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Survey and population dynamics of scale insects (Hemiptera :Coccoidea) infesting apple trees and thier natural enemies in Egypt

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Abstract :

Apple (*Malus domostica* Borkhis) one of the most important deciduous fruit trees in Egypt. Scale insects (Hemiptera : Coccoidea) are the most important pests infested orchard trees including apple . The present work dealt with the survey of scale insects infested apple trees and their natural enemies in different locations in Egypt as well as population dynamics of the dominant species infested apple of these pests. The results indicated that 21 species of scale insects were recorded infested apple trees in Egypt. The dominant species were *Hemiberlesia lataniae* (Signoret), *Lepidosaphes beckii* (Newman) , *Lepidosaphes pallidula* (Williams), *Parlatoria oleae* (Colvée) ((Hemiptera :Coccoidea: Diaspididae) , *Planococcus citri* (Risso), *Planococcus ficus* (Signoret) (Hemiptera :Coccoidea: Pseudococcidae) and *Russellaspis pustulans pustulans* (Cockerell) (Hemiptera :Coccoidea: Asterolecaniidae). Also, in the present work 19 parasitoids and 2 hyperparasitiods and 33 predators were recorded associated with scale insects infesting apple trees. The dominant species were, the parasitoids *Aphytis chrysomphali* (Mercet), *Aphytis maculicornis* (Masi), *Aphytis lepidosaphes* Compere, *Encarsia citrina* (Craw) (Hymenoptera: Aphelinidae), *Leptomastidea abnormis* (Girault) , *Metaphycus asterolecanii* (Mercet) and *Zaplatycerus kemticus* (Trjapitzin and Triapitsyn) (Hymenoptera : Encyrtidae) and the predators *Chilocorus bipustulatus* L. (Coleoptera: Coccinellidae), *Chrysopa vulgaris* L., *Chrysoperla carnea* (Stephens) (Neuroptera : Chrysopidae) , *Dicrodiplosis manihoti* Harris (Diptera: Cecidomyiidae) , *Exochomus flavipes* Thunb. and *Scymnus syriacus* Mars. (Coleoptera: Coccinellidae). Also, during the present work the populations dynamics of scale insects infested apple trees and their natural enemies were provided as well as the effect of whether factors on scale insects.

Introduction :

Apple is one of the most important fruit in Egypt as far as its acreage, production and exportation potentials are concerned. Apple trees are at damage of sustaining by scale insects infestations. Scale insects (Hemiptera : Coccoidea) are comprising about 7,500 species in 45 families while in Egypt, are 209 valid species names in 12 families: Aclerdidae (Grass scales), Asterolecaniidae (Pit scales), Coccidae (Soft scales), Dactylopiidae (Cochineal

scales), Diaspididae (Armored scale insects), Eriococcidae (Felt scales), Halimococcidae, Lecanodiaspididae (False pit scales), Monophlebidae (true mealybug), Ortheziidae (Ensign scales), Phoenicococcidae (Date scales), Pseudococcidae (Pseudomealybug) (Abd-Rabou and Evans, 2020).

Scale insects are the major pests infesting different horticulture crops including apple in Egypt (Abd-Rabou, 2003, Wawrzynski and Ascerno, 2009 and Moustafa and Abd-Rabou, 2010). The damage of scale insects caused sucking the juices from the plants sap. Scale feeding slowly reduces plant vigor, heavily infested plants grow poorly and suffer dieback of twigs and branches. Some of scales often secrete a sticky honeydew which supports the growth of black sooty molds, interfering with photosynthesis and makes the plants unattractive. Hammad and Moussa (1973) reported 62 host plants attacked by scale insects including, apple trees. *Parlatoria oleae* (Colvee) (Hemiptera: Diaspididae) and *Russellaspis pustulans pustulans* (Cockerell) (Hemiptera:Asterolecanidae) recorded infested apple by El-Minshawy *et al.* (1974).The parasitoids and predators associated with scale insects in Egypt studied by Priesner and Hosny (1940), Hafez (1988), Abd-Rabou (1997, a, b, 1999, 2000, 2001, 2001a), Awadallah *et al.*(1999), Morsi (1999) and Evans and Abd-Rabou (2005).

The aim of the present work is to study, a survey of scale insects infesting apple trees and their natural enemies in Egypt as well as the population dynamics of them and the effect of weather factors.

Materials and methods:

1. Survey of scale insects infesting apple trees in Egypt:

A survey of scale insects infested apple trees and their natural enemies were carried out all over Egypt from July 2018 to July 2020. Infested plants with scale insects were examined in the field, using a pocket lens. Leaves, stems and twigs 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. Thereafter, the leaves and twigs were kept in a closed paper bag and transferred to the laboratory for further examination and counting. Each leaf was stored in a well-ventilated emergence glass tube and monitored daily for parasitoid emergence. Predators were also, collected and identified.

2. Population dynamics of scale insects infesting apple trees and their natural enemies :

Population dynamics of scale insects and their natural enemies infested apple trees were carried out on apple during 2018-2019 and 2019-2020 in Alexandria, Behira, Demyaat, Gharbiya , Ismailia , Qalyubyia and Sharqiya Governorates**.** The plant areas selected for these investigations received no chemical control measures for several years. Thirty trees of apple almost similar in age, size, shape and growth condition were randomly chosen for sampling at a month interval for each location. On each sampling, 30 leaves and 15 twigs of apple were chosen at random. Thereafter, the leaves and twigs were kept in a closed paper bag and transferred to the laboratory for further examination and counting. Each leaf was stored in a well-ventilated emergence glass tube and monitored daily for parasitoid emergence. Predators were counted in filed and transferred to the laboratory for further examination. The meteorological data (MxT, MnT and RH) over 2018, 2019 and 2020 was obtained from the Meteorological Central Laboratory, Agricultural

Research Center, and Ministry of Agriculture. Simple correlation and regression values were calculated to obtain information about the relationships between the three tested weather factors and the population of the pest and its natural enemies.

3. Statistical analysis:

All the data obtained during the trials over the tested seasons were subjected to analysis by using SAS (SAS Institute Inc., 1988) program.

Results and discussion

1. Survey of scale insects infesting apple trees in Egypt:

As shown in Table (1) the apple trees were infested by 25 scale insect species: 15 species belonging to Family Diaspididae, four species belonging to family Pseudococcidae, three species belonging to family *Monophlebidae*, two species of family Coccidae and one species of family Asterolecanidae . Also, in the present work 19 parasitoids and 2 hyperparasitiods and 33 predators were recorded associated with scale insects infesting apple trees. Eleven armored scale insect species attacking 62 host plant species including apple (Hammad and Moussa, 1973). The host plant crop of *P. oleae* and *R. pustulans* was apple (El-Minshawy *et al*., 1974). Hafez (1988) recorded *Aphytis lingnanensis* Comepre (Hymenoptera:Aphelinidae) as the most common species of *A. aurantii* on apple. *Encarsia citrina* (Craw) (Hymenoptera: Aphelinidae) was recorded for the first time in Egypt by Priesner and Hosny (1940). *Pteroptrix aegyptica* Evans and Abd-Rabou (Hymenoptera: Aphelinidae) was recorded for the first time in Egypt by Evans and Abd-Rabou (2005). *Leptomastidea abnormis* (Girault) (Hymenoptera: Encyrtidae)was recorded for the first time in Egypt by Abd-Rabou and its reared from *Maconellicoccus hirsutus* (Green) wit h maximum parasitism rate was 21% (Abd-Rabou, 2000). *Coccophagus* scutellaris (Dalman) (Hymenoptera: Aphelinidae) collected for the first time in Egypt by Priesner and Hosny (1940). The range of host plants of the monophlebid, *Icerya seychellarum* (Westwood) includes 44 host plant species (Assem , 1991). Abd-Rabou (1997) studied the parasitoids attacking some species of scale insects. He mentioned that total parasitism of *A. aurantii* by *A. chrysomphali, A. lingnanensis, E. citrina* and *Encarsia lounsburyi* (Berlese and Paoli) (Hymenoptera: Aphelinidae) reached a maximum during September at South Sinai and Qalyubiya.

