and 89.13% reduction followed by chlorpyrifos (Dursban H) (90.05 and 87.93%), thiamethoxam (Actara) (87.99 and 84.13), Mineral oil (Tiger) (87.19 and 87.35), buprofezin (Applaud) (81.12 and 84.13), lufenuron (Match) (79.16 and 79.37) and deltamethrin (Decis) (76.79 and 77.45). Considering the probable occurrence of side effects of the tested compounds on the non-targeted parasitoid *A. mytilaspidis* during 2019 and 2020, the data shown in Tables 4 and 5 and Figures 1 and 2 illustrate that deltamethrin (Decis) compound caused the lowest reduction effect (71.55 and 70.76%) followed in the ascending order by lufenuron (Match) (73.02 and 73.85%), then buprofezin (Applaud) (74.10 and 77.39%), and Mineral oil (80.87 and 78.90%) with no significant differences between them, then malathion (Ictathion), chlorpyrifos (Dursban H), imidacloprid (Ecomida), and thiamethoxam (Actara) which caused the highest parasite reduction percentages that reached 85.29 and 83.15%, 85.16 and 81.95%, 84.93 and 87.16%

Table 6. Reduction percentage of different compounds on the armored scale *Avidovaspis phoenicis* and its parasitoid on date palm in Atfih (Giza) during 2019.

Treatment	Rate of Applic. /L.W.	% Reduction after									Average % reduction			
		15			30			45						
		A	N	P	A	N	P	A	N	P	A	N	T	P
Mineral oil (Tiger 97% EC)	10 ml/L	80.45	83.90	76.42	85.94	89.37	81.09	90.47	93.03	85.12	85.62	88.76	87.19 ab	80.87 a
Iufenuron (Match 5% EC)	160 ml/ Fed.	71.5	75.03	68.26	77.73	82.48	73.56	81.46	86.82	77.26	76.89	81.44	79.16 c	73.02 b
Chlorpyrifos (Dursban H 48% EC)	1 L/Fed.	84.01	86.61	82.96	89.04	92.27	85.98	92.97	95.13	88.82	88.67	91.43	90.05 a	85.16 a
Malathion (Ictathion 57%)	1.5 ml/L	85.04	88.31	81.67	89.23	92.88	85.15	93.47	96.01	89.06	89.24	92.4	90.82 a	85.29 a
Deltamethrin (Decis 2.5% EC)	5 ml/L	68.82	70.7	66.92	76.98	79.25	72.17	79.98	84.82	75.57	75.26	78.32	76.79 c	71.55 b
Buprofezin (Applaud 25% Sc)	600 ml/ Fed.	73.18	78.17	70.12	78.93	84.94	74.47	82.65	88.86	77.72	78.25	83.99	81.12 bc	74.10 b
Thiamethoxam (Actara 25% WG)	2.5 g/L	85.2	89.64	81.15	88.81	94.28	84.72	72.77	97.24	87.78	82.26	93.72	87.99 ab	84.55 a
Imidacloprid (Ecomida 30.5% SC)	6 ml/L	86.16	90.99	82.47	90.77	95.27	85.18	94.17	98.02	87.15	90.36	94.76	92.56 a	84.93 a

A: Adult; N: Nymph; P: Parasitoid; T: Total.
F value for insect = 4.589542 L.S.D. for insect = 8.243777.
F value for parasitoid = 8.088504 L.S.D. for parasitoid = 6.438664.
a, b, c letters indicate significant differences between treatments.

Table 7. Reduction percentage of different compounds on the armored scale *Avidovaspis phoenicis* and its parasitoid on date palm in Atfih (Giza) during 2020.