Tawfik *et al.* (1970) recorded the insect predators associated with the black scale, in Egypt. These predators are *Chilocorns bipustulatus* L. (Coleoptera: Coccinellidae), *Scymnus syriacus* Muls., *Pharoscymnus varius* Kirsch., *Rodalia cardinalis* Muls. and the larvae of *Chrysopa carnea* Steph., *C. bipustulatus* L. seem to be the most important predator of this scale infesting apple orchard. The coleopterous insect predators feeding on soft scale infesting different crops in Mansoura region were *Cydonia vicina* isis Cr., *Coccinella septempunctata* L., *C. undecimpunctata* (Coleoptera: Coccinellidae), *Scymnus* interruptus Goez, *S. cyriacus, Exochomus flavipes* Thunb., *Rodalia cardinalis* Muls. and *Paederus alfierii* Koch. He added two neuropetrous predators, *Chrysopa carnea* Steph. (Neuroptera: Chrysopidae) and *C. septempunctata* Wesm.; two hemipterous predators, *Orius laevigatus* Fieb. and *O. albidipennis* (Reuter) (Hemiptera: Anthocoridae) and two dipterous predators, *Metasyrphus corollae* Fab. and *Paragus compeaitus* Wied. (Abd Allah, 1988). *C. bipustulatus, S. syriacus, C. carnea, C. septempunctata* and *O. laevigatus* , recorded associated with different species of soft scale

insects in Kafr El-Sheikh (El-Agamy *et al*., 1994). The predator *R. cardinals* recorded associated with *Icerya* spp. Later, Abd-Rabou *et al.* (2012) reviewed the predator species of scale insects in Egypt.

Table (1) : List of scale insects infesting apple trees and their natural enemies in Egypt .

No.	Scale insects		Natural enemies	
	Family	Species	Parasitoids	Predators
1	Asterolecaniidae	*Russellaspis pustulans pustulans* (Cockerell)	*Metaphycus asterolecanii* (Mercet)	*Chilocorns bipustulatus* L.
2	Coccidae	*Ceroplastes floridensis* Comstock		*Scymnus syriacus* Muls., *Coccinella undecimpunctata* L and *Cydonia vicina nilotica* Muls.
3		*Kilifia acuminata* (Signoret)	*Coccophagus scutellaris* (Dalman)	*Clitostethus arcuatus* Rossi *Coccinella septempunctata* L. Rhyzobius *littura* Fab.
4	Diaspididae	*Aonidiella aurantii* (Maskell)	*Aphytis linganensis* Comper, *A. chrysomphali* (Mercet), *A. coheni* DeBach, *A. diaspidis* (Howad), *Encarsia citrina* (Craw), and *E. aurantii* (Howard) and the secondary parasitoids, *Marietta javensis*	*Scymnus syriacus* Mars. ,*Stethorus* sp. *Chrysoperlla carnae* Steph. and *Chrysopa vulgaris* L.
5		*Aspidiotus nerii* Bouche	*Aphytis chrysomphali* (Mercet)	*Pharoscymnus various* Kirsch. and *Orius laevigatus* Fieb.
6		*Dynaspidiotus britannicus* (Newstead)	*Aphytis lingnanensis* Comepre	*Chilocorus bipustulatus* L., *Coccinella undecimpunctata* L., *Exochomus flavipes* Thunb. and *Pharoscymnus various* Kirsch.
7		*Hemiberlesia lataniae* (Signoret)	*Encarsia citrina* (Craw)	*Coccinella undecimpunctata* L., *Exochomus flavipes* Thunb. and *Pharoscymnus various* Kirsch.
8		*Hemiberlesia rapax* (Comstock)	*Encarsia citrina* (Craw)	*Chrysopa carnea* Steph., *Rhyzobius lophanthae* (Blaisdell), *Scymnus syriacus* Mars. and *Stethorus* sp.
9		*Lepidosaphes beckii* (Newman)	*Aphytis lepidosaphes* Compere , *Encarsia citrina* (Craw.) and *Aphytis lingnanensis* Comepre	*Chilocorus bipustulatus* L. , *Chrysoperlla carnae* Steph., *Chrysopa vulgaris* L and *Typhlodromus* sp.
10		*Lepidosaphes gloverii* (Packard)	*Aphytis mytilaspidis* (Le Baron)	*Typhlodromus* sp. and *Rhyzobius lophanthae* (Blaisdell)
11		*Lepidosaphes pallidula* (Williams)	*Aphytis chrysomphali* (Mercet)	*Chilocorus bipustulatus* L., *Exochomus flavipes* Thunb., *Scymnus syriacus* Mars. and *Stethorus* sp.
12		*Lepidosaphes tapleyi* Williams	*Aphytis lingnanensis* Comepre	*Coccinella undecimpunctata* L, *Pharoscymnus various* Kirsch., *Rhyzobius lophanthae* (Blaisdell) and *Stethorus* sp.
13		*Lepidosaphes ulmi* (Linnaeus)	*Encarsia citrina* (Craw)	*Chilocorus bipustulatus* L., *Coccinella undecimpunctata* L., *Exochomus flavipes* Thunb. and *Scymnus syriacus* Mars. *Stethorus* sp.

Table (1) : Continued

No.	Scale insects		Natural enemies	
	Family	**Species**	**Parasitoids**	**Predators**
14	Diaspididae	*Melanaspis inopinata* (Leonardi)	*Pteroptrix aegyptica* Evans and Abd-Rabou	*Chilocorus bipustulatus* L., *Typhlodromus* sp., *Exochomus flavipes* Thunb., *Pharoscymnus various* Kirsch., *Rhyzobius lophanthae* (Blaisdell) and *Stethorus* sp.
15		*Mycetaspis personata* (Comstock)	*Encarsia citrina* (Craw)	*Coccinella undecimpunctata* L., *Exochomus flavipes* Thunb. and *Rhyzobius lophanthae* (Blaisdell)
16		*Parlatoria oleae* (Colvée)	*Aphytis chrysomphali, A. diaspidis, A. maculicornis, Coccophagoides* sp., *E. aurantii , M. leopardina* and *Aphytis maculicornis* (Mercet)	*Pharoscymnus various* Kirsch., *Chrysopa vulgaris* L. and *Rhyzobius lophanthae* (Blaisdell)
17		*Parlatoria pergandii* Comstock	*Aphytis lingnanensis* Comepre	*Rhyzobius lophanthae* (Blaisdell) *Exochomus flavipes* Thunb. *Pharoscymnus various* Kirsch.
18		*Quadraspidiotus perniciosus* (Comstock)	*Aphytis proclia* (Walker)	*Stethorus* sp. *Orius laevigatus* Fieb.
19	Monophlebidae	*Icerya aegyptiaca* (Douglas)	None	*Rodalia cardinalis* Muls.
20		*Icerya purchasi* Maskell	None	*Rodalia cardinalis* Muls.
21		*Icerya seychellarum* (Westwood)	None	*Rodalia cardinalis* Muls.
22	Pseudococcidae	*Ferrisia virgata* (Cockerell)	*Gyranusoidea indica* Shafee, Alam and Agarwalb and *Leptomastix dactylopii* Howard	*Chrysoperla carnea* (Stephens) (Chrysopidae) , *Orius albidipennis* (Reuter) , *Scymnus syriacus* Mars. and *Homalotylus vicinus* Silvestri
23		*Maconellicoccus hirsutus* (Green)	*Leptomastix flava* Mercet	*Hyperaspis vinciguerrae* Capra, *Nephus* (Sidis) *hiekei* Fursch , *Scymnus interruptus* Goeze and *Scymnus seriacus* Mars.
24		*Planococcus citri* (Risso)	*Leptomastidea abnormis* (Girault)	*Scymnus syriacus* Mars. , Navas and *Chrysoperla carnea* (Stephens)
25		*Planococcus ficus* (Signoret)	*Neoplatycerus kemticus* Trjapitzin and Triapitsyn	*Dicrodiplosis manihoti* Harris, *Chrysoperla carnea* (Stephens) and *Chrysopa vulgaris aegyptica* (Schneider) .

2. Population dynamics of scale insects infesting apple trees and their natural enemies :

2.1. *Hemiberlesia latania* and its natural enemies :

The seasonal abundance of *Hemiberlesia latania* (Signort) (Hemiptera : Diaspididae) was studied for two successive years from 2018-2019 and 2019-2020 on apple trees in Gharbiya Governorate. The obtained results in Figures (1 and 2) showed that, the insect population reached maximum during October 2018 (1111 / 30 leaves and 15 twigs) and May 2019 (1320 /30 leaves and 15 twigs) in the first year and in the second year the maximum population was during October 2019 (658 / 30 leaves and 15 twigs) and May 2020 (1466 /30 leaves and 15 twigs) respectively. Numbers by the parasitoid , *Encarsia citrina* (Craw) (Hymenoptera : Aphelinidae) reached maximum (32 / 30 leaves and 15 twigs) during July and (40 / 30 leaves and 15 twigs) during May of the first year.

While in the second year reached maximum (23/ 30 /15 twigs) during February and during May (41/ 30 leaves and 15 twigs). In case of the predator, numbers by the predators , *Exochomus flavipes* Thunb. (Coleoptera: Coccinellidae) reached maximum (65 / 30 leaves and 15 twigs) during October and (87/ 30 leaves and 15 twigs) during May of the first year. While in the second year reached maximum (45/ 30 /15 twigs) during October and during May (66/ 30 leaves and 15 twigs).

Data in Tables (2 and 3), showed that the simple correlation between the population of parasitoids *Encarsia citrina*, *Exochomus flavipes*, maximum, minimum temperatures and % of relative humidity and the mean number of pests during the first and second years.

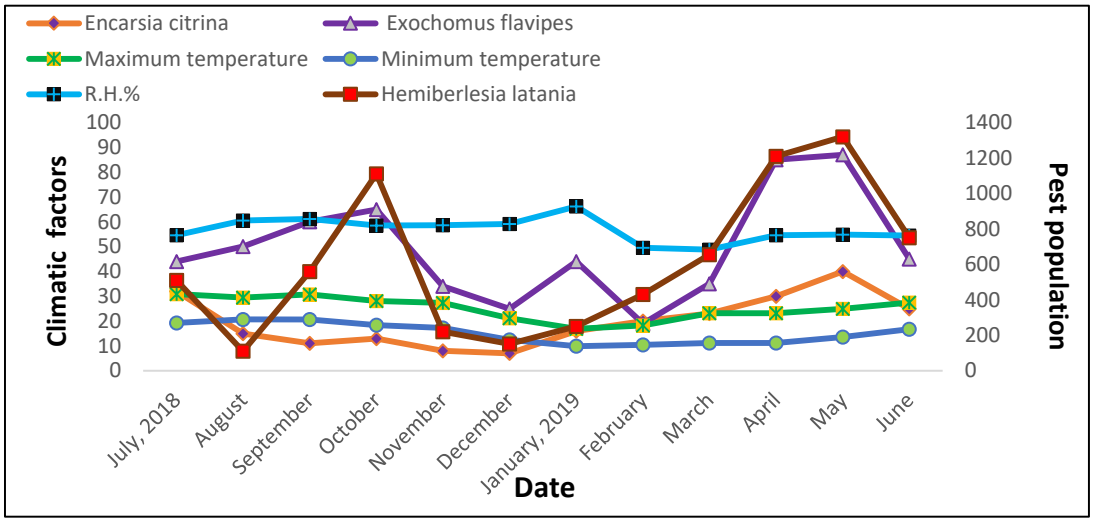

Figure (1): Population dynamics of *Hemiberlesia latania* and its natural enemies on apple trees in Gharbiya Governorate during 2018-2019 season.

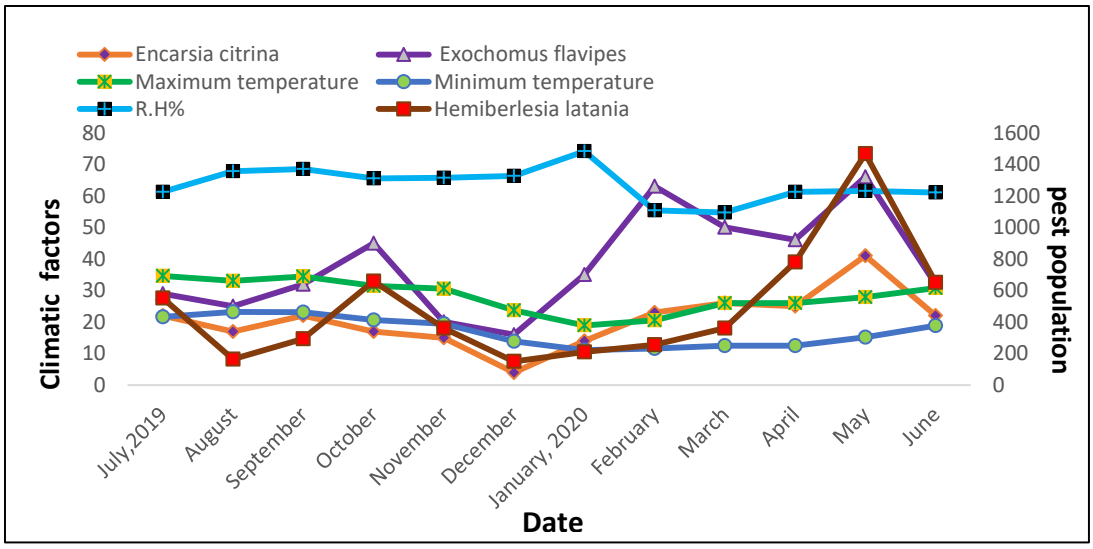

Figure (2): Population dynamics of *Hemiberlesia latania* and its natural enemies on apple trees in Gharbiya Governorate during 2019-2020 season.

Table (2): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Hemiberlesia latania* on apple trees in Gharbiya Governorate during 2018-2019 season.

Variable	Simple correlation "r"	Probability "P""
Encarsia citrina	0.66337	*
Exochomus flavipes	0.79859	**
Max. Temp. ◦C	0.11737	-
Min. Temp. ◦C	- 0.10983	-
RH%	-0.36288	-

Table (3): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Hemiberlesia latania* on apple trees in Gharbiya Governorate during 2019-2020 season.

Variable	Simple correlation "r"	Probability "P""
Encarsia citrina	0.79808	**
Exochomus flavipes	0.58084	*
Max. Temp. ◦C	0.16657	-
Min. Temp. ◦C	-0.04541	-
RH%	-0.28207	-

In Egypt, there are three generations per year for this pest (El-Minshawy *et al*., 1974). Abd-Rabou (1999) recorded 2 parasitoid species associated with latania scale. These are *Aphytis mytilaspidis* (LeBaron) (Hymenoptera: Aphelinidae) and *Haprolepis aspidioti* Compere and Annecke (Hymenoptera: Encyrtidae). Later the same author (2006) stated that *Aphytis lingnanensis* Comepre (Hymenoptera: Aphelinidae) is one of the most important parasitoids associated with armored scale insects including *H. lataniae*. Moustafa and Abd-Rabou (2011) mentioned that, the latania scale *H. lataniae* is a dangerous pest in different locations in Egypt. They recorded 17 species of natural enemies from samples of *H. lataniae*. Abundance of the latania scale *H. lataniae* natural enemies were evaluated in different locations in Egypt, representing various bioclimatic regions during two successive years 2009-2010. The results indicated that the parasitoid *H. aspidioti* the most abundant species associated with *H. lataniae* infested mango trees in Giza. The maximum rate of parasitism reached 9.1 and 7.3% in October, 2009 and 2010, respectively. The percentage of parasitism ranged from 0.1 to 9.1% in the first year and from 0.3 to 7.3% in the second year. The predator *C. carnae* was the most abundant species and occurred all over the years under investigation on *H. lataniae* on olive trees in Alexandria and the maximum number was 25 individuals /60 leaves and 15 twigs in July in the first year and 17 individuals/60 leaves and 15 twigs in June in the second year.

2.2. *Lepidosaphes beckii* and its natural enemies :

The seasonal abundance of *Lepidosaphes beckii* (Newman) (Hemiptera : Diaspididae) was studied for two successive years from 2018-2019 and 2019-2020 on apple trees in Alexandria. The obtained results in Figures (3 and 4) showed that, the insect population reached maximum during October 2018 (1203 / 30 leaves and 15 twigs) and May 2019 (1550 /30 leaves and 15 twigs) in the first year and in the second year the maximum population was during October 2019 (987 / 30 leaves and 15 twigs) and May 2020 (2100 /30 leaves and 15 twigs) respectively. Numbers by the parasitoid , *Aphytis lepidosaphes* Compere (Hymenoptera: Aphelinidae) reached maximum (28 / 30 leaves and 15 twigs)

during October and (41 / 30 leaves and 15 twigs) during May of the first year. While in the second year reached maximum (43/ 30 /15 twigs) during November and during May (46/ 30 leaves and 15 twigs). In case of the predator, numbers by the predators , *Chilocorus bipustulatus* L. (Coleoptera: Coccinellidae) , reached maximum (21 / 30 leaves and 15 twigs) during July and (9/ 30 leaves and 15 twigs) during June of the first year. While in the second year reached maximum (31/ 30 /15 twigs) during August and during May (9/ 30 leaves and 15 twigs).

Data in Tables (4 and 5), showed that the simple correlation between the population of *A. lepidosaphes*, *C. bipustulatus*, maximum, minimum temperatures. % of relative humidity and the mean number of pests during the first and second years.