Treatment	Rate of Applic. /L.W.	% Reduction after									Average % reduction			
		15			30			45						
		A	N	P	A	N	P	A	N	P	A	N	T	P
Mineral oil (Tiger 97% EC)	10 ml/L	81.55	84.95	73.49	86.1	89.08	79.87	89.75	92.65	83.35	85.8	88.89	87.35 ab	78.90 bcd
Iufenuron (Match 5% EC)	160 ml/ Fed.	72.2	75.09	68.58	78.35	82.14	73.69	82.16	86.25	79.28	77.57	81.16	79.37 c	73.85 cd
Chlorpyrifos (Dursban H 48% EC)	1 L/Fed.	82.54	86.1	77.05	85.87	91.29	83.16	88.54	93.22	85.66	85.65	90.20	87.93 ab	81.95 abc
Malathion (Ictathion 57%)	1.5 ml/L	83.79	87.55	79.58	86.88	91.97	83.84	89.36	95.23	86.03	86.67	91.58	89.13 ab	83.15 ab
Deltamethrin (Decis 2.5% EC)	5 ml/L	68.25	73.0	62.29	76.45	80.82	72.33	81.61	84.59	77.68	75.43	79.47	77.45 c	70.76 d
Buprofezin (Applaud 25% Sc)	600 ml/ Fed.	75.05	82.08	72.15	80.75	89.55	76.82	85.33	92.06	83.2	80.37	87.89	84.13 bc	77.39 bcd
Thiamethoxam (Actara 25% WG)	2.5 g/L	86.03	87.57	81.79	90.33	92.68	85.79	95.53	96.02	88.6	89.63	92.75	91.19 ab	85.39 ab
Imidacloprid (Ecomida 30.5% SC)	6 ml/L	87.35	91.45	83.72	90.02	93.89	87.37	93.09	97.1	90.4	90.15	94.14	92.15 a	87.16 a

A: Adult; N: Nymph; P: Parasitoid; T: Total.
F value for insect = 4.306145 L.S.D. for insect = 7.730804.
F value for parasitoid = 3.881436 L.S.D. for parasitoid = 8.586844.
a, b, c, d letters indicate significant differences between treatments.

and 84.55 and 85.39%, respectively, without significant differences between them.

Results of statistical analysis (F value and L.S.D.) (Tables 6 and 7) showed that seven treatments had a significant effect on populations.

3.3.2. In Qayubiya

The obtained data shown in Tables 8 and 9 revealed that the treatment with imidacloprid (Ecomida) was the most effective against *A. phoenicis* throughout the experiment period 2019 and 2020. The reduction percentage for imidacloprid (Ecomida) was 92.93 and 92.46, respectively. In addition, thiamethoxam (Actara) gave 91.1 and 92.30 reduction followed by Malathion (90.01 and 90.76%), chlorpyrifos (Dursban H) (88.97 and 87.51%), Mineral oil (Tiger) (88.2 and 88.87), lufenuron (Match) (80.89 and 82.14), buprofezin (Applaud) (76.63 and 80.1), and deltamethrin (Decis) (76.87 and 78.29). Considering the probable side effects of the tested compounds on the non-targeted parasitoid *A. mytilaspidis* during 2019 and 2020, the data shown in Tables 4 and 5 and Figures 1 and 2 illustrate that buprofezin (Applaud) compound caused the lowest reduction effect (68.29 and 72.40%) followed in the ascending order by deltamethrin (Decis) (74.64 and 70.81%), lufenuron (Match) (with no significant differences between them), then thiamethoxam (Actara), malathion (Ictathion), Mineral oil (Tiger), chlorpyrifos (Dursban H), and imidacloprid (Ecomida), which caused the highest parasitoid reduction percentage that reached 83.25 and 85.97%, 83.69 and 82.01%, 84.15 and 84.68%, 84.39 and 81.64% and 85.76 and 87.04, respectively with no significant differences between them.

Results of statistical analysis (F value and L.S.D.) (Tables 8 and 9) showed that seven treatments had a significant effect on populations.

Eight insecticide compounds namely Mineral oil (Tiger), Lufenuron (Match), Malathion (Ictathion), Deltamethrin (Decis), Chlorpyrifos (Dursban H), Imidacloprid (Ecomida), Thiamethoxam (Actara), and Buprofezin (Applaud) were evaluated for their controlling activity on the scale insect, *A. phoenicis* as well as its parasitoid *A. mytilaspidis* on date palm in Giza and Qalyubiya Governorates during two successive seasons 2019 and 2020.