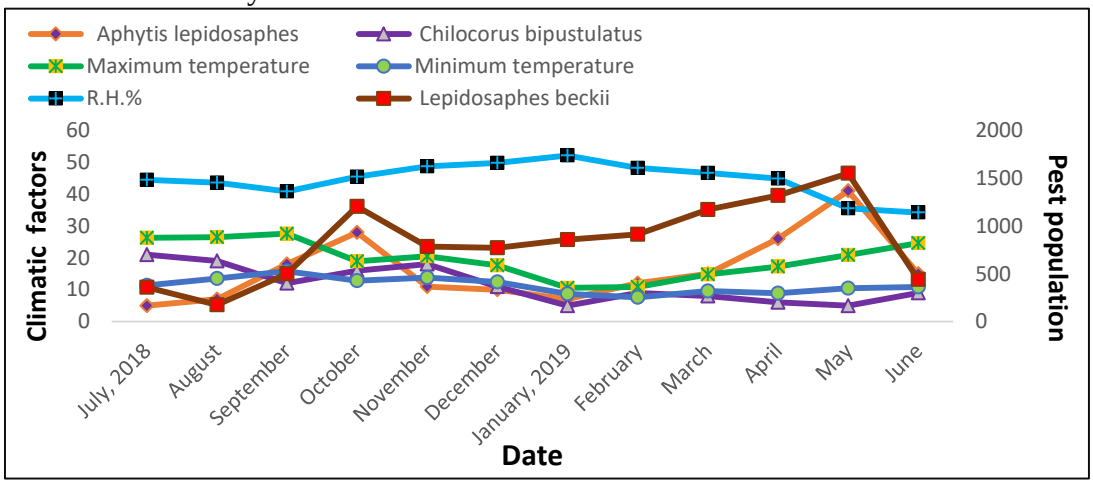

Figure (3): Population dynamics of . *Lepidosaphes beckii* and its natural enemies on apple trees in Gharbiya Governorate during 2018-2019 season.

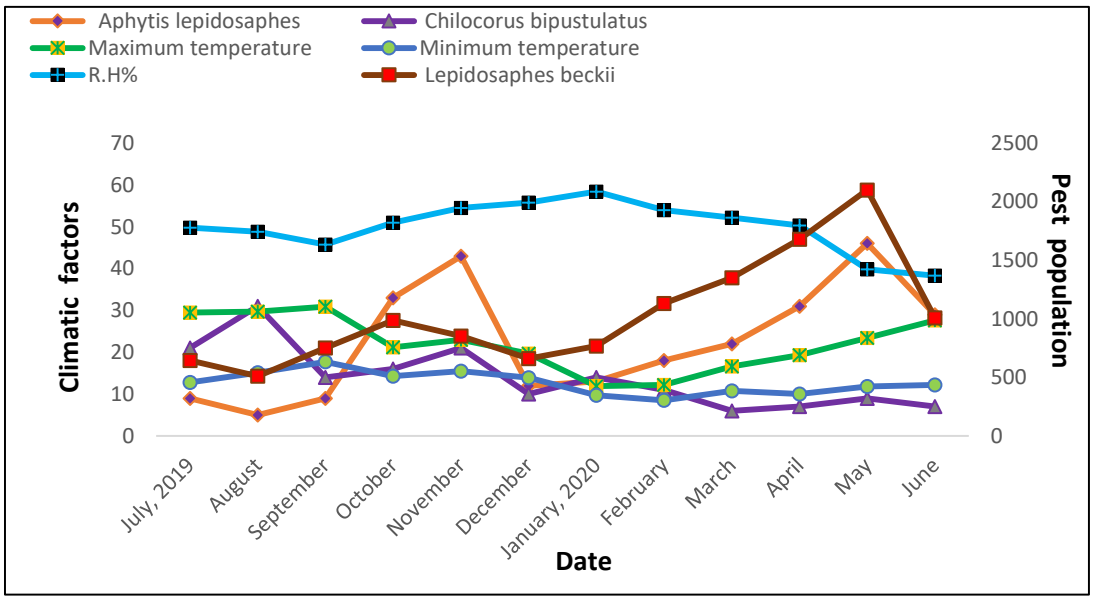

Figure (4): Population dynamics of . *Lepidosaphes beckii* and its natural enemies on apple trees in Gharbiya Governorate during 2019-2020 season.

Table (4): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Lepidosaphes beckii* on apple trees in Alexandria Governorate (Nobaria) during 2018-2019 season.

Variable	Simple correlation "r"	Probability "P""
Aphytis lepidosaphes	0.77468	*
Chilocorus bipustulatus	-0.61970	*
Max. Temp. ◦C	-0.56645	*
Min. Temp. ◦C	-0.45870	-
RH%	0.02324	-

Table (5): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Lepidosaphes beckii* on apple trees in Alexandria Governorate (Nobaria) during 2019-2020 season.

Variable	Simple correlation "r"	Probability "P""
Aphytis lepidosaphes	0.70819	*
Chilocorus bipustulatus	-0.62850	*
Max. Temp. ◦C	-0.27024	-
Min. Temp. ◦C	-0.47377	-
RH%	-0.40368	-

During the present work the results indicated that the purple scale, *L. beckii* has two peaks on apple trees in Alexandria . Also, one parasitoid *A. lepidosaphes* and one predator *C. bipustulatus* were recorded. Karam (1979) studied the armored scale insects and their hymenopterous parasitoids on the grapefruit trees. Who found two parasitoids from purple scale, *L. beckii*, namely, *A. lepidosaphes* and *Encarsia* sp. In Kafr El-Sheikh, El-Agamy (1981) recorded *A. lepidosaphes* associated with *L. beckii*. The abundance of the various stages of ectoparasitoid, *Aphytis* sp. on *L. beckii* in an orange orchard of apple. The highest percentage of parasitism was 19.5-30% by immature stages of *Aphytis* during the winter season (November-February), with lower levels present during the rest of the year. The rate of adult emergence of *Aphytis* was in March through August (26.5- 58.6%) and lower during the remainder of the year (Hafez *et al*.,1987). Abd-Rabou (1997c) recorded total parasitism of *L. beckii* by different aphelinid species reached a maximum during August in Behira.

2.3. *Lepidosaphes pallidula* and its natural enemies:

The seasonal abundance of *Lepidosaphes pallidula* (Williams) (Hemiptera : Diaspididae) was studied for two successive years from 2018-2019 and 2019-2020 on apple trees in Behira. The obtained results in Figures (5 and 6) showed that, the insect population reached maximum during November 2018 (988/ 30 leaves and 15 twigs) and May 2019 (966/30 leaves and 15 twigs) in the first year and in the second year the maximum population was during November 2019 (52 / 30 leaves and 15 twigs) and May 2020 (78 /30 leaves and 15 twigs) respectively. Numbers by the parasitoid , *Aphytis chrysomphali* (Mercet) (Hymenoptera: Aphelinidae) reached maximum (16 / 30 leaves and 15 twigs) during November and (19/ 30 leaves and 15 twigs) during May of the first year. While in the second year reached maximum (9/ 30 /15 twigs) during October and during June (14/ 30 leaves and 15 twigs). In case of the predator, numbers by the predators , *Scymnus syriacus* Mars. (Coleoptera: Coccinellidae) reached maximum (9 / 30 leaves and 15 twigs) during October and (15/ 30 leaves and 15 twigs) during May of the first year. While in the second year reached maximum (11/ 30

/15 twigs) during October and during April (13/ 30 leaves and 15 twigs).

Data in Tables (6 and7), showed that the simple correlation between the population of parasitoids , *A. chrysomphali*, *S. syriacus*, maximum, minimum temperatures, % of relative humidity and the mean number of pest during the first and second years.

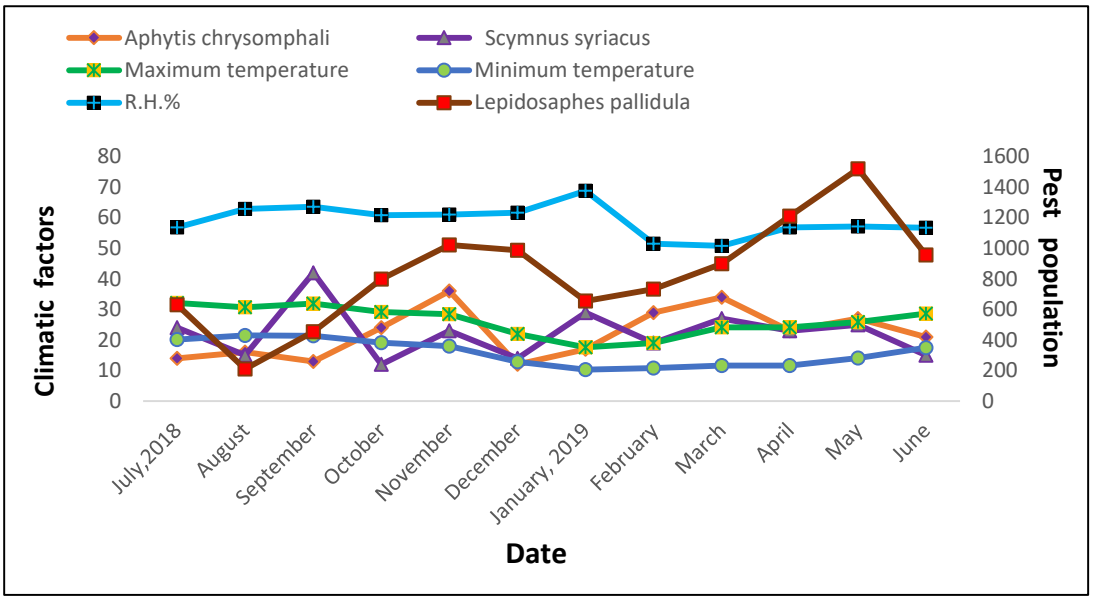

Figure (5): Population dynamics of *Lepidosaphes pallidula* and its natural enemies on apple trees in Behira Governorate during 2018-2019 season.

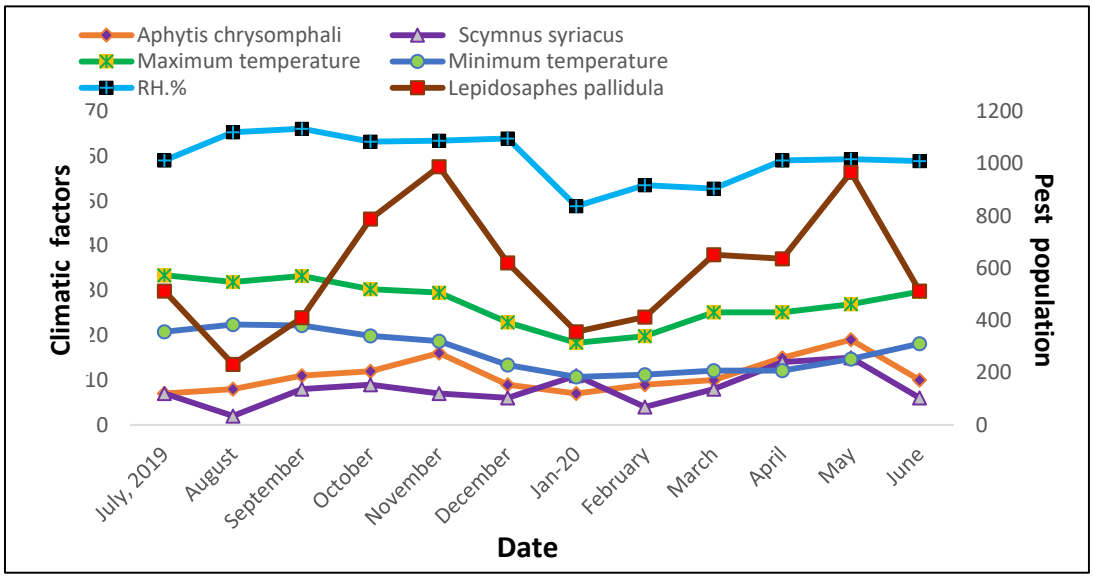

Figure (6): Population dynamics of *Lepidosaphes pallidula* and its natural enemies on apple trees in Behira Governorate during 2019-2020 season.

Table (6): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Lepidosaphes pallidula* on apple trees in Behira Governorate during 2018-2019 season.

Variable	Simple correlation "r"	Probability "P""
Aphytis chrysomphali	0.46857	-
Scymnus syriacus	-0.10763	-
Max. Temp. ◦C	-0.27567	-
Min. Temp. ◦C	-0.49271	-
RH%	-0.35847	-

Table (7): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Lepidosaphes pallidula* on apple trees in Behira Governorate during 2019-2020 season.

Variable	Simple correlation "r"	Probability "P""
Aphytis chrysomphali	0.82268	**
Scymnus syriacus	0.51702	-
Max. Temp. ◦C	0.07807	-
Min. Temp. ◦C	-0.08665	-
RH%	0.16397	-

The main host plant crops of *L. pallidula* were mango, guava , citrus and apple trees. It has 3-4 annual generations in Egypt . Abd-Rabou, S. and Evans (2005 and 2019) recorded the parasitoid *Encarsia perniciosi* (Tower) associated with *L. pallidula.*

he aphelinid parasitoids *Aphytis* attack the pest and several Phytoseiidae developed when feeding on the eggs of *L. pallidula*. The mean percentages of parasitism in the field were 13 % on *L. pallidula* (Shalaby *et al*., 2000). The maximum parasitism rates of *Aphytis hispanicus* (Mercet) on *L. pallidula* on mango in Ismailia was 9.4% during Oct., with an average rates 3.7% (Abd-Rabou, 2006).

2.4. *Parlatoria oleae* and its natural enemies:

The seasonal abundance of *Parlatoria oleae* (Colvée) (Hemiptera: Diaspididae) was studied for two successive years from 2018-2019 and 2019-2020 on apple trees in Demyaat. The obtained results in Figures (7 and 8) showed that, the insect population reached maximum during November 2018 (112 / 30 leaves and 15 twigs) and May 2019 (121 /30 leaves and 15 twigs) in the first year and in the second year the maximum population was during October 2019 (658 / 30 leaves and 15 twigs) and May 2020 (1466 /30 leaves and 15 twigs) respectively. Numbers by the parasitoid , *Aphytis maculicornis* (Masi) (Hymenoptera: Aphelinidae) reached maximum (32 / 30 leaves and 15 twigs) during July and (40 / 30 leaves and 15 twigs) during May of the first year. While in the second year reached maximum (13/ 30 /15 twigs) during November and during May (17/ 30 leaves and 15 twigs). In case of the predator, numbers by the predators , *Chrysopa vulgaris* L. (Neuroptera : Chrysopidae) reached maximum (65 / 30 leaves and 15 twigs) during October and (87/ 30 leaves and 15 twigs) during May of the first year. While in the second year reached maximum (15/ 30 /15 twigs) during December and during May (23/ 30 leaves and 15 twigs).

Data in Tables (8 and 9), showed that the simple correlation between the population of *Aphytis maculicornis, Chrysopa vulgaris*, maximum, minimum temperatures. % of relative humidity and the mean number of pests during the first and second years.

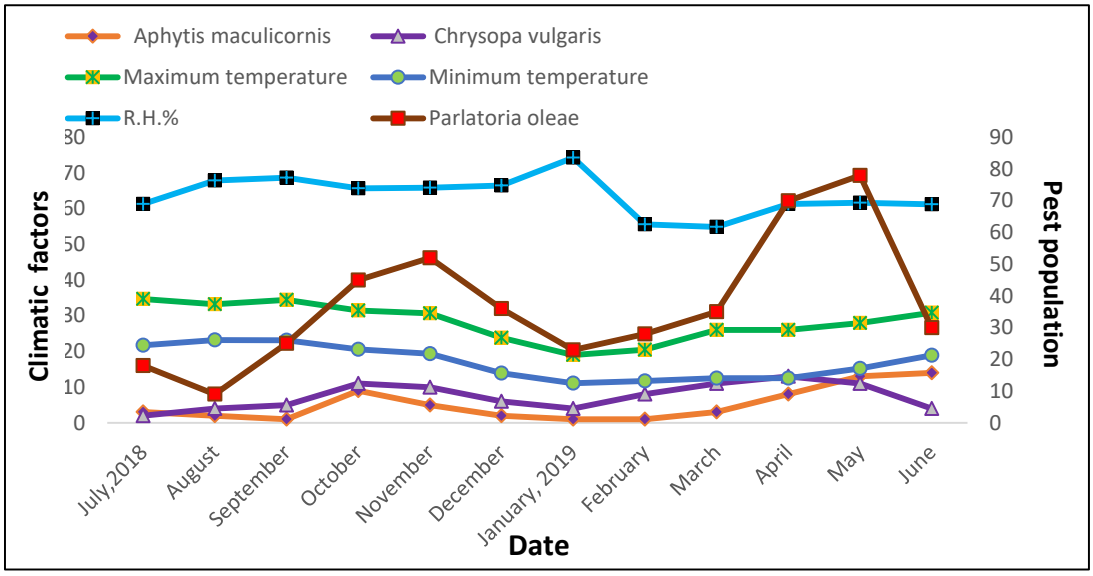

Figure (7): Population dynamics of *Parlatoria oleae* and its natural enemies on apple trees in Demyaat Governorate during 2018-2019 season.