Chemical insecticides are not the best solution to the problem of scale insects, because they have more effect on the natural enemies while the scales on the body of white scale insects serve as a barrier and protect them from the applied chemicals [34]. The obtained results revealed that Imidacloprid (Ecomida) induces the highest reduction ranging from 84-92% for *A. phoenicis* and its parasitoid, *A. mytilaspidis* during the two experimental years, while the reduction in Qayubiya ranged from 85-92%. On the other hand, deltamethrin (Decis) showed fewer reduction percentages for *A. phoenicis* and its parasitoid *A. mytilaspidis* during the two successive (2019-2020) years in the two locations (Giza and Qalubiya). Also, the percentage value for both Giza and Qayubiya is given as 70-77. These results are in agreement with Howard and Weissling [35]. They stated that Imidacloprid used as a soil drench can be very effective; however, it should be mixed at a very high concentration. Also, these results are quite similar to Palmer and Vea [36] who confirmed that the mortality was 49.6 and 76.5% after 14 and 28 days, respectively, and when the foliar spray application was done on the tea scale on Japanese camellia (*Camellia japonica*) the mortality reached 85%. They also confirmed the efficacy of distance 10 EC (Pyriproxyfen) and talus 70 DF (Buprofezin) on Southern Magnolia against False oleander scale where Distance 10 EC and Talus 70 DF showed 32.3 and 50.2% reduction (2 weeks interval). These findings are in agreement with our results where pyriproxyfen 10.8 EC and buprofezin 25 WP were 38.15 and 51.19% effective, 15 days after foliar application. Pyriproxyfen 10.8 EC was more effective as foliar sprays (68.45%) as compared to the basin (45.03%) application method. These findings are supported by Raupp *et al.* [37] who conducted an experiment on the efficacy of foliar applications, trunk injections, and soil drenches of IGR (Pyriproxyfen) and horticultural oil in reducing the population of Elongate Hemlock Scale (*Abgrallaspis ithacae*). Results indicated that foliar application of pyriproxyfen and horticultural oil provided superior levels of control of the

Table 8. Reduction percentage of different compounds on the armored scale *Avidovaspis phoenicis* and its parasitoid on green beans in Qaha (Qalyubyia) during 2019.

Treatment	Rate of Applic. /L.W.	% Reduction after									Average % reduction			
		15			30			45						
		A	N	P	A	N	P	A	N	P	A	N	T	P
Mineral oil (Tiger 97% EC)	10 ml/L	81.37	85.96	77.55	87.84	90.04	86.03	90.84	93.16	88.87	86.68	89.72	88.2 a	84.15 a
Iufenuron (Match 5% EC)	160 ml/ Fed.	73.37	79.49	71.86	80.48	83.41	76.78	83.05	85.56	80.12	78.96	82.82	80.89 b	76.25 b
Chlorpyrifos (Dursban H 48% EC)	1 L/Fed.	83.77	86.09	81.41	88.19	90.84	84.09	91.16	93.82	87.67	87.70	90.25	88.97 a	84.39 a
Malathion (Ictathion 57%)	1.5 ml/L	85.86	88.66	78.41	88.33	91.52	85.26	91.27	94.42	88.01	88.48	91.53	90.01 a	83.89 a
Deltamethrin (Decis 2.5% EC)	5 ml/L	70.66	74.6	71.02	76.95	79.4	74.57	78.16	81.77	78.33	75.15	78.59	76.87 b	74.64 bc
Buprofezin (Applaud 25% Sc)	600 ml/ Fed.	69.99	75.92	65.9	74.66	79.81	67.75	77.17	82.19	71.22	73.95	79.30	76.63 b	68.29 c
Thiamethoxam (Actara 25% WG)	2.5 g/L	84.33	87.12	80.85	91.66	93.33	83.63	93.85	96.35	85.29	89.94	92.26	91.1 a	83.25 a
Imidacloprid (Ecomida 30.5% SC)	6 ml/L	86.88	89.76	82.41	91.55	94.55	85.67	93.36	97.2	89.21	90.95	93.83	92.93 a	85.76 a

A: Adult; N: Nymph; P: Parasitoid; T: Total.
F value for insect = 8.3705 L.S.D. for insect = 6.635613.
F value for parasitoid = 7.711207 L.S.D. for parasitoid = 6.718299.
a, b, c letters indicate significant differences between treatments.