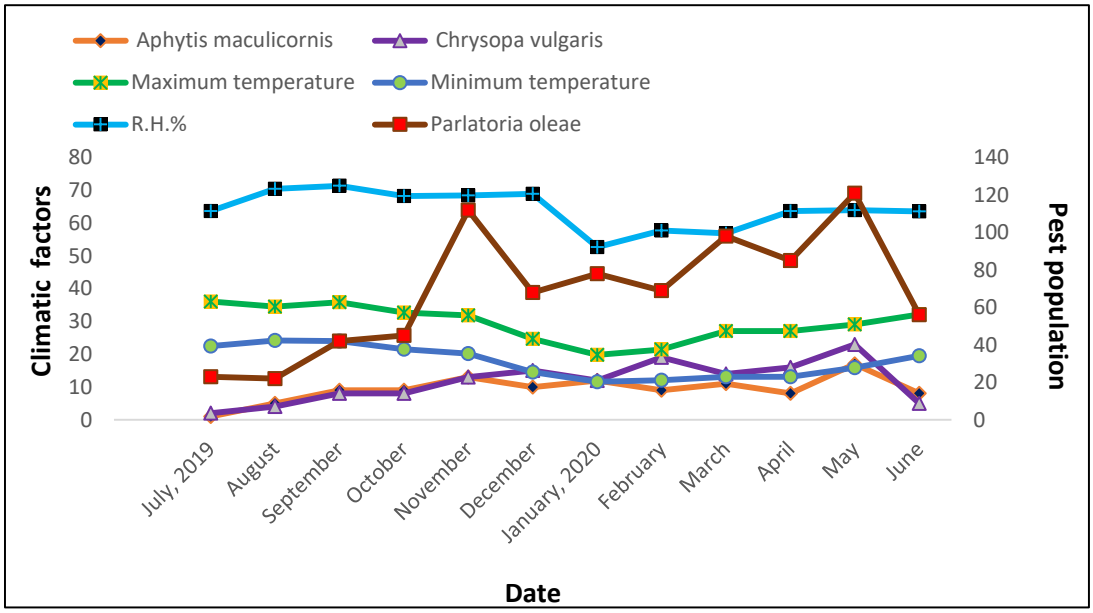

Figure (8): Population dynamics of *Parlatoria oleae* and its natural enemies on apple trees in Demyaat Governorate during 2019-2020 season.

Table (8): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Parlatoria oleae* on apple trees in Demyaat Governorate during 2018-2019 season.

Variable	Simple correlation "r"	Probability "P""
Aphytis maculicornis	0.62216	*
Chrysopa vulgaris	0.82310	**
Max. Temp. ◦C	-0.14095	-
Min. Temp. ◦C	-0.34663	-
RH%	-0.22930	-

Table (9): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Parlatoria oleae* on apple trees in Demyaat Governorate during 2019-2020 season.

Variable	Simple correlation "r"	Probability "P""
Aphytis maculicornis	0.86554	***
Chrysopa vulgaris	0.82383	**
Max. Temp. ◦C	-0.48012	-
Min. Temp. ◦C	-0.61807	*
RH%	-0.34139	-

El-Hakim and Helmy (1982) and Kasim (1995) studied the population dynamics of in *P. oleae* n different crops including apple trees. They recorded two peaks in Alexandria on olive trees and two generations of on plum and peach in Beheira, respectively . While Asfoor (1997), reported two generations on plum, pear and apple trees.

2.5. *Planococcus citri* and its natural enemies:

The seasonal abundance of *Planococcus citri* (Risso) (Hemiptera : Pseudococcidae) was studied for two successive years from 2018-2019 and 2019-2020 on apple trees in Qalyubyia The obtained results in Figures (9 and 10) showed that, the insect population reached maximum during November 2018 (1036 / 30 leaves and 15 twigs) and May 2019 (1745 /30 leaves and 15 twigs) in the first year and in the second year the maximum population was during November 2019 (810 / 30 leaves and 15 twigs) and May 2020 (925 /30 leaves and 15 twigs) respectively. Numbers by the parasitoid , *Leptomastidea abnormis* (Girault) (Hymenoptera :Encyrtidae) reached maximum (45 / 30 leaves and 15 twigs) during November and (67 / 30 leaves and 15 twigs) during May of the first year. While in the second year reached maximum (29/ 30 /15 twigs) November and during May (29/ 30 leaves and 15 twigs). In case of the predator, numbers by the predators , *Chrysoperla carnea* (Stephens) (Neuroptera : Chrysopidae) reached maximum (35 / 30 leaves and 15 twigs) during November and (55/ 30 leaves and 15 twigs) during May of the first year. While in the second year reached maximum (24/ 30 /15 twigs) during November and during May (22/ 30 leaves and 15 twigs).

Data in Tables (10 and 11), showed that the simple correlation between the population of *Leptomastidea abnormis*, *Chrysoperla carnea*, maximum, minimum temperatures. % of relative humidity and the mean number of pests during the first and second years.

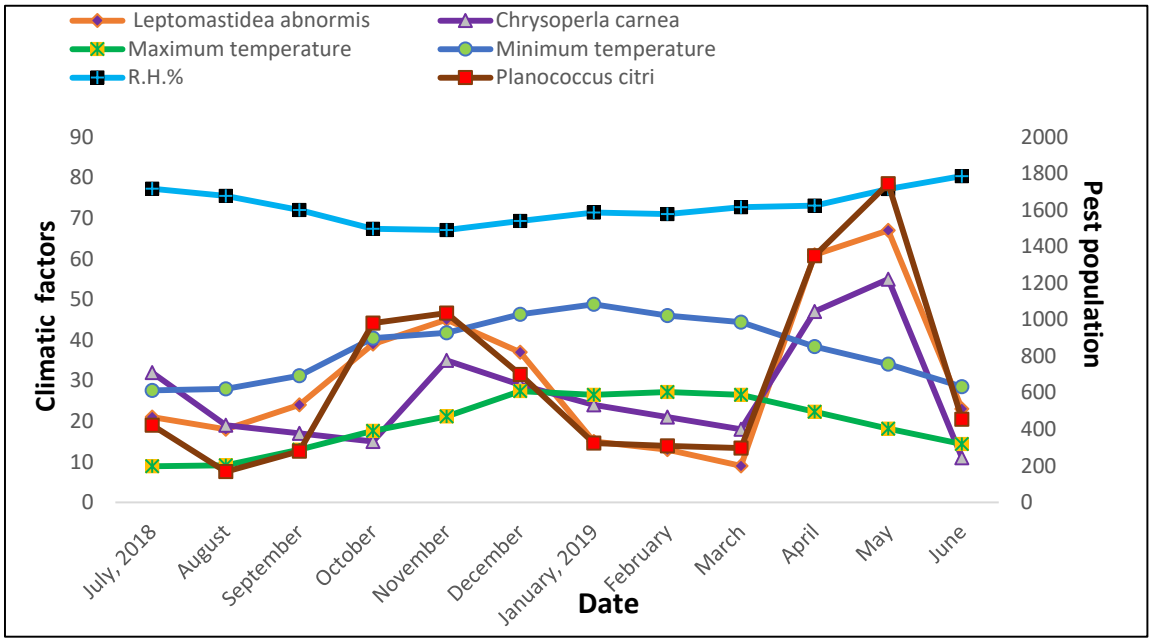

Figure (9): Population dynamics of *Planococcus citri* and its natural enemies on apple trees in Qalyubyia Governorate during 2018-2019 season.

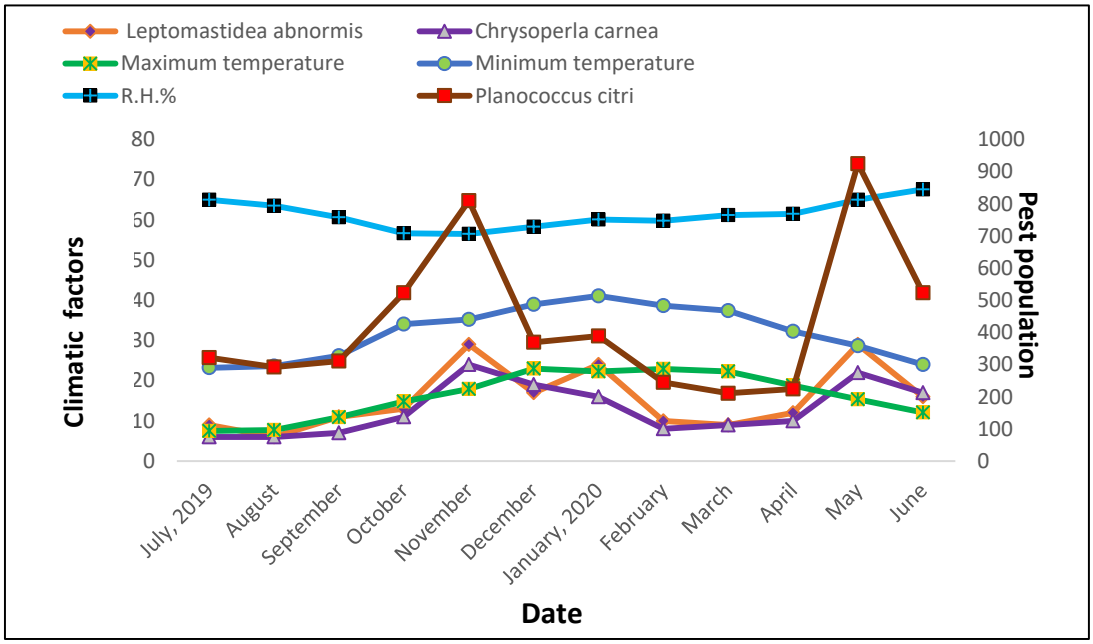

Figure (10): Population dynamics of *Planococcus citri* and its natural enemies on apple trees in Qalyubyia Governorate during 2019-2020 season.

Ahmed and Abd-Rabou (2010) studied in details the bionomics of the citrus mealy bug, *P. citri*. Their results indicated that the citrus mealy bug infested 65 plant species belonging to 56 genera in 36 families and distributed in 20 Governorates. Twelve species of parasitoids were collected and the dominant one was *L. abnormis*. Also collected nine species of predators attacked *P.citri* and the dominant one is *Chrysopa vulgaris aegyptica* (Schneider) (Neuroptera: Chrysopidae). The results also observed the host plants and temperatures greatly influenced on the development of *P. citri*. The lowering of the temperature increased the dimension of the mealy bug and lengthened the developmental period.

2.6. *Planococcus ficus* and its natural enemies :

The seasonal abundance of *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae) was studied for two successive years from 2018-2019 and 2019-2020 on apple trees in Ismailia. The obtained results in Figures (11 and 12) showed that, the insect population reached maximum during December 2018 (127 / 30 leaves and 15 twigs) and June 2019 (155 /30 leaves and 15 twigs) in the first year and in the second year the maximum population was during November 2019 (128 / 30 leaves and 15 twigs) and May 2020 (124 /30 leaves and 15 twigs) respectively. Numbers by the parasitoid , *Zaplatycerus kemticus* (Trjapitzin and Triapitsyn) (Hymenoptera :Encyrtidae) reached maximum (12 / 30 leaves and 15 twigs) during January and (34 / 30 leaves and 15 twigs) during June of the first year. While in the second year reached maximum (14/ 30 /15 twigs) during December and during June (23/ 30 leaves and 15 twigs). In case of the predator, numbers by the predator, *Dicrodiplosis manihoti* Harris (Diptera: Cecidomyiidae) reached maximum (18 / 30 leaves and 15 twigs) during December and (24/ 30 leaves and 15 twigs) during May of the first year. While in the second year reached maximum (15/ 30 /15 twigs) during December and during May (19/ 30 leaves and 15 twigs).

Data in Tables (12 and 13), showed that the simple correlation between the population of *Zaplatycerus kemticus*, *Dicrodiplosis manihoti* , maximum, minimum temperatures. % of relative humidity and the mean number of pests during the first and second years.

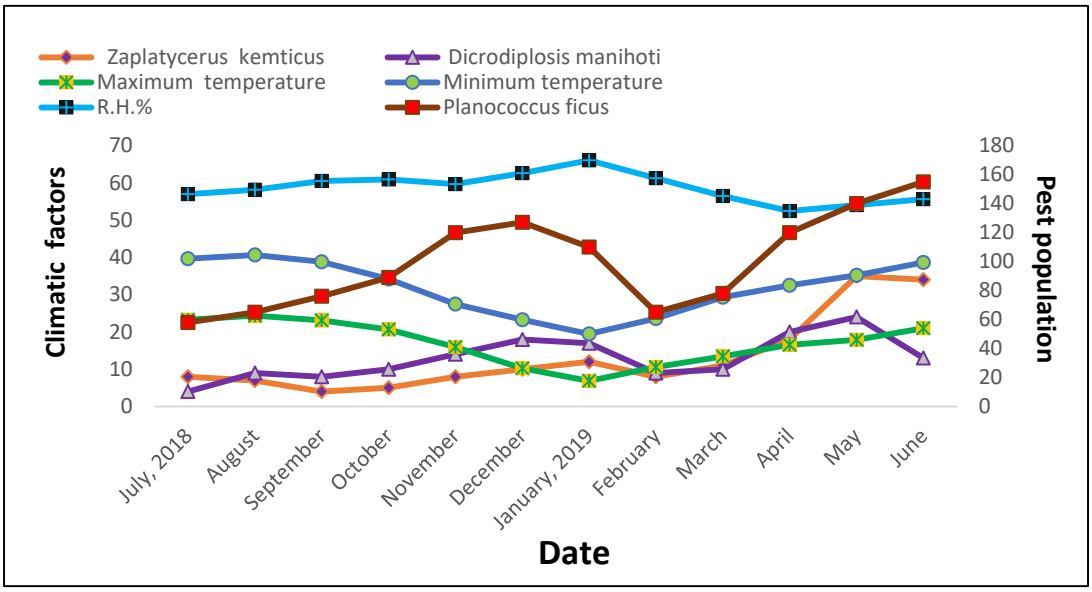

Figure (11): Population dynamics of *Planococcus ficus* and its natural enemies on trees in Ismailia Governorate during 2018-2019 season.

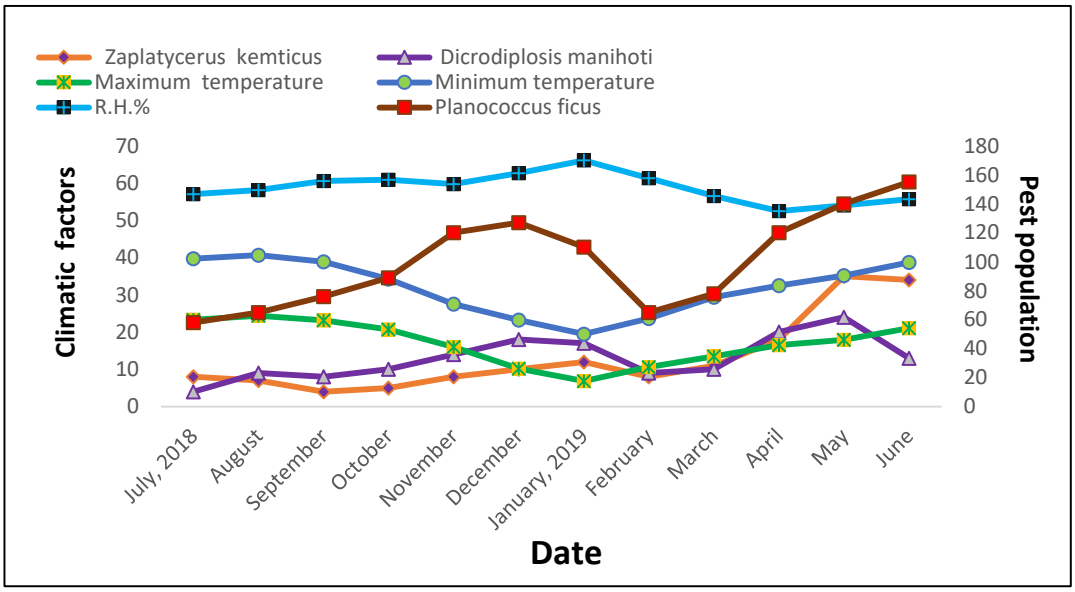

Figure (12): Population dynamics of *Planococcus ficus* and its natural enemies on trees in Ismailia Governorate during 2019-2020 season.

Table (12): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Planococcus ficus* enemies on apple trees in Ismailia Governorate during 2018-2019 season.

Variable	Simple correlation "r"	Probability "P""
Zaplatycerus kemticus	0.76599	**
Dicrodiplosis manihoti	0.79791	**
Max. Temp. ◦C	-0.22474	-
Min. Temp. ◦C	-0.15851	-
RH%	-0.21792	-

Table (13): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Planococcus ficus* enemies on apple trees in Ismailia Governorate during 2019-2020 season.

Variable	Simple correlation "r"	Probability "P""
Zaplatycerus kemticus	0.87191	***
Dicrodiplosis manihoti	0.69989	*
Max. Temp. ◦C	-0.13158	-
Min. Temp. ◦C	-0.10861	-
RH%	-0.16424	-

P. ficus recorded infesting apple trees by Granara *et al*.(1997) . The individuals of mealybugs were found throughout the year beneath the bark and infestation with *P. ficus* began in mid April and appeared in mid June. The most active period covered from mid August to October 1st showing the highest peak. The population of mealybugs on root showed in February 1st. The decrease of mealybug individuals after this date referred to the movement of individuals from roots to trunks (Hassan *et al*., 2012). Trjapitzin and Trjapitsyn (2002) and Tawfik *et al*. (2005) reported *Neoplatycerus* spp. parasitized *P.ficus*. Later Fallahzadeh *et al.* (2011) studied **natural enemies of *P. ficus* in Iran. They recorded** seven primary, two primary/secondary, three secondary parasitoid species, two coccinellids, primary parasitoids, and four predator species were associated with *P. ficus*. The eulophids *Aprostocetus trjapitzini* and *Baryscapus sugonjaevi* are new records for Iran.