Table 9. Reduction percentage of different compounds on the armored scale *Avidovaspis phoenicis* and its parasitoid on date palm in Qaha (Qalyubyia) during 2020.

Treatment	Rate of Applic. /L.W.	% Reduction after									Average % reduction			
		15			30			45						
		A	N	P	A	N	P	A	N	P	A	N	T	P
Mineral oil (Tiger 97% EC)	10 ml/L	83.49	86.69	81.86	87.52	90.92	84.6	90.32	94.28	87.58	87.11	90.63	88.87a	84.68 ab
Iufenuron (Match 5% EC)	160 ml/Fed.	77.45	80.08	75.3	80.59	84.2	77.83	83.79	86.75	81.23	80.61	83.67	82.14 bc	78.12 c
Chlorpyrifos (Dursban H 48% EC)	1 L/Fed.	81.46	85.83	78.98	86.69	89.67	82.79	88.93	92.46	84.04	85.69	89.32	87.51 ab	81.64 bc
Malathion (Ictathion 57%)	1.5 ml/L	86.45	89.96	79.52	88.41	92.57	84.07	92.14	95.05	82.45	89.0	92.52	90.76 a	82.01 ab
Deltamethrin (Decis 2.5% EC)	5 ml/L	71.36	76.87	67.49	74.99	81.74	71.34	79.02	84.84	73.6	75.12	81.45	78.29 c	70.81 d
Buprofezin (Applaud 25% Sc)	600 ml/ Fed.	74.11	78.1	68.14	78.55	82.54	73.13	81.42	85.35	75.94	78.02	81.99	80.01 c	72.40 d
Thiamethoxam (Actara 25% WG)	2.5 g/L	85.95	88.79	81.84	92.06	94.31	86.39	95.35	97.31	89.09	91.12	93.47	92.30 a	85.97 ab
Imidacloprid (Ecomida 30.5% SC)	6 ml/L	86.89	90.3	83.02	91.77	94.96	87.95	93.39	97.48	90.17	90.68	94.24	92.46 a	87.04 a

A: Adult; N: Nymph; P: Parasitoid; T: Total.
F value for insect = 7.30915 L.S.D. for insect = 6.257429.
F value for parasitoid = 10.85975 L.S.D. for parasitoid = 5.491156.
a, b, c, d letters indicate significant differences between treatments.

Elongate Hemlock Scale as compared with soil drenches and trunk injections. Pyriproxyfen 10.8 EC and thiamethoxam 25 WG gave a minimum reduction of 45.03, 68.45%, and 54.77, 61.25% in the basin and spray method, respectively after 3 weeks of treatments. These findings are not in agreement with Taha *et al.* [38] who checked the effects of the powder of argel (*Solenostemma argel*) and usher (*Calotropis procera*) on females of green pit scales (*P. phoenicis*) in the soil dressing method in comparison with Actara (thiamethoxam) 25 WG (standard insecticide). It is thus concluded that systemic insecticides or insect growth regulators will be the best option to control the date palm white scale. Direct spraying of insecticides will yield better results than the basin application method. Foliar applications of a variety of oil-based compounds have proven effective against the immature stages of the pest [26]. Sprays of oil emulsion with dimethoate, malathion, or methyl-parathion, and of methyl-parathion alone, also lead to significant mortality of the pest. Oil emulsion with dimethoate increased the yield/tree up to 74% [39]. The oils cover the insects and suffocate them making the surface of the plant difficult for crawlers to settle [35].

CONCLUSION

Finally, it could be concluded that the most effective treatment for controlling the armored scale insect, *A. phoenicis* during winter months when the parasitoid *A. mytilaspidis* population occurs at a low level, is using deltamethrin (Decis). On the other hand, when the parasitoid population is high during the summer and spring months, we recommend spraying with deltamethrin (Decis) which gives low reduction percentages to the aphelinid parasitoid with more effect on the target insect pest.

CONFLICT OF INTEREST STATEMENT

There are no conflicts of interest.

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