2.7. *Russellaspis pustulans pustulans* and its natural enemies:

The seasonal abundance of *Russellaspis pustulans pustulans* (Cockerell) (Hemiptera: Asterolecaniidae)was studied for two successive years from 2018-2019 and 2019-2020 on apple trees in Sharqiya. The obtained results in Figures (13 and 14) showed that, the insect population reached maximum during October 2018 (1204 / 30 leaves and 15 twigs) and June 2019 (892/30 leaves and 15 twigs) in the first year and in the second year the maximum population was during October 2019 (1128 / 30 leaves and 15 twigs) and June 2020 (788 /30 leaves and 15 twigs) respectively. Numbers by the parasitoid , *Metaphycus*

asterolecanii (Mercet) (Hymenoptera :Encyrtidae) reached maximum (47 / 30 leaves and 15 twigs) during October and (26 / 30 leaves and 15 twigs) during June of the first year. While in the second year reached maximum (45/ 30 /15 twigs) during October and during June (18/ 30 leaves and 15 twigs). In case of the predator, numbers by the predators *Chilocorns bipustulatus* L. (Coleoptera: Coccinellidae) reached maximum (46 / 30 leaves and 15 twigs) during October and (38/ 30 leaves and 15 twigs) during June of the first year. While in the second year reached maximum (40/ 30 /15 twigs) during October and during June (31/ 30 leaves and 15 twigs).

Data in Tables (14 and 15), showed that the simple correlation between the population of *Metaphycus asterolecanii*, *Chilocorns bipustulatus*, maximum, minimum temperatures. % of relative humidity and the mean number of pests during the first and second years.

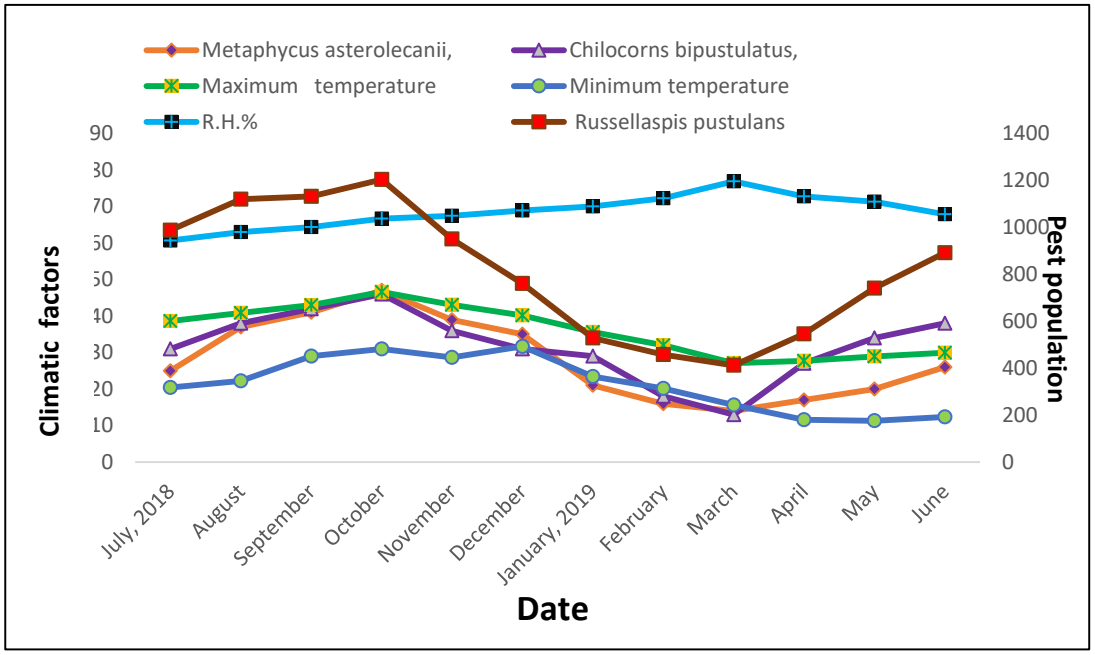

Figure (13): Population dynamics of *Russellaspis pustulans* and its natural enemies on apple trees in Sharqiya Governorate during 2018-2019 season.

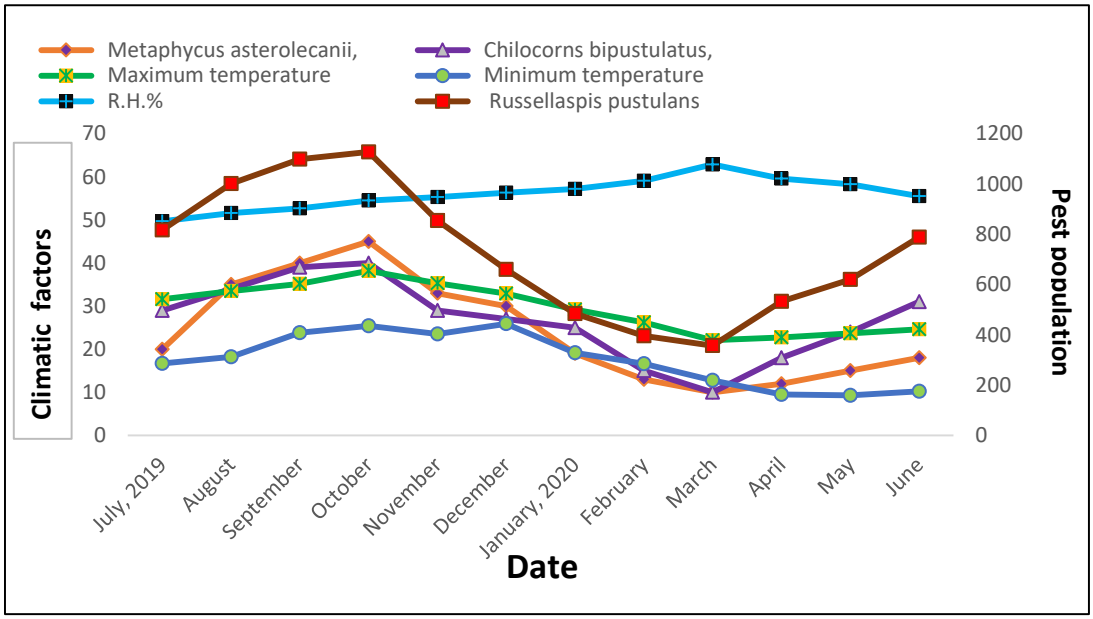

Figure (14): Population dynamics of *Russellaspis pustulans* and its natural enemies on apple trees in Sharqiya Governorate during 2019-2020 season.

Table (14): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Russellaspis pustulans* on apple trees in Sharqiya Governorate during 2018-2019 season.

Variable	Simple correlation "r"	Probability "P""
Metaphycus asterolecanii	0.88467	***
Chilocorns bipustulatus	0.90103	***
Max. Temp. ◦C	0.78930	**
Min. Temp. ◦C	.49858	-
RH%	0.84762-	***

Table (15): Statistical analysis based on correlation coefficient indicating the effects of some weather factors and natural enemies on *Russellaspis pustulans* on apple trees in Sharqiya Governorate during 2019-2020 season

Variable	Simple correlation "r"	Probability "P""
Metaphycus asterolecanii	0.89368	***
Chilocorns bipustulatus	0.95222	***
Max. Temp. ◦C	0.80119	**
Min. Temp. ◦C	0.52811	-
RH%	-0.80129	**

R. pustulans pustulans is a major pest of different orchard trees including apple (Habib, ,1943 and El-Minshawy *et al.* , 1972) . The former species had two generations, the first about four months from January till the end of April, while the second generation took about 3 months from the beginning of October till the end of December (Eraki, 1991). Later Darwish (2007) reported four peaks of the total population recorded in the two seasons; November 11th, May 5th, July 14th and August 25th throughout the first season from October 21st 2004 till October 20th 2005. In the consecutive season (2005/2006) the four peaks were recorded in November 17th, April 6th, July 13th and October 19$^{th.,}$ Abd-Rabou and Evans (2010) recorded *M. asterolecanii* associated with *R. pustulans pustulans* in Alexandria.

